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Editorial

This regular Issue of the *World Transactions on Engineering & Technology Education* (WTE&TE), designated as Vol.6, No.2, includes 37 research and development articles submitted by authors representing 17 countries worldwide. The authors of these articles strive to present the current status of engineering and technology education, and the contemporary tendencies in research and development carried out in this particular area of academic endeavour.

In completing this sixth Volume of the WTE&TE, we have been impressed by the variety of topics, issues and ideas presented by the authors of the articles included in this Volume. Particular emphasis is being placed on research, development and promotional activities concerning the application of modern technologies in the teaching/learning process. Also, considerable interest is being noted in the problem and project-based methods more often used in engineering and technology education, which facilitate the student-centred approach to education.

Under the editorial policy of the Journal, we also endeavour to promote a broad scope of articles, tackling such issues and problems as new and critical developments in science, the application of the Internet for the search, storage and retrieval of information, the impact of new technological advances on societies, the development and cultivation of engineering and technology teachers, and others. This is in order to facilitate the preparation of high school students for their future ventures with modern technologies and production processes.

We are, indeed, proud and honoured by the fact that we have been able to establish and maintain the WTE&TE as an important source of information through which recent research, development and promotion of academic achievements can be documented, presented and transmitted to a broad international audience. Hence, the Journal's specific editorial policy is that the submitted articles have to undergo a strict and rigorous refereeing process in order to ensure the highest possible outcome.

Further, we are delighted by the fact that we have been able to attract so many exceptional engineering and technology experts to the Journal's Editorial Board, whose task is to assess the articles submitted to the Journal. I wish to express our sincere gratitude to the following senior academics, members of the UICEE Global Family of Engineering Educators, who have refereed the articles included in this Issue:

- Prof. Tuncay Birand, Middle East Technical University, Ankara, Turkey
- Prof. Romuald Cwilewicz, Gdynia Maritime University, Gdynia, Poland
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- Prof. Claudiu V. Kifor, *Lucian Blaga* University of Sibiu, Sibiu, Romania
- Prof. Romanas V. Krivickas, Kaunas University of Technology, Kaunas, Lithuania
- A/Prof. Wojciech Kuczborski, Edith Cowan University, Perth, Australia
- Prof. Nikos J. Mourtos, San José State University, San José, USA
- Prof. Remigiusz Sosnowski, Silesian University of Technology, Gliwice, Poland
- Prof. Algirdas V. Valiulis, Vilnius Gediminas Technical University, Vilnius, Lithuania

I would like to take this opportunity to mention the fact that this Journal would not have been a great success without so many distinguished colleagues contributing their articles and who are thus eager to share their accomplishments with others. Their efforts are being widely recognised and greatly appreciated.

It is also my pleasant duty to acknowledge, with sincere thanks, that the publication of this Issue would not have been possible without the considerable contribution of the UICEE staff to the collection and processing of the articles and, then, to the preparation of the final version of this Issue. We all trust that this publication will become another useful material released by the UICEE in our efforts to promote engineering and technology education.

Zenon J. Pudlowski

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Educating – Crisis

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ABSTRACT: *Crisis management* has become a recognised part of the overall management literature and there is a reasonable body of literature dealing directly with it, plus many writings on related matters such as disasters and catastrophes, both natural and human-made. In addition, there are publications on personal crisis situations and how one may deal with them, but in this paper, the author concentrates entirely on crisis management in industry and business. However, one may reason that the term *crisis management* is an oxymoron, which becomes somewhat apparent if examined via the commonly-recognised management tasks of planning, organising, leading and controlling. For example, although a manager may prepare plans how to deal with a crisis, no manager plans to have a crisis happen and similar reasoning may be applied to the other management tasks. The defined nature of a crisis, an unexpected event intruding into normal life, makes planning, etc, exceedingly difficult, for no matter how much preparation may be made for whatever situations can be imagined, the diabolic nature of crisis situations means an unexpected and interrupting event can occur. The above leads to why engineering students need and should be given crisis management instruction.

INTRODUCTION

We begin with a definition: *what is a crisis?* The answer depends what is taken as a source. The *Oxford Dictionary* gives:

> *Turning-point, especially of disease, moment of danger or suspense in politics, commerce, etc. (Latin, from Greek krisis, decision)* [1].

A definition that covers *commerce* has been given by Irvine and Miller: *A significant business disruption which results in extensive news media coverage and public scrutiny* [2].

Barton defines crisis more thoroughly in terms of the following six characteristic features:

- It is unexpected, that is, there is no background;
- Therefore no-one knows what to do;
- The people who must deal with it are already busy with *normal*, *everyday* matters;
- It is usually treated initially as *just something else to be done*;
- Therefore, it very often escalates through a time period from something that could be controlled to something well out of control;
- This escalation features the involvement of more than one organisation, which increases control difficulty [3].

Mitroff, a recognised guru in crisis understanding and crisis management, answered the question: *What is a crisis?* by stating (citing Perrow [4] for this):

> *There is no single, universally accepted, definition of a crisis, although there is general agreement that a crisis is an event that can destroy or affect an entire organisation* [5].

In a later work, Mitroff et al stated that *it is not possible to give a precise and general definition of a crisis* [6]. He went on to offer as a *guiding definition*, a crisis is *an event that affects or has the potential to affect the whole of an organisation*, and proceeded to distinguish between minor and major crises [6].

Rather than simply define crisis, Heath gave an example (the fire at Kings Cross Station, Sydney, Australia, in 1987) and extracted from that the following three elements:

- Little time in which to act (or respond);
- Missing or uncertain (unreliable) information;
- A threat to resources or people [7].

Heath stressed that although crises happen suddenly, they may have a trail of signals that become apparent in a post-event review. Of course, such hindsight is of no preventive value.

Has crisis management been recognised by management writers generally? A check through the indexes of some half-dozen well-known management texts has found only one reference, which defines a crisis problem and distinguishes it from no crisis:

> *A crisis problem is a serious difficulty requiring immediate action. An example is the discovery of a serious cash-flow deficiency with the potential to evolve into a serious loss* [8].

It can only be concluded that crisis management is such a specialised section of management that it has not been mentioned in most of the general literature. Indeed, the development of crisis management is very recent; the earliest reference found was dated from about 1975.

A COMMENT ON RELATED TOPICS

One may reasonably conclude, after thinking through this topic, that crisis is something to be avoided. Ideally, that is. But what leads to a crisis? That question has led the author to recognise a sequence beginning with *safety*, or more precisely the observation and exercising of safe working practices, which will minimise *risk*, a condition which can be managed, that is, controlled, to be within acceptable limits. However, if risk is not managed, controlled and minimised, then there is a higher probability that safe practices will be compromised and a *crisis* will occur. The irony of this is, of course, that even if risk is reduced to a low value, there is a similarly low-value probability that a crisis event may still occur.

This sequence of safety-risk-crisis has not been found spelled out in the literature, although there are many writers who deal with the above three items, many individually, some in pairs, but none found linking all three together. Having recognised that sequence, the author resolved to write about each. The first two were covered in two prior articles published in the *World Transactions on Engineering and Technology Education* [9][10].

FROM THE LITERATURE

As remarked above, the management literature, in its general form, does not deal with crisis and/or its management. Crisis in management affairs, and crisis management as a management response to crisis, is a specialised area covered by a few select writers.

One who has attracted this author's attention is Meyer, not only by the ease of reading his output with examples and sensible reasoning, but also by the quaint title (although a careful skim through the book has not revealed to what Meyer was referring as hitting the fan) [11].

He has identified the biggest reason for reluctance in preparing for hard times: it is simply that management thinking is geared to success, that is, managers are conditioned to think positively. So when one of his nine types of business crisis occurs, there is usually no crisis management protocol or formula that can be opened up to tell the manager-in-trouble what to do. The result is essentially the same series of emotions a person experiences, as given by Kubler-Ross, when diagnosed with a life-threatening affliction: denial and isolation, anger, bargaining for time, depression and grief, finally acceptance (incidentally, this author confirms those emotions by having observed them).

Mitroff made the same point, with reference to the extent of complexity of today's systems and the extent of the coupling between systems [6]. Curiously, he did not mention the original use of these terms by Perrow, who dealt with them very thoroughly as complicating factors in today's enterprises, particularly those using innovative technology [5].

Referring specifically to hazardous industries (eg chemical and nuclear) Perrow argued that close *coupling*, such as absence of buffer capacity between production units, increased process hazards because it makes the operation of the process more sensitive to small variations of the operating conditions, particularly if the plant under consideration is continuous and operating close to maximum design output. This connection has been agreed, generally, by technologists.

Perrow also argued against *complexity,* the extent to which the integrity of one section of a production system depends upon the next, and the extent to which there are interactions between sections. His point was that complexity can promote the occurrence of human error, and other writers (eg Dorner, Ouchi and Wilkins, and Reason) have agreed that complex situations can increase the probability of mistakes occurring. However, technologists (eg Kletz and Roberts) have pointed out shortcomings in Perrow's arguments on this.

Whatever criticisms there may be, Perrow's arguments should be noted and understood by engineers, indeed, by all technical people, because coupling and complexity has tended to be part of what is used in industry, not only in those using hazardous processes, but much of industry generally. So many industrial processes and procedures are totally unforgiving and can hurt or kill the undefended person, which is why the delicatessen section of supermarkets insist that workers wear a steel mesh glove when using a meat-slicing machine.

Mitroff itemised 11 types of crisis, including some not mentioned by Meyer, such as criminal and loss of information, with up to nine sub-types, yielding a total of 54 [4]. In both works cited, he stressed that a crisis is usually, if not always, preceded by *signals*, indicators that something may happen. Other writers on crisis management agree there are early events, whether signal or *precursors*, another term used (for example, by Andriole [12]).

Signals, precursors or preconditions may be present in a system for a long time, having arisen from errors committed in the past and lying dormant. Reason has termed such errors as *latent*, buried in the system and waiting for an opportunity to play havoc [13]. What changes the latent error to a crisis is a *trigger event* that may be another error: an unsafe act within the organisation, an action from outside or possibly a management decision. There is general agreement that the trigger event which actually initiates the crisis is usually sudden, virtually instantaneous.

However, two factors can be seen that argue against claiming that a crisis itself is sudden in every case. These are:

- The origin of that trigger event is often buried in the past, perhaps several years before, perhaps the length of time taken to reach that management decision;
- The action that occurs after the trigger event can take some time to have full effect on the organisation involved.

Therefore, from a management viewpoint, the time of the escalation or development into the full-blown crisis-onset situation (generally overlapping the tentative response) is more significant than the usually rapid onset of the trigger event.

The essence of those few paragraphs above is that the *recognition* of signals or precursors gives time to stop the trigger from acting and time to damp down the crisis itself if it begins.

Unfortunately, latent errors and triggers are often ignored. Among the injury cases this author has investigated was one in which a child's hand was crushed in a machine. The latent error was allowing the mother (who worked in the factory) to bring the child with her during the school holidays, an error shared by the mother and management. The trigger, probably, was allowing the child to assist the mother at the machine.

This author must confess to being unable to identify the reference he has seen to *psychological denial*, which refers to ignoring signals that may lead to a crisis. The classic example of psychological denial is how people living close downstream from a large dam may refuse to recognise the possibility of the dam bursting and flooding where they live. Psychological denial goes through the following four stages:

- Failure to anticipate what might eventuate by thinking about it;
- Failure to see the potential that exists;
- Failure to try to solve a problem that has been noticed;
- Failure to solve the problem.

All the references cited, except one, deal with disasters caused by human and/or industrial activity, and the management crisis behaviour that followed. Heath is the one exception; his work also covers some crises caused by natural disasters [7].

ILLUSTRATING CRISIS DEVELOPMENT

There have been plenty of major events in the last decades. Australian examples include the landslide at Thredbo, the National Bank losing millions, the fire at the Moomba plant that cut gas supply to Sydney, the explosion and fire at the Longford gas plant which cut gas supply to southern Victoria, and the Port Arthur shooting, just to name a few. However, there is no need to refer to a major disaster to illustrate crisis and here is a small example which adequately illustrates crisis development.

Several years ago, this author was requested to act as an expert witness giving an opinion on a case in which two workers (who operated a garbage collection truck) sued their employer (a city council located about 100 km from Sydney) [14]. The workers had been collecting garbage left in bins outside properties several kilometres from their base when they became extremely ill. They had to leave the vehicle and sit on the roadside and call for help while describing the odour from the truck that had affected them. Their office did act, by passing on the message to the local ambulance. The paramedics arrived, treated the men, confirmed that the truck could not be safely approached and called for the fire brigade. They arrived, assessed the situation and called for a HAZMAT team, who set up a portable shower system, donned full protective equipment, and emptied the truck onto the roadway.

They found some plastic bottles of pesticide that must have come from a bin or bins emptied into the truck. These bottles had been crushed by the compacting device and their contents had become mixed into the general garbage and produced the sickening odour. The final clean-up took several hours.

Such an event had never happened before and was hence certainly unexpected, which meant there was no standard procedure or protocol to cover the follow-up action, so no-one knew what should have been done. Those in the office who responded to the phone call were busy with their usual duties, so they had to divert attention and work out what action to take to deal with this extra job that had turned up.

Looking back through the two or three hours during that morning, the events quietly escalated from a normal garbage collection activity to employees being sick, then panic involving an ambulance, the fire brigade, HAZMAT, bringing a front-end loader to the site to put the spilled garbage back into the truck, and finally to litigation with the two workers suing the council for whatever after-effects they were able to claim from chemical exposure.

A small crisis? Yes, quite small, but containing all the features that can be found in any of the major events recorded.

WHY INCLUDE CRISIS MANAGEMENT IN ENGINEERING MANAGEMENT?

Most engineering faculties have in their curriculum some subject or subjects of a management nature. Crisis management is a specialised section of that overall topic, so it can be asked: is there a case for including crisis management in the engineering management subject? An answer comes from Stoner et al who quoted a diagram of five phases of growth many companies experience, each phase followed by a crisis [15]. The sequence is as follows:

- Growth through *creativity* followed by a crisis of *leadership*;
- Growth through *direction* followed by a crisis of *autonomy*;
- Growth through *delegation* followed by a crisis of *control*;
- Growth through *co-ordination* followed by a crisis of *red tape*;
- Growth through *collaboration* followed by a crisis of ?

Although the original diagram specifically stated *five* phases, the query provided at the end implies the probability of further crises. Perhaps the fifth would be stagnation followed by growth through takeover or buy-out.

A similar list has been given by Smith of seven causes of crisis in business [16]. These are growth, responsibility, control, antitrust, leadership, judgement and competition, all of which can occur in Australia with the exception of antitrust, as Australia does not have the American antitrust laws.

Engineering graduates and those students working while studying may enter an organisation that then goes through any of those growth stages leading into a crisis situation. The probability of that occurring depends on many factors, both inside and outside the organisation, but the author's experiences through some 50 years suggest that it is a very real possibility (reductions in the aircraft industry in the 1950s, LPG marketing changes around 1960, cash flow crises of two employers in the 1970s, the shrinkage of consulting work in the 1980s, hostile takeovers in the 1990s, and legislation changes which stopped a (quite legitimate) business activity around 2000).

It is reasonable to conclude, therefore, that an engineering student or graduate is likely to meet at least one of those many possible situations during his/her working life. Hence, including at least a brief description of crisis management in a more general management subject, illustrating how to recognise its approach, how to prepare for it and how to cope after it happens, will help students (or graduates) to meet the demands of such a situation. They may not be in a position that requires them to respond, in a corporate sense, by actually managing the crisis, but they will be better able to survive personally. In the extreme, the lesson given by rats that desert a ship that will sink may be appropriate – the rats are smart enough to survive.

Mitroff et al have given another reason why engineers need to understand crisis management, based on the extent of the complexity of the systems today's engineers have to deal with, and the extent of the coupling between systems, as discussed above [6].

CRISIS MANAGEMENT IN A MANAGEMENT SUBJECT FOR ENGINEERS

Through four semesters in 1988 and 1989, students in a subject titled *Engineering Management* were given serial assignments in a 10-week series. This has been reported elsewhere in detail with a summary presented here of the process and results [17][18].

Each assignment was a case study in the form of a short story covering events in a factory that were designed principally to supplement the week's lecture material by presenting the student with decision problems to be answered *as if you (the student) were in the position of the character who has to make the decision*.

The general scheme of each week's case-assignment was that the case contained three *levels* of a decision-making problem. The first was a technical engineering problem of relatively trivial value in this context. The second level was an *obvious* yet *local* management problem, which students were required to solve, or at least resolve, as it related to the week's lecture topic. The third level was some other management-related feature of the factory or the company as a whole.

However, buried in the narrative of each case assignment, there was either a dangerous occurrence (a potential for an accident) or a minor accident (causing either property damage or personnel injury), with nothing in the text to draw students' attention to the event. There were two series of assignments; the first had only minor accidents and dangerous occurrences, while the second, following on chronologically from the first, continued those events and ended with a fatality.

The hypothesis leading to performing this experiment (which had been given ethics approval) was that management will ignore dangerous occurrences and minor accidents in favour of concentrating on the immediate management issues present.

The author realised there were two potential faults in the experiment. One was using students as *managers*, which depended on their ability to imagine themselves acting as the managers in the narrative would; the other was the use of a simulation and not a real situation. The first was partially overcome by the students, all part-time with some supervisory work experience, and hence practical experience in management. However, nothing could be done to compensate for the second.

So what happened? Although the evidence is not what lawyers would call *the best evidence*, there were results that tended to agree with the hypothesis.

This double series were used in spring 1988 and autumn 1989, as well as in autumn and spring of 1991. On both occasions, the results were similar to the pattern that had appeared in any other semester with a small number of students commenting on the technical element. Most of them faithfully worked through the second level (the local problem for the week) and ignored all aspects of the third level, while a small number noticed and commented on the third level.

When the first series was first used, with a dangerous occurrence or minor accident happening each week, 14 students in a class of 35 foresaw the possibility of something serious, but only two analysed the accidents carefully, made decisions concerning them and predicted a consequence. One student stated very plainly that someone was going to get killed if the management (in the narrative) did not tighten up procedures.

When the second series, which ended with a fatality, was first used, only 25 out of 55 reacted to the fatality, the majority of the class answered the *local management problem* only.

Similar results came from the second use of the double series. At the end of each semester's lectures, after having used each series, the series content was reviewed. The majority of each class was rather embarrassed by discovering how they had ignored such an important problem (the exceptions, of course, were the few who had responded to the accidents and dangerous occurrences; they looked smug), and there seemed to be general agreement that *we've learned something from this*.

The conclusion from the experiment was that management people focus on what has to be done *today* and will ignore the signals of an impending crisis. Indeed, the results appeared to indicate that managers may even ignore a serious event, such as a fatality, until (the real-world follow-up) the media gets hold of what has happened.

A PROPOSED CRISIS MANAGEMENT SUB-SUBJECT FOR ENGINEERS

Having reached this stage in outlining what crisis and crisis management is all about, and in recognition that this article is to be an education item, the author suggests how a one-lecture subject could be formed, to be fitted into whatever *Engineering Management* subject an institution might have.

The lecture should begin by pointing out that crises may be purely personal, then there can be natural crises (storms, bushfires, earthquakes) and industrial (human-made) crises, which may cause personal crises. A few examples of each category can be found very easily, emphasising the engineering component behind the causes of the industrial ones and the engineering input into recovery from natural ones.

Then one can move to the crisis management aspect. There seems to be little in the literature spelling out the content of a lecture, the nearest to such an outline is by Mitroff et al, who give what is described as the form of an ideal crisis management manual [4]. This contains the following sections:

- Scenarios – crisis types, eg likely versus worst case;
- Criteria – required to initiate a response;
- Signals – early warnings of an imminent crisis;
- Containment – how to prevent the damage spreading;
- Recovery – overcoming the immediate effects;
- Post-crisis – an audit of the causes and lessons learned;
- Stakeholders – those involved and affected.

There is the need to have a Crisis Management Team, and for the Team to have meetings and be trained. This Team should contain the smallest number needed to cope with a crisis, with the recommended participants coming from these departments: legal, security, human resources, health and safety, quality assurance or operations, and corporate communications or public affairs. Here one must disagree with Mitroff et al because their Team contains no technical/engineering people, except any who might be included under *operations*. The author considers that an industrial crisis, the essence of this reference, should have a technical/engineering person in such a Team.

However, apart from that, Mitroff et al do give the basis of presenting a lecture on crisis management. The only addition that one would like to see would be a heading titled *Response*, which comes before *Containment*. Rapid response to the sudden onset of a crisis may save a person from injury, or even death, as reported to this author by a country lawyer; a young worker at a local abattoir was accidentally stabbed in the heart by a fellow-worker and was clinically dead within minutes. Fortunately, the abattoir management was able to call an ambulance immediately and the worker was revived for transfer to a hospital. Emphasising the importance of rapid response, he died again in the ambulance, was revived again, and died on the operating table while being repaired. The report concluded with information that the person had fully, finally, recovered and returned to work.

As an example of the sort of simple readiness and awareness features that should be incorporated, the author recalls one factory where he was employed that required the security guard to keep a record of how many people were on the site at any time. The reason was that the factory had an evacuation procedure with an emergency meeting place outside the gate. The reason for the numbers-in was so that the numbers-out could be counted, giving a figure for the number of bodies that might have to be found; a somewhat macabre thought, but sensible.

Heath does not present, as concisely as the above, the content of a two-to-three-hour lecture in his truly monumental work [7]. A few points come out; first, his crisis management modules, which are as follows:

- Reduction – by risk management;
- Readiness – awareness, training, test and exercise;
- Response – impact analysis, plans and audit;
- Recovery – impact analysis, plans and audit.

In a later chapter, he added *Resilience* with the following details:

- Stage 1 – reduce the number of crisis situations;
- Stage 2 – determine the warning and alert systems;
- Stage 3 – train the Crisis Management Team;
- Stage 4 – spread the developed skills into the community.

There is sufficient in a section on crisis management specifically, and in the text generally, to assemble material for a lecture, but it would require extracting notes intensively; Heath's book goes so deeply into so many areas.

An Australian writer has covered much the same ground, but with an additional important point: risks (all around us and recognisable) are distinct from threats (which may develop from those risks) [19]. However, threats may develop in ways other than from recognised risks, and therefore with no preparation.

All the above references stress the best ways of dealing with the media, a difficult task under any conditions, at its worst when a crisis eventuates. This author recalls a chlorine gas leak from a site where he worked in the early 1970s; the word was spread by residents across the street, and within an hour, reporters were driving in past the security guard at the gate to demand interviews. That was a particularly difficult confrontation for someone with purely engineering experience at that time, and this situation emphasises the need for engineering students to be prepared for such a situation.

HOW TO DEAL EFFECTIVELY WITH A CRISIS

Having been through all the above, one can turn full-circle back to beyond crisis management and, indeed, before that, to how, really, to cope with a crisis situation. The answer is very simple: do not have a crisis and avoid its happening.

That is a very obvious statement, bringing up the question: how does one avoid a crisis?

The answer comes from the concept of signals or precursors, which usually (though, as admitted above, not always) precede a crisis. If those indicators can be recognised, then the crisis condition can be avoided by shifting attention and correcting the situation before the crisis actually occurs.

Here is an illustration of a fictional nature, but based on a combination of conditions that make the scenario sufficient to demonstrate what can occur and be done. (This scenario has been set up with the intended complexity to strengthen the possible opportunity for a crisis and its impact, with both those factors buried in the complexity).

Let us consider a small company, which has operated successfully for (say) several decades by having leased land from a much larger organisation, the *owner* of the land. The small company is *owned* by a small number of shareholders, whose income has been generated by the company building on the land and leasing out the buildings. Through all that time, the company has been managed by non-shareholder directors, who have an income from their positions and who have full knowledge of the leasing agreement for the land; however, those details have never been revealed to the shareholders. The managers and shareholders are aware that the deal with the larger organisation was that after a set time, the land would return to the landowner with the buildings, which, of course, by now are getting older and some are becoming in need of repair. That set time is now only a few years away.

Over the last 10 (say) years, there has been soft rumblings from the landowner related to the condition of the buildings – nothing very specific, just recognition that some expenses could be involved in repairs, updating and so on, all supported by inspection reports. That led to a vague question floating around: will the company have to have that work carried out before handing over the land and buildings? So far, no-one could answer that. However, this seems to have faded into semi-obscurity through the last couple of years and not been mentioned for that length of time.

Now, let us consider that the directors/managers of the small company have expressed their desire to retire from active duties, so they approach the shareholders with a suggestion they (the shareholders) might like to take over the directors' positions and hence the task of actually managing the company. The benefit to the directors, of course, is that they can retire to golf and other relaxing activities, and the benefit to the shareholders is they can have a closer relationship to the actual company's operations. One may well imagine that the shareholders would be delighted by this opportunity and are tempted to accept the change as described. This is so inviting that it is an offer too good to refuse and the first thought must be: *go for it!*

But hold it: what about this question of repairs to the buildings? What is the latest from the landowner? Has anything come from them recently, anything which would explain why the directors want to get out at this time? And why are the directors prepared to give up some of their income, which would shift from them to the newly appointed directors? Using the concept in Meyer's reference, is something about to hit the fan?

In this scenario, one can go no further than point out those questions which should be asked (particularly the fourth one), and the possible results of asking versus not asking. If not-asking leads to straightforward acceptance, then there is a possibility of a financial crisis with the landowner invoking some clause buried in the lease contract so that the small firm must repair the buildings before handover.

If the questions are asked, then depending on what answers are received, the shareholders might refuse to take over the director positions. Or they might accept, given certain conditions that need to be agreed upon. Or else there may be other solutions that satisfy all the parties. Any of those choices can avert a crisis. But if the questions are not asked, then the shareholders may be lurching into a crisis situation.

The important steps in avoiding a crisis are as follows:

- Look for signals that something may be hidden, something left undisclosed, in the information provided;
- Seek more information by asking questions one way or another;
- Base decisions on the total information gathered;
- If the choice finally requires some risk-taking, then follow appropriate risk-minimising processes.

Entering a *managed crisis* with eyes wide open can be worked out, but falling blindly into an unexpected crisis will usually swallow and digest those involved.

By the way, the precursors in this case are the directors not informing the shareholders of the land-leasing conditions and then the directors announcing that they want to retire. The trigger causing the crisis to eventuate would be the shareholders accepting the change.

SUMMARY AND CONCLUSION

By now, there is, at least 30 years of crisis management literature on which to draw information on what can happen and how crises may be confronted, not overcome, but handled in ways that reduce their possibly serious impact.

It must be admitted that the author's experiences with employment crises are, unfortunately, a single sample from a population of one, which reduces their statistical significance. Nevertheless, the number experienced does at least strongly suggest that engineers can meet such situations.

It is recommended, therefore, that adequate coverage of crisis management should be included in the management subject already part of most engineering curricula, not as a separate subject, but as a topic within the general subject.

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The needs in continuing education courses for professional engineers

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ABSTRACT: In this article, the authors present a case study on the current needs in continuing education courses for professional engineers. This study is based on data from the Technical Chamber of Greece (TEE) regarding the attitudes of professional engineers of different specialties. Specific surveys on the demographic profile, engineering education and preparation for the profession, the employment and competition in the profession, the unemployment experience and searching for jobs, entrepreneurship, as well as earnings have indicated the need of continuing education courses in certain subjects. These subjects cover the areas of computers and new technologies, business and marketing, renewable energies, the environment, quality control, health and safety, energy saving, refurbishment, waste and pollution, biotechnology, and electronics. Also, continuing education courses are needed in the fields of employment benefits, labour standards, equal employment opportunities, employee rights and responsibilities, labour-management relations, safety and health in the workplace, and job interviewing and negotiating.

INTRODUCTION

This article is based on data from a survey performed on behalf of the Technical Chamber of Greece (TEE). Two companies were involved: TNS/CAP, which selected the data, and VENTRIS, which performed the analysis [1]. The research involved interviews with engineers from all over Greece using a telephone interviewing system, ie Computer-Aided Telephone Interviews (CAITI). The timing of the research was within the period 25 October to 7 December 2006. For the evolution of certain issues, data were used from the 1997 research made on behalf of the TEE by MRB-Hellas and ORCO, and the 2003 research conducted by MRB-Hellas [1][2].

The membership to the TEE is compulsory to all engineers of Greek nationality with degrees from the National Technical University of Athens, other university-level engineering schools in Greece, or with accredited degrees from engineering universities abroad. The requirement to become a member of the TEE is the obtaining of the Professional Engineering (PE) license.

The Technical Chamber of Greece is the organisation that grants the PE license to engineers of all the specialties, graduates of engineering schools in Greece and their equivalent schools from abroad. The PE license is given after examinations that are organised by the TEE three times a year.

Those engineers who are members of the TEE number approximately 93,000 and are distributed among 11 specialties as shown in Table 1 [3]. The number of engineers in each specialty is also shown in Table 1 (end of 2006 data).

The goal of this article is to utilise the data from the TEE survey, and formulate the engineering and business areas in which continued education courses are needed. These courses can assist engineers in their profession, not only regarding areas of engineering and technological developments, but also labour issues, the rights of employed engineers and the knowledge needed in starting new businesses.

Table 1: The distribution of TEE members into specialties.

	Specialty	No. members
1	Civil engineers	25,969
2	Architects	16,843
3	Mechanical engineers	12,819
4	Electrical engineers	13,813
5	Mechanical-electrical	2,458
6	Surveying engineers	5,989
7	Chemical engineers	8,312
8	Mining and metallurgical engineers	2,166
9	Ship-building engineers	84
10	Naval and mechanical engineers	1,482
11	Electronic engineers	2,677
	Total	92,612

SAMPLE EXAMINED AND SIMILAR STUDIES

The sample examined included 2,400 engineers, and it was an ad hoc sample, representative of the body of engineers who are members of the TEE. The sample was based on the membership database of the TEE and included all the specialties of engineers and could separate groups of engineers with PE licenses from 1971 to 2006 at five-year intervals.

For the members of the sample, the same participation was kept as in the total of the TEE members with regard to the specialty of engineers, the year of obtaining the PE license, and the area of professional activity. Also, special research was performed on the 209 engineers who belonged to the new specialties compared to those engineers with traditional specialties.

Specific questions were asked concerning the goal to assemble information regarding demographics, family situation, engineering education, preparation for the profession, employment, competition, unemployment, searching for jobs, earnings and entrepreneurship.

Greek engineering universities and the TEE are the main organisers of continuing education courses with respect to the needs and the wants of the professional engineers [4]. University education in Greece is public, while new legislation expected in 2008 will allow education in private universities in Greece, which will grant accredited degrees. Since the areas of technology and business are those moving at a great pace, private companies may organise continuing education courses in the future as being more flexible in their management decisions and finances.

The assessment methodologies that have been used repeatedly in the evaluation of engineering courses, curricula and educational research suggested the need for sound and rigorous assessment in engineering education [5]. Engineering courses should be restructured every year, not only to apply educational theories, but also to upgrade the contents of each course in areas of fast technological developments [6-8]. In the same way, continuing education courses should be regularly assessed, and continuously restructured and upgraded.

While effective teamwork implies producing high quality engineering products, the need for knowledge on how to work effectively in teams was not considered in the survey [9]. Teamwork skills need to be practiced professionally in engineering classrooms [10]. Students with work experience in engineering companies expressed the necessity to incorporate business classes in the curricula that would facilitate their positioning in the workplace and understanding their responsibilities [11].

New technologies in distance learning were not considered in the questionnaire as a means of continuing education, although the World Wide Web (WWW) and the computer technologies can deliver engineering education content, not only to engineering students, but also to professional engineers in continuing education programmes [12].

The gender influence was considered in certain aspects of this study, such as unemployment and graduate studies. However, the education of engineers at universities is the same for men and women, and the degrees obtained have the same value, although there are slight differences in the educational outcomes of students regarding gender [13].

The level of emotional intelligence of the sample was not considered in this study, although there was the general question to the sample of the satisfaction gained from the profession. Considering that people may be positive or negative in their attitudes towards the profession, as well as other aspects, like starting their own business, the emotional intelligence consideration of the sample might show extreme cases of positive or negative behaviour, similar to the emotional intelligence of engineering students [14].

The retention of engineers in the profession was considered in this study. The low earnings of engineers, unemployment and competition within the profession can make some engineers consider changing their profession. The belief that an engineering degree enhances career security at a respectable salary was the main predictors of short and long-term persistence in engineering [15]. This belief may have been true up to a certain level in this study.

Continuing education in Greece is private and not public, while undergraduate and graduate education is public. Greek engineering universities develop and upgrade their courses to keep up with technological developments and the needs of professional engineers, but only in engineering areas. In other areas, such as business administration, management, human resources, marketing, labour laws, employment issues, the rights and responsibilities of employees, laws when starting and operating a company, finances and risks, taxation laws, plus other issues, engineers do not have the necessary education and they need to take courses at business schools before entering the workforce or starting their own businesses.

RESEARCH FINDINGS

The research findings are presented and discussed below regarding the demographics and family status of the surveyed engineers, engineering education and their preparation for the profession, the level of employment and competition within the profession, unemployment and jobs searches for professional engineers, and the entrepreneurship and engineering earnings.

Demographics and Family Status

Demographics refer to selected population characteristics as utilised in government, marketing or opinion research. A demographic profile is a term used in marketing and broadcasting to describe a demographic grouping or a market segment. This typically involves age bands, economic characteristics, gender, occupation and consumer preferences. Several programmes at the Bureau of Labour Statistics (USA) provide significant amounts of data available for specific demographic categories.

The demographic profile of the participation rate in various engineering specialties of TEE members versus the year of obtaining the PE license is shown in Figure 1. There has been a continuous increase in the number of civil engineers, since one in three new graduates is a civil engineer. The average age of engineers is 40.8 years with 1 out of 3 members being within 31-40 years of age. Younger ages were detected in new engineering specialties (eg naval and electronic engineers) with an average age of 30.8 years. This indicates a fast growing redistribution of ages among engineers and an increase of engineers in numbers, since one in five engineers entered the workforce during the last five years [1].

The demographic profile of male and female professional engineers according to the year they obtained their PE license is shown in Figure 2. A continuous demographic development of the gender participation of engineers showed that one in three new engineers was a woman. This indicates a trend of equal numbers of men and women engineers within the next 10 to 15 years.

Female engineers whose specialty was architecture comprised $^{1}/_{3}$ of the total number of engineers in the TEE (46.6% of women within the specialty). Women also constituted 36.6% in the chemical engineering group, 33.5% in the civil engineering group and 30.9% in the surveying group. Women in the mechanical and electrical engineering group comprised only 2.3% of that group and 9.8% in the naval engineering group [1].

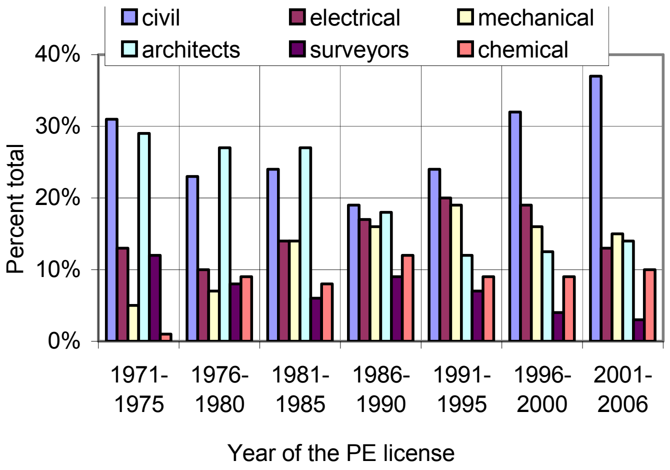

Figure 1: Demographic profile of the participation rate in engineering specialties in the TEE membership by the year of acquiring the PE license.

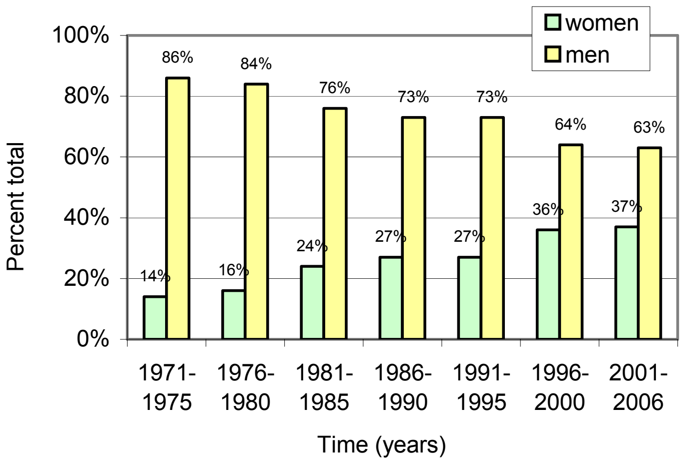

Figure 2: Demographic profile of men and women professional engineers according to the year of obtaining their PE licenses.

Family status was structured upon family obligations incorporating socially agreed-upon duties. Also, the converging demographic trends of increased longevity indicate obligations to aging parents.

Family obligations can take many forms in different societies, and trends in both the labour market and the family are making the more family-friendly work conditions increasingly necessary. Marrying and having children created conditions that made it difficult for women and men to enter the workforce regarding the available type of work and place of work. Temporary medical conditions or family emergencies made people see employment as a threat to life, a perceived inability to fulfil family obligations, or a conviction that getting a job and staying away from home during work hours was against their beliefs.

Family status and the number of children of the sampled engineers are shown in Figure 3. The percentage of unmarried engineers was high, as well as the percentage of those who did not have a child, since seven out of 10 above the age of 40 lived alone. The children of engineers of the 1970s followed (up to a degree) the steps of their parents to become engineers. The proportion of 22% of TEE members in 2006 declared that one of their parents was an engineer compared to the low 5% figure for the 1971-1980 period. This suggests that engineering is becoming a type of *hereditary* profession [2].

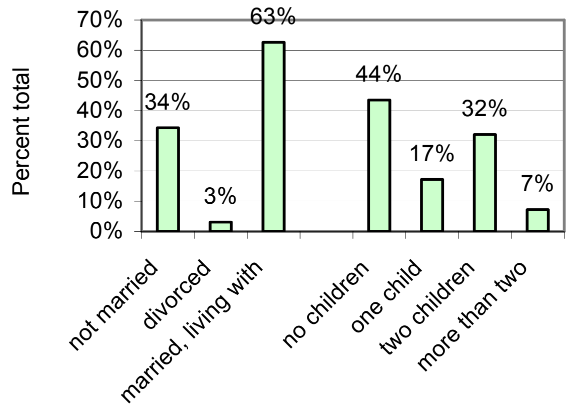

Figure 3: Family status and the number of children of the sample of engineers participating in the survey.

Engineering Education and Preparation for the Profession

Regarding the undergraduate studies of the surveyed engineers, one out of four (25%) of those questioned obtained their first engineering degree abroad. More accurately, 24.7% declared that they gained their first engineering degree from a university abroad, with men being 27.2% and women 18.2%. The preferred specialities for those choosing to study abroad was architecture (44.5%) and electronics (41.9%) as a participation rate, while at the other extreme regarding study abroad preference, surveying engineering was 0.7% and civil engineering was 18.7% [2].

From those who obtained their undergraduate degree abroad, the country of preference with a 30.7% participation rate was Italy, as shown in Figure 4. Of those, the amazing percentage of 59.9% studied architecture. The second preference was found to be Great Britain with a score of 24.5% for studies in mechanical and civil engineering.

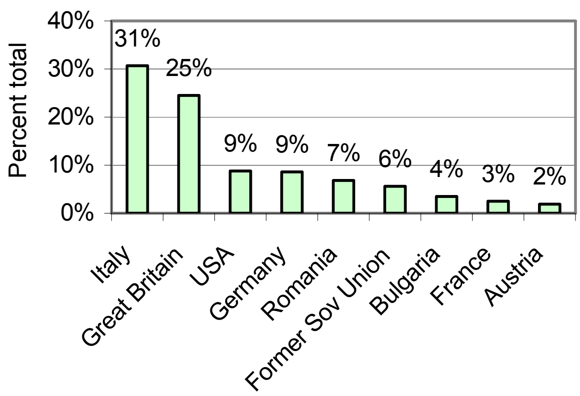

Figure 4: Country of preference for the first engineering degree from abroad.

Regarding graduate studies, 37% of the total engineers surveyed had a graduate degree, a percentage that has increased continuously over the last 15 years, with more than half of the engineers today pursuing a graduate degree mainly within Greece. More specifically, regarding graduate studies, 37.2% of those engineers with graduate degrees declared that they continued directly after their Bachelor's degree, with women being 38% compared to men being 36.9%. Regarding specialty, 47.7% of chemical engineers and 47.3% of electronic engineers had graduate degrees, followed closely by mechanical engineers, electrical engineers and naval engineers [1].

Of those with PE licenses in the period 2001-2006, 53.4% declared graduate studies, which is almost twice as much as the proportion of 27.1% for the 1986-1990 period. Today, six out of 10 engineers gained their graduate degrees from a Greek university, while in the 1971-1980 period, seven out of 10 acquired their graduate degrees from a university abroad [2]. Figure 5 shows the distribution of graduate degrees gained by Greek engineers between Greece and abroad.

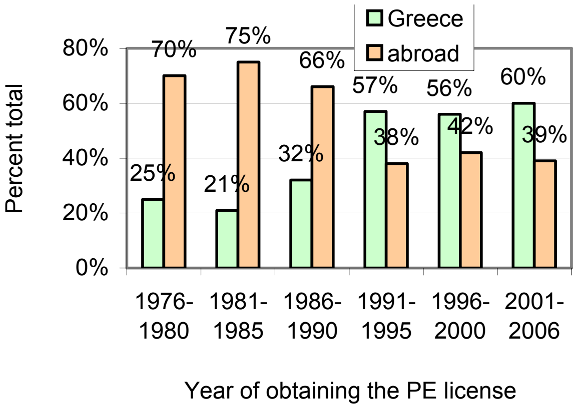

Figure 5: Graduate studies in Greece and abroad for the period 1976-2006.

Over the last few years, there has been the impression that Greek universities do not prepare engineering students well for the engineering profession. Today, less than half of the surveyed engineers (44%) considered that the engineering curriculum prepared them well to face the job market. In 2003, 27.6% of engineers declared that the university curriculum had not adequately prepared them for the job market. In 2006, this percentage had dropped to 20.8%. The specialties in which engineers considered themselves less prepared for their profession were mining-metallurgy, surveying, civil and mechanical.

Regarding the needs of engineers in continuing education courses, the lack of knowledge and skills was found to be mainly in subjects that were complementary to the main subjects of their studies. Most engineers (66.1%) considered that the level of their theoretical studies was excellent to very good, 45% of the surveyed engineers thought that their engineering knowledge was good, 23.1% considered themselves knowledgeable of how to use specialised computer programs, while 21.5% thought that they had obtained good engineering skills in general, but only 16.2% considered that they had obtained financial and managerial knowledge [2].

These percentages indicate that there are large numbers of engineers with interests in new computers technologies, business management and marketing. There was also a large percentage of those who needed continuing education in renewable energy and the environment. The preferences of the questioned engineers in subjects of continuing education courses are shown in Figure 6.

Regarding the question of the length of studies at engineering universities, which is five years today, the majority disagreed with the lowering of the length of studies, with architects being scoring the highest in this regard. Naval and mining engineers favoured the lowering of the length of the studies from five years to four [1].

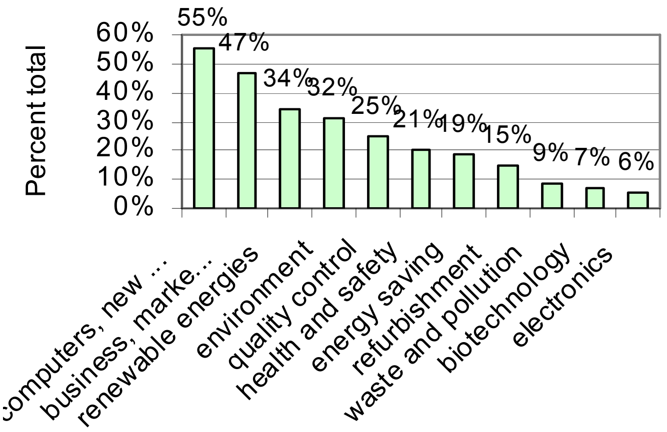

Figure 6: Areas of interest for courses in continuing education for engineers.

Employment and Competition

Economic data are considered as measures of employment and unemployment, which in turn reveals the general level of economic activity. Labour force surveys on employment, unemployment, earnings and other labour market topics are associated with demographic characteristics.

Only 8.3% the total number of engineers worked in the secondary economic sector of production (de-industrialisation of the country), while 2% worked in the primary economic sector. The majority of engineers worked in the tertiary economic sector of services, which covered employment in building construction and public works (49.4%), education and research (7.4%), and in the general public sector (6.9%) [1].

Two out of four engineers were found to have their own engineering practice, one over four worked in public services, and one over four worked in private companies. There was a continuous trend of more engineers to try self-employment (32.1% today compared to 24.8% in 2003), while the proportion reduced for those employed in government jobs (18.1% today compared to 23.8% in 2003), as well as self-employed with personnel in their offices (15.1% compared to 17.3 in 2003), those employees with short contracts in public offices, and those contracting their services.

Almost one out of three (or 29.3%) engineers answered that they were not covered by a labour contract, while 11% did not know if they were covered. Figure 7 shows the study results with the percentages of engineers who had a second job [1].

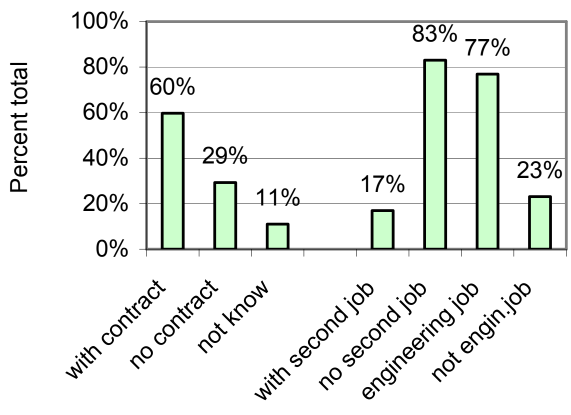

Figure 7: Percentage of employed engineers with or without labour contracts and those with a second job.

Almost two out of 10 engineers (17%) were employed in a second job; of those, 23.1% did not work as an engineer. This, along with the fact that about six out of 10 (61%) who worked in the private sector paid by themselves the contribution to the Pension Fund of Engineers and Contractors of Public Works (TSMEDE), indicates the difficult position encountered by engineers within the last few years. If this was combined with the number of working hours, which averaged 8.8 hours a day in the main job and 2.8 hours a day in the second job, then for those who have a second job, it is obvious that engineers are working long hours. It was revealed that 11.9% of those who had a second job worked in this job for more than five hours a day, which made a total of 13 to 14 hours a day, while those with one job worked more than 10 hours a day [1].

Seven out of 10 engineers (69.3%) worked or were employed in their specialty in 2006, compared to eight out of 10 in 2003. Also, the work in non-specialty jobs was 11.7% and had increased in 2006 compared to the 2003 results. The results on the employment both within and outside the specialty are shown in Figure 8.

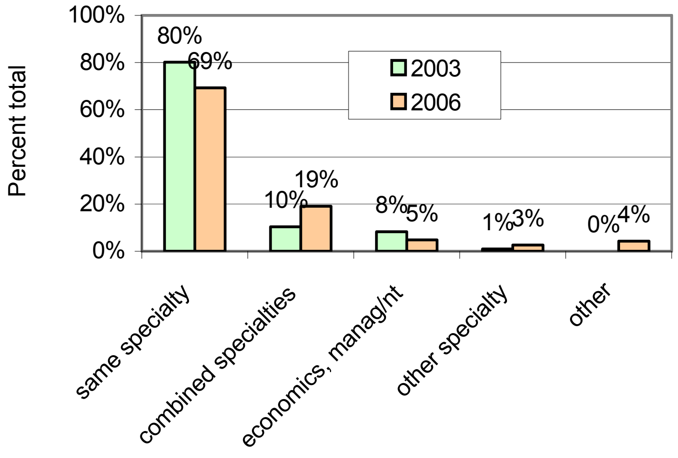

Figure 8: Employment within or outside the specialty.

An important employment issue was found to be professional competition. The main competitors of engineers who are TEE members were graduates of Technological Educational Institutions (TEIs), other specialties of engineers, engineers from within the European Union (EU), university graduates with degrees in different disciplines, and graduates of business and economic schools, as shown in Figure 9.

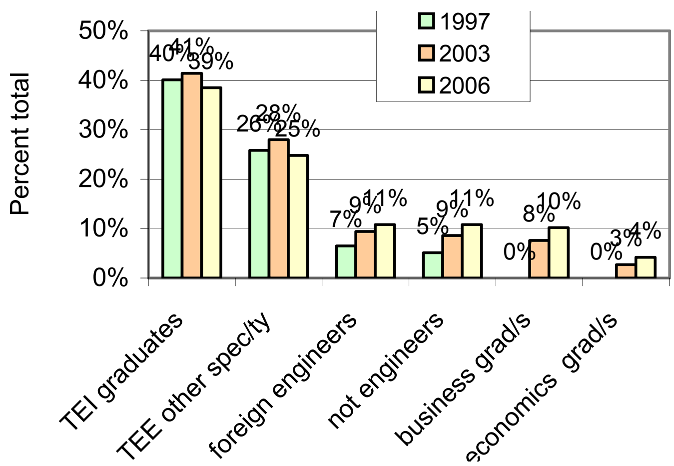

Figure 9: Sources of major competition for professional engineers in Greece.

In connection with the conditions of employment is the degree of knowledge that engineers have regarding the legal aspects and social security status of their labour contract. The statistics were disappointing: 6.2% declared that they were very informed, 26% said that they were rather informed, while 67.8% declared that they were not informed [2].

Engineers declared that from year to year, they were satisfied with the profession, 67.2% stating this now when compared to 66.4% in 2003 and 52.7% in 1997. While 77.7% accepted that they were satisfied with the subject of their job, 51.7% were not satisfied with their earnings.

Unemployment and Searching for Jobs

The unemployment rate was 4.5% and has remained constant over the last 10 years. Employment in non-engineering fields was 11%, while 11% considered that their job required a lower level of education than what they presently had. Currently, the highest unemployment rate of 13.7% is for young engineers and women, and in the specialties of metallurgical engineering (11.3%) and chemical engineering (10.2%), which are connected to the diminishing branch of manufacturing (transformation) [1].

The percentage of unemployed increased in 2006 and the proportions for new specialties were large as well, although the population of new specialties was small. The employment status of the sample of engineers is shown in Figure 10.

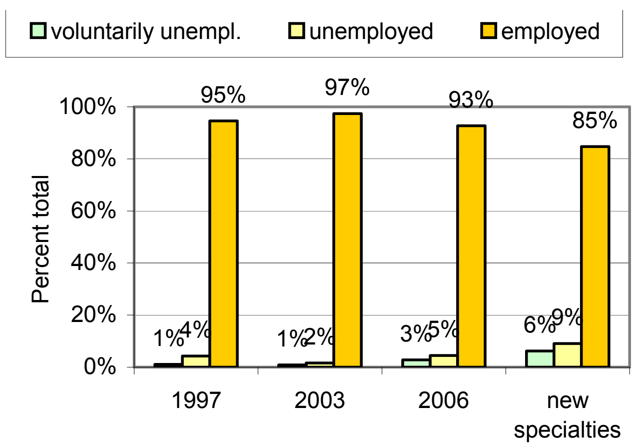

Figure 10: Employment status for the period 1997-2006.

The percentages of unemployed engineers regarding specialty and gender are shown in Figure 11. The unemployment rate was larger for metallurgical engineers and chemical engineers, young engineers (65% for those who obtained the PE license within the last five years), new specialties (9.1% of the total), women (7.1% of the total compared to 3.5% of men). Regarding the location of engineers, unemployment was greater in Thessaloniki compared to Athens [1].

Continuous demographic development was also present for the engineers who lived and worked outside the large urban areas of Athens and Thessaloniki. The demographic profile of engineers in the areas of Athens, Thessaloniki and the rest of Greece in 1997, 2003 and 2006 is shown in Figure 12 and shows that the decreasing proportion of engineers in the Athens and Thessaloniki areas is accompanied by an increased percentage of engineers in the rest of Greece. Regarding the unemployment rate in Athens, Thessaloniki and the rest of Greece, Thessaloniki suffered the largest unemployment rate of 7% [1].

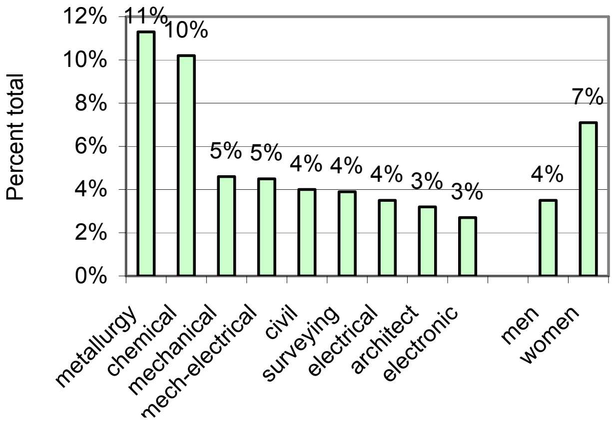

Figure 11: Percentage of unemployed engineers regarding specialty and gender.

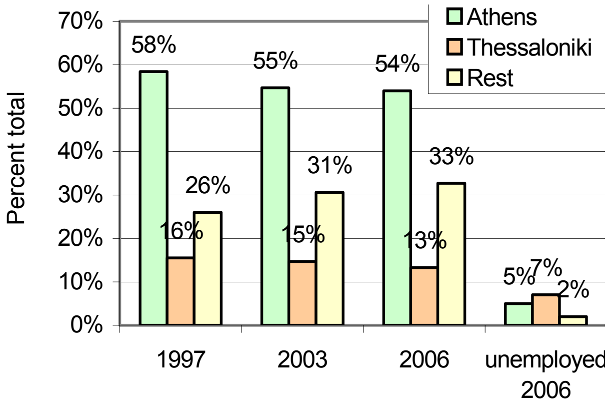

Figure 12: Demographic profile of engineers and unemployed in the areas of Athens, Thessaloniki and the rest of Greece for 1997, 2003 and 2006.

The new unemployment rate of 15.7% belonged to those entering the job market. The long-term unemployed, who had been seeking a job for more than 12 months, regardless if they were young or old engineers, comprised 20.3% of the total unemployed. According to the government data for the last quarter of 2006, the unemployment rate of engineers was 8.9% and for new engineers, this rate was 36.2%, while the old unemployed rate was 54.8%.

A rather unusual result was associated with long-term unemployment in that 20.3% of unemployed engineers had looked for a job for a period longer than 13 months, and of those, 8.3% for a period longer than 25 months. From those unemployed, one out of three declared that he/she had worked for less than six months before being fired, while one out of five worked for a period of seven to 12 months [1].

In order to find a job when unemployed, personal contacts and recommendations were considered very important by 56.5% of respondents and former professional experience also rated highly with 54.4%. On-the-job experience was also deemed to be important [2].

Entrepreneurship and Earnings

Entrepreneurship for engineers means taking an opportunity to start their own business. For younger engineers, it is important to think about developing good business ideas and starting their own companies. Self-employment and entrepreneurship have become increasingly important in modern economies. Immigration fuels entrepreneurship since immigrants are more likely to start businesses because they are younger and less risk-averse on average.

The majority of engineers declared that they intended to remain in the profession, since almost seven out of 10 (or 67.2%) considered themselves satisfied with their profession. However, almost 10.8% of employees and those who gained their PE license in the last five years answered that their job was temporary until they found something better, while 11.8% said they would remain in the engineering profession only if they gained better professional development or better income from their job [1].

The rate of self-employment has increased – especially among new engineers. Employment by contracting engineering services was similar to self-employment, but was subject to employment rules, which was not what engineers preferred, particularly the younger ones. Although 43.8% of employees declared that they chose to be self-employed by contracting their services, 54.8% of those reported that it was at the suggestion of their employer.

Entrepreneurial activity was preferred as the choice for free time, independent and flexible employment conditions, rather than as an exit from unemployment. More than half of those asked did not have their personal business and of those, about seven out of 10 (69%) declared that they did not intend to start their own business in the future. Of those who intended to start their own business, building construction and public works was most preferred at a rate of 56.3%, while second was engineering consulting at a rate of 10.1% and informatics at 9.3%. Also, 0.8% considered the sector of engineering economics [1]. The indication of interest in developing entrepreneurship is shown in Figure 13.

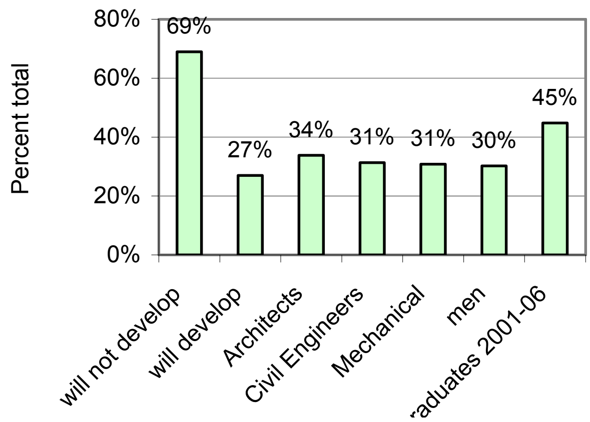

Figure 13: Indication of interest in developing entrepreneurship as a total of the sample, separate specialties, men and 2001-2006 graduates.

Engineers who had their own business and employed personnel created businesses by themselves at a rate of 87%. Concerning private businesses, 83.3% remained with the same number of employees that they had started with, while only 11.7% declared an increase of the number of employees. The reasons for developing private businesses were independence in engineering and economic activities, and a better future for professional development (68.3%) [1].

Six out of 10 unemployed engineers faced unemployment with the financial help of their family, while 13.9% found occasional employment in other types of jobs. The variation of low and high earnings of engineers living with family or alone is shown in Figure 14 for the total of the sample and for portions of the sample regarding engineering groups of certain age intervals.

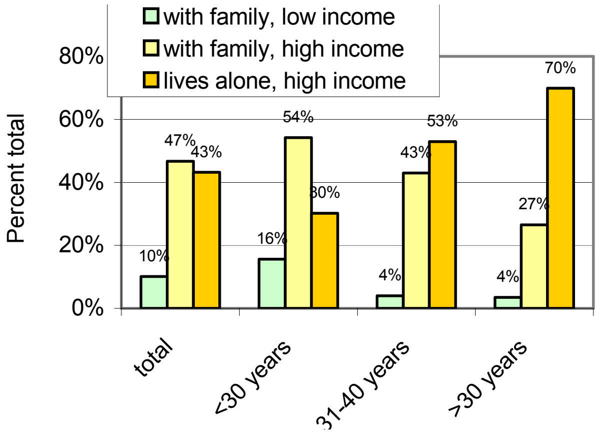

Figure 14: Variations of low and high earnings of engineers living with family or alone.

The annual earnings (in Euros) according to engineering specialty are shown in Figure 15. One in 10 of those questioned gave no answer as to what his/her income was. Four out of 10 declared income over €25,000, and 51% declared income less than €25,000. The amount of income shown in Figure 15 is the gross income before taxes and insurance. One in 10 engineers (10%) declared a gross monthly income of €1,000, while 6.9% declared €1,000-1,150 [1].

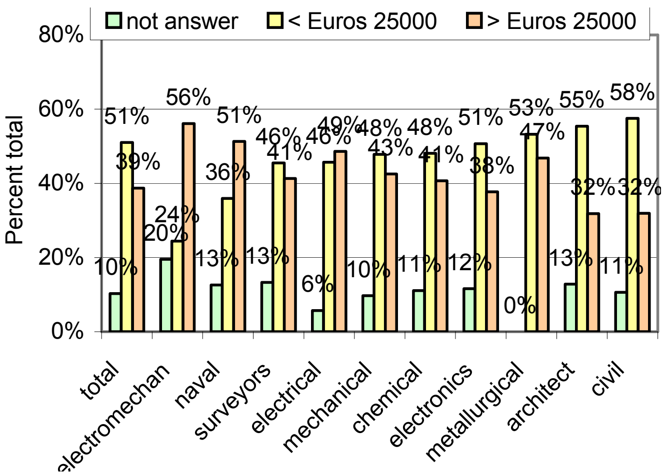

Figure 15: Annual earnings in Euros according to engineering specialty.

Mechanical-electrical engineers and naval engineers declared higher incomes, while architects and civil engineers claimed lower incomes. Self-employed engineers declared higher incomes, and those employed in the public and private sectors with long-term contracts followed. Employees with short-term contracts were at the lower end of gross earnings.

DISCUSSION

With regard to the demographic profile, it can be seen that the majority of engineers who are TEE members comprise civil engineers and architects with an average age of about 40 years, although this trend is becoming smaller. Those engineers of certain specialties, being at the halfway point of their professional lives, were willing to pursue continuing education courses.

The constant increase of the participation of women in the membership of the TEE did not seem to have an effect on the organisation regarding continuing education programmes, since women get exactly the same education as men, and have the same professional rights and responsibilities. Family responsibilities, such as taking care of children and aging parents, were major issues for engineers that affected their employment status and continuing education participation. However, only about half of the engineers were affected at any particular time, and for those engineers family responsibilities could be intense for only short periods of their professional lives, restricting them temporarily from their professional development and continuing education.

With consideration to engineering education, the data shows that the engineer members of the TEE have university degrees from Greek universities at a rate of about 75% and from foreign universities at a rate of about 25% without distinguishing or affecting the level of the mobility of engineers in their professional employment. Graduate studies pursued in Greece are at a rate of 60% and abroad at about 40%; this indicates more a financial problem of engineers or job obligations in Greece, than expressing an aversion to pursue a graduate degree abroad.

Regarding preparation for the profession, most of the surveyed engineers considered that they were well prepared for the profession from their university-level engineering studies. However, during their professional life, they declared a great interest in attending continuing education courses in the following areas with a scale from 55% (maximum) to 6% (minimum): computers and new technologies, business and marketing, renewable energy, the environment, quality control, health and safety, energy saving, refurbishment, waste and pollution, biotechnology, and electronics.

With regard to employment and competition, almost half of the engineers were employed in the building construction industry, and less in the education and public sectors. One third of the engineers surveyed were self-employed, while one fifth were employed in public jobs, and one sixth had their own businesses. Almost 40% of the engineers were not covered or did not know if they were covered by a labour contract, indicating the need to provide education in labour law and the contents of labour contracts. Engineers face competition in their profession from technological university graduates, other specialties, foreign engineers and non-engineers with university degrees in applied science, business and economics. Courses in the rights and responsibilities of the engineers, along with the laws covering the rights and responsibilities of each specialty, should be offered to engineers in their continuing education. However, in the free market environment, competition is present and the priority of the competitiveness of the company becomes the priority of those engineers employed by it. This also has an effect on the satisfaction levels of engineers and the retention rates in the profession.

Concerning unemployment and searching for jobs, about 10% of the surveyed engineers declared that they were unemployed, with younger engineers, women and certain specialties having larger percentages. Unemployment and searching for jobs may be short-term or long-term. Although engineers declared that personal contacts and recommendations were very important in finding a job, as well as professional and on-the-job experience, no one mentioned the importance of CV writing, interview skills and the salary negotiation process as subjects that could be taught. Also, the issue on how much the candidate fitted in the activities of the company and whether the company needed this candidate should be considered. Hence, courses on job interviewing and negotiating are needed to better match the candidate to a company.

Regarding entrepreneurship and earnings, about 70% affirmed that they did not intend to start their own business in the future, while only about 15% had their own businesses. Of the different specialties, those who would be willing to start their own enterprises were civil engineers, architects and mechanical engineers. Also, a large proportion of new graduates were oriented towards entrepreneurship. Although about 60% of those unemployed were assisted by their families when facing economic problems, and from those employed, one half had an annual income of less than €25,000, there was not much interest indicated in starting their own firms. To start a new business, especially by younger people, and beyond the financial support needed for starting the business, education in labour management relations would be useful, as well as employee benefits and labour law, and business courses in business administration, finance and accounting.

Organisations, such as the TEE, are interested in organising continuing education courses for their members, and seek sponsorship from private companies plus state and local governments where engineers are employed. The TEE is committed to original public policy research and education on economic security, compensation and employee benefits regarding pensions, health and other employee benefit plans. Courses can be prepared on employment benefits, labour standards, equal employment opportunities, employee rights and responsibilities, labour-management relations, and safety and health in the workplace.

CONCLUSIONS

The demographic profile indicates that the majority of professional engineers are civil engineers and architects, with the increasing participation of women. Family responsibilities affect the employment status and continuing education of engineers.

Regarding engineering education and preparation for the profession, the survey indicated that engineers have university degrees from Greece or abroad, an increasing rate of graduate degrees, and interest in continuing education courses like computers and new technologies, business and marketing, renewable energy, the environment, quality control, health and safety, energy saving, refurbishment, waste and pollution, biotechnology, and electronics.

The employment and competition parts of the survey showed that almost half of the engineers were employed in the building construction industry with a large percentage facing competition from other professionals, highlighting the need for courses in labour law, the rights and responsibilities of employees, etc.

The unemployment survey showed an unemployment rate of about one tenth, with larger participation from young engineers, women and certain engineering specialties. In order to achieve success in searching for jobs, courses on job interviewing and negotiating are required.

The entrepreneurship survey revealed that civil engineers, architects and mechanical engineers, as well as younger engineers, were willing to start their own business. Some of the reasons for this might be that some engineers are assisted financially by their families, while one half of engineers have an annual income of less than €25,000. For those engineers who start new businesses, and beyond financial support, courses are needed in labour-management relations, labour law, employee benefits, business administration, finance and accounting.

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Assessing Education for Sustainable Development (ESD) within engineering

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ABSTRACT: Engineers can play a key role in the development and implementation of sustainable development principles into everyday living. Therefore, it is essential that engineers have a practical understanding about, and can make engineering decisions for, sustainable development. In this paper, the authors highlight the importance of the assessment and evaluation of sustainable development within the engineering curriculum, and introduce the results from a *self-reported knowledge* survey on sustainable development, which was administered to engineering students at the University of Bristol in Bristol, England, UK. The results indicated that while students at the University of Bristol had a good knowledge of the terminology associated with both environmental and sustainable development principles, their understanding of some of the diverse subject areas and tools for sustainable development was discrepant. The need to deliver more effective Education for Sustainable Development (ESD) for engineers is briefly discussed and strategies for improvements are presented.

INTRODUCTION

In 2005, the United Nations (UN) declared a decade (2005-2014) for Education for Sustainable Development (ESD). The UN's aim here is to challenge global educational policymaking by highlighting the global significance and importance of ESD, and actively encourage the coordination and dissemination of best practice. According to the World Federation of Engineering Organisations (WFEO), it is critical that engineering graduates are equipped with the relevant knowledge and skills to effectively address such challenges in society [1]. The most significant challenge currently viewed is climate change.

One of the roles of ESD is to question the current educational systems that are in practice and determine their effectiveness at fostering how the principles associated with sustainable development and growth are taught.

The importance of sustainable development was clearly identified by the Engineering Council, UK, with its publication of the UK Standard for Professional Engineering Competence (UK-SPEC) [2]. This stated that Chartered Engineers must *undertake engineering activities in a way which contributes to sustainable development*. This commitment highlights the need for the increased use of appropriate technologies and practices, both in the developed and developing world, where resource consumption and environmental pollution have come to the forefront of scientific and public opinion.

In 2006, the Higher Education Academy (HEA), UK, produced a progress report on the subject of ESD for senior managers in higher education [3]. The document discusses the concept of *sustainability literacy* and defines it as *learning about how human actions affect the immediate and long-term future of the economy and ecology of our communities*; stating that sustainability literacy needs to be a *core competency for professional graduates*. The purpose of the HEA report was to determine how 17 different subject disciplines (including engineering) were contributing to developing graduates who are *sustainability literate*, identifying and disseminating good practice in both teaching and curriculum development. The key findings of the report indicted that ESD is rising across all disciplines, but despite this rise, the overall coverage of ESD in the curriculum is uneven both within and across disciplines. The report concluded that there were three broad levels of progress in the embedding of ESD by subject disciplines: those who had effectively adopted ESD into their undergraduate and postgraduate courses (such as engineering); those who have made limited progress into embedding ESD (such as economics); and finally those who had an interest in ESD but had not embedded it into their curricula (such as mathematics).

There are numerous publications addressing the role that universities have on the creation of a more sustainable world future [4-6]. However, care must be taken to ensure that all sustainable development education is delivered within the context of engineering. If engineering content is *watered down* and too much emphasis is given on other subject areas pertinent to sustainable development, there is a risk of producing *poor* engineers. The aim is to produce a new breed of professional engineers who have proper regard to environmental, social and economic factors.

It is necessary to determine the *definition* or purpose of any teaching programme prior to its delivery. There is a clear distinction between education *about* sustainable development and education *for* sustainable development. The former simply implies an awareness of the issues and the ability to discuss them in context, while education *for* sustainable development implies not simply an understanding of the issues, but an ability to apply, design and operate systems which are sustainable [7]. An additional issue is the perceived format that sustainable development education should take. For example, should it be taught as an independent subject or in the context of the *traditional* engineering subjects as case studies? The type of approach is dependent on what individual lecturers or institutions feel is most applicable to their teaching and curriculum, and will also be influenced by any existing materials/teaching resources. For either option, the lecturer/tutor needs to be at least familiar with the principles of sustainable development, ensuring that the taught *skills base* is sufficient to fulfil the educational requirements of the course and any external accreditation requirements such as the UK SPEC [2].

In order to achieve education for sustainable development, it is necessary to give individuals/students more than simply the knowledge and skills for recognising sustainable development, but also the capacity to develop sustainable development practices in their *own world*. Thus, the scale of the focus of the education must also be considered.

An early paper from 1984 reflecting an author's views on the education of engineers acknowledged a shortfall in the level of public education for the understanding of social, industrial or technological innovations; and made the observation that unless wider technological understanding is applied, the *rising demand for products will be accompanied by a rising resistance to its social impacts* [8]. The same paper also discussed the growing need for engineers to be familiar with an increasing range of disciplines in order to impart the necessary breadth of experience and learning. Overall, the paper stressed the importance of engineers having a new range of skills and knowledge, in particular relating to the overall UK economy and social aspects (such as communication and management skills) but failed to directly mention a role for engineers to consider the environment, resource consumption or those subjects currently considered to be integral to sustainable development.

Today, the focus has changed; the question is how engineers can potentially save the planet by making all their decisions with the correct consideration to the potential environmental, social and economic impacts.

EDUCATION FOR SUSTAINABLE DEVELOPMENT AT THE UNIVERSITY OF BRISTOL

The theme of Sustainable Development (SD) is now high on the agenda and people are starting to look beyond the concept to some practical solutions. This vital component has been introduced across the engineering programmes at the University of Bristol in Bristol, England, UK, with a particular focus on design and project activities.

Professional Studies (PS) is a cross-faculty programme (Aeronautical; Electronic; Civil; Mathematics; Mechanical; Computer) at the University of Bristol. This programme has been innovatively structured around the latest requirements of the Engineering Council for professional accreditation. It complements the technical tools of engineering with the knowledge and skills of business and management, with a special emphasis on sustainable development. PS comprises two units, which are taken by more than 600 students each year. The PS course is designed to provide the generic professional knowledge and awareness required to meet the accreditation criteria of relevant professional institutions. It is structured around the five *Principle Learning Outcomes* specified in the latest professional accreditation guidelines issued by the Engineering Council covering the following topics:

- Commercial and economic;
- Management techniques;
- Sustainable development;
- Legal framework, and health and safety;
- Professional and ethical conduct [2].

In addition to enabling professional accreditation, the PS programme aims to stimulate the acquisition of knowledge and skills. It also is aimed at introducing visionary goals for the role and value of engineering in society.

The programme was designed to provide guidance and insight into the professional engineer's personal, organisational, and health and safety roles and responsibilities. The course addresses the interrelationship between engineering processes and the wider context within which they operate, focusing on sustainability and covering commercial drivers, legal frameworks, health and safety, environmental, and professional and ethical issues. As part of the PS units, students work in teams to audit real life engineering companies regarding their sustainable development practices and make recommendations for possible improvements.

Sustainable energy and transport are now afforded additional attention within the PS units and other specific engineering programmes, for example, through research and design projects. There are also other taught units such as *Engineering for the Built Environment* (sponsored by the Royal Academy of Engineering, UK and ARUP), *Building Systems*, *Energy Management*, *Power Generation for the 22nd Century*, and a cross-faculty open unit (*Sustainable Development*).

ASSESSING ENGINEERING KNOWLEDGE OF SD

Assessment is an integral part of teaching and learning [9]. It is an ongoing process that is aimed at the following:

- Understanding and improving student learning;
- Involving making course and institution expectations explicit;
- Setting appropriate criteria and standards for learning quality;
- Disseminating how well performance matches those expectations;
- Using the information available to improve performance [10].

Elizondo-Montemayor goes on to state that the main purpose of the assessment process is to evaluate the standard of competence, based on a framework of reference criteria that clearly emphasises the achievements of standards [11].

There has been little previous research undertaken to determine the level of knowledge on sustainable development attained by engineering students. One international study, which sought to evaluate student's knowledge on sustainable development, surveyed undergraduate engineers from 21 different universities in nine different countries [12]. The survey was carried out between October 2000 and June 2002, and involved a brief two-page tick-box style survey being delivered to a total of 3,134 engineering students across several disciplines and at different stages of their courses. The survey was divided into four parts starting with information about the students, their level of knowledge and understanding of the environment and sustainable development, the perceived importance of sustainable development by the students, and previous environmental/sustainability education.

The survey results indicated that although the engineering students were knowledgeable about high profile environmental issues, such as acid rain and global warming, the level of knowledge relating to 15 particular aspects, including ISO 14001, the Kyoto Protocol and the Rio Declaration, industrial ecology, components and approaches to sustainable development and inter- and intra-generational equity, was very poor, with some students acknowledging that they had not previously heard of these concepts. The survey also highlighted differences between countries, with students from some areas of Europe (Sweden and Germany) and the Far East (Vietnam) having the highest knowledge and understanding of sustainable development. More encouragingly, however, despite a relatively low understanding of sustainable development by the engineering students overall, most students recognised sustainable development to be either *important* or *very important*.

The authors of this research acknowledged their perceived difficulties of teaching sustainable development to engineers as engineering students *needed to see an immediate and direct relevance between the theory of sustainable development and engineering practice* [12]. One reason for this is the perception by engineering students that sustainability is often perceived as *soft-science* rather than the *hard-science* of engineering [13].

ASSESSMENT OF EDUCATION FOR SUSTAINABLE DEVELOPMENT AT THE UNIVERSITY OF BRISTOL

Although course evaluations are conducted for every module and a wide range of student assessment techniques (eg examinations, assignments, reports) are used to determine the effectiveness of student learning and understanding; a greater rationale of the student knowledge of SD is required in order to determine the level of understanding of SD among engineering students undertaking the PS programme at Bristol University.

The survey design was identical to that used within the previously-discussed study as its parameters accurately reflected the educational topics administered in the PS programme, and also to facilitate the direct investigation and comparison of results [12]. The survey was *posted* to the electronic *Blackboard* network during March 2006, following the completion of the PS programme. This approach allowed access to all participating PS students (608 in total). Unfortunately, by this time, many students did not access their PS learning resources, but to present the survey earlier would have been prior to the completion of the programme. It is also understood that not all students access the electronic *Blackboard* system, or have the capacity to do so, once outside the teaching environment.

The survey received a response rate of 18% (108 students). Table 1 provides the breakdown of responses by different variables. The variables stated in the survey responses are reflective of the overall variables/demographics across the Faculty of Engineering at the University of Bristol. It is appreciated that the results from the Bristol study did not canvass the same number of students as the previous study [12]. As such, the specific analysis and comparison of participants' nationalities and engineering disciplines was not undertaken due to a lack of significance.

Figure 1 shows the level of understanding of environmental issues across Years 1 and 2, and Years 3 and 4 at the University of Bristol compared to the results of the Azapagic et al study [12]. While the level of understanding is similar between year groups, it is clearly lower than the previous findings [12].

Figure 2 shows the level of understanding of the principles of sustainable development. Year 3 and 4 Bristol University students were particularly confident with the definition, concepts, components and approaches to SD. Figure 3 shows the level of students' self-reported knowledge regarding the range of environmental tools and technologies.

Table 1: The breakdown of responses by different variables.

		Number	%
Gender	Male	89	82
	Female	19	18
Year of Study	Year 1 or Year 2	54	50
	Year 3 or Year 4	54	50
Discipline	Civil Engng.	30	28
	Mechanical Engng.	29	27
	Electrical Engng.	10	9
	Aeronautical Engng.	23	21
	Engineering Maths	3	3
	Computer Science	6	6
	Engineering Design	7	6
Nationality	UK	86	80
	France	7	6
	Other European	6	6
	Other Countries	9	8
Total		108	100

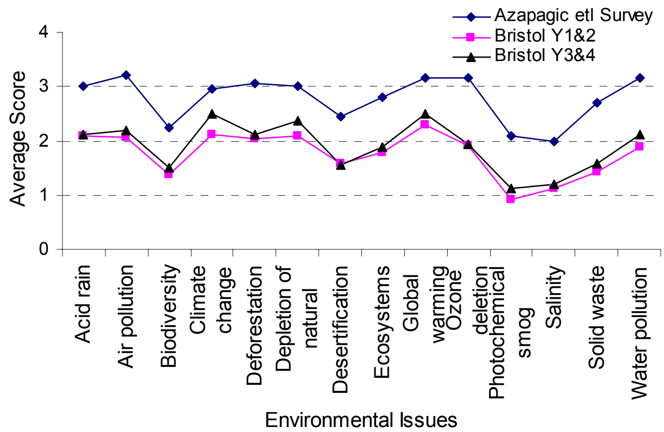

Figure 1: Understanding of environmental issues.

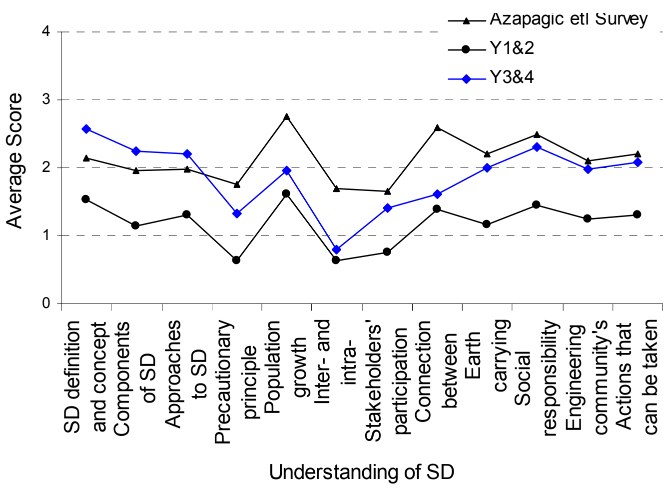

Figure 2: Understanding of SD principles.

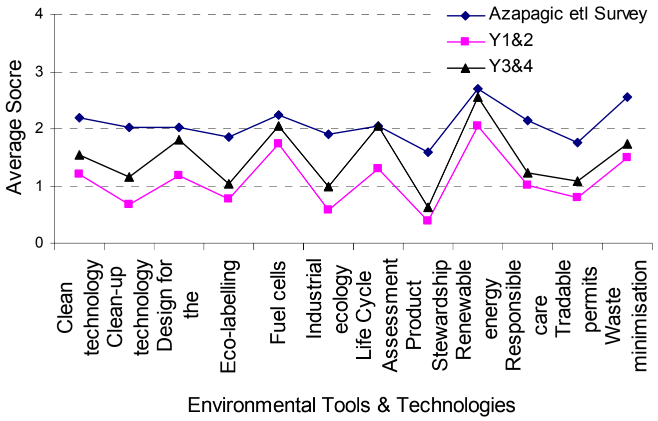

Figure 3: Knowledge of environmental tools and technologies.

While the previous survey shows a consistent level of knowledge across the range, the students at Bristol University (across both year sets) demonstrated variable levels of knowledge across the range of tools. This may be as a result of the differences in the sample sizes. However, all survey results indicated increased knowledge (or possibly confidence) regarding renewable energy and waste minimisation, perhaps because these areas contain synergies to a range of core engineering subjects. Correspondingly, the level of knowledge for certain areas, such as industrial ecology and product stewardship, were all low, which was consistent with previous results [12]. This may be due to these concepts not being closely related to engineering and also possibly beyond the *comfortable teaching scope* of some engineering tutors/ lecturers, consequently reinforcing the importance of inter-disciplinary teaching opportunities.

Overall, the results indicated that education for SD at Bristol University is progressive. For example, in all cases, the level of knowledge and understanding of environmental and SD principles increased over the duration of study, with Year 3 and 4 students exhibiting higher levels than Year 1 and 2 students.

CONCLUSIONS

There is an increasing demand for engineering graduates who have experienced *joined-up* learning experiences and have developed interdisciplinary skills that are essential for modern forward-thinking organisations, and it is essential that universities provide students with the best opportunities for success in the job market and furnish them with enough understanding to make decisions that assist rather than hinder the advancement towards sustainable development [7]. Therefore, it is essential that institutions can qualify the level of understanding of SD by their students. However, a demonstration of the ability to work within SD principles and to best practice may only be effectively exhibited within the workplace or during practical industry-based projects.

Universities who fail to deliver high quality education for sustainable development will find that their courses do not meet the requirements of the accrediting institutions and the Engineering Council, resulting in their students being unable to demonstrate their ability to *undertake engineering activities in a way which contributes to sustainable development* and ultimately unable to gain Chartered status without further study. Engineering courses that do not furnish students with the ability of becoming Chartered will ultimately be unpopular and, in the increasingly competitive higher education sector, will become obsolete while potentially harming the reputation of the institution. The PS programme at the University of Bristol allows engineering students to meet their requirements under the UK SPEC without further study requirements after graduation. However, the survey has indicated that some principles and tools for SD appear not to be adequately covered or that engineers are failing to understand the significance of these principles. To address this, additional teaching and learning resources are being made available during lessons and also via electronic media. These resources include case studies that demonstrate SD in practice [7].

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Decision-making models for choosing CAD software

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ABSTRACT: In this article, the authors provide a short history of entry-level Computer-Aided Design (CAD) and discuss three models that have helped Pennsylvania State University, University Park, USA, choose CAD software for undergraduate engineering students, namely: the scientific model, the trade expert model and the stakeholder model. Student survey data are used to illustrate their role as stakeholders.

INTRODUCTION

Since 1983, Computer-Aided Design (CAD) has been a part of the curriculum in the first year engineering course (EDSGN 100) at Pennsylvania State University, University Park, USA. The 24 years since then have seen many changes in both software and hardware platforms. The only commonalities over this period have been the fact that the College of Engineering at Penn State has always had a networked computer system, a reliance on undergraduates for running the computer networks and being teaching assistants for CAD in the first year course, plus a need to control costs in a potentially expensive environment. Throughout this time, the College has experimented with many software packages for teaching CAD to first year engineering students.

In this article, the authors document the accumulated CAD teaching experience of several faculty in addition to recommending how to select CAD software for the first year engineering curriculum. Furthermore, the results of a survey that document students' perceptions of the usage of two CAD packages are presented to support these recommendations.

The authors conclude with speculations about the future of CAD education and recommendations for future research. One caveat is that the authors are not trying to make a choice of CAD software in this article, but rather to lay out issues and decision-making approaches. The situation is also viewed as a *battle of the positives*. There are many different good CAD software choices with potentially similar effectiveness in an introductory CAD curriculum. Moreover, because professionals often use more than one software to do similar things and often have to change to new platforms with changes in organisational needs and/or changes in clients, instead of selecting the best software package providing an account of issues to be considered when selecting CAD software is more appropriate.

A Brief History of CAD

While the history of CAD dates back to the 1950s, most researchers consider the SketchPad thesis of Ivan Sutherland at MIT as the most dramatic moment in the history of computer graphics and hence CAD [1][2]. Sutherland was again at the centre of CAD history when he worked with Dale Evans and students, such as Bob Sproull, at the University of Utah in the late 1960s – along with stints at Harvard University and the University of California, Berkeley. Sutherland, his brother Bert, and Sproull later became an important nucleus at Sun Microsystems in 1990 as that company started developing rapidly.

The early to mid-1980s saw the emergence of affordable, if limited-featured, desktop CAD and computer graphics with 2D systems running on the Apple II+s and IBM PCs. One of the earliest low-cost and popular 2D systems was *Generic CADD*, which was acquired by Autodesk and is still on the market at the low end. Autodesk itself was founded in 1984 and marketed *AutoCAD*, the best known name in desktop CAD, and still a major player in 2007. Another current major player is Dassault Systemes, which owns *CATIA*, high-end CAD software that was first developed in 1969 and is very widely used, especially in Europe. Dassault Systemes also acquired the mid-range package *SolidWorks* in 1997 (first developed in 1994), which is now an industry leader at its level. Another powerful company is EDS, which acquired *Unigraphics*, which had in turn acquired *SolidEdge* (created by Intergraph in 1996) and is also a competitive mid-range CAD package on the scene in 2004. In 2001, EDS also acquired SRDC, the owner of *IDEAS*, which is a very powerful competitor at the high end, particularly during the 1990s, and therefore a competitor with EDS' own *Unigraphics*. This acquisition process, which leaves companies with competing products rather than one getting terminated, is an odd characteristic of the CAD industry, and it has happened again recently with Autodesk buying *Revit* while upgrading its own *ADT 2004* [3]. Presumably the customer base of the acquired software is too large and too resistant to change.

Some pioneering CAD packages did not make it. One of the earliest CAD software packages for the Apple II+ was *New Kensington CAD*, named after a Penn State campus where it was developed circa 1984. The first good 3D wire-frame CAD for the PC was developed by Peter Smith and *CADKEY* in 1984-1986. Smith agreed to provide the University with 100 licenses of *CADKEY* free in 1985. This was one of the first efforts by a CAD vendor to use education as a marketing strategy. The first good desktop solid modeller was *Silver Screen*, developed around 1989, which was very popular on campuses throughout the 1990s, but not adopted widely in industry, although it is still extant. Nevertheless, these *desktop pioneers* figure prominently in the history of CAD education at Penn State in the first year engineering programme.

History of Entry-Level CAD Education at Penn State

At Penn State, CAD has been taught for over 20 years within the first year engineering course. The University's history of low-cost desktop computing and CAD software is reflected in several curricular changes (in addition to the computer platform and the software used throughout this period) were realised in order to keep up with software advances. A sketch of that history is given in Table 1 showing the platform, software and the relative presence in the curriculum of the first year course compared to traditional graphics instruction. While high-end CAD instruction has also been offered over the last decade, Table 1 only includes the developments in the College's CAD teaching for the first year course using entry- and mid-level software, which is the focus of this article.

In the 1980s, the emergence of desktop computer graphics and CAD caused much excitement, but the actual CAD products at the low-end were, at best, poor and of interest mostly as a glimpse into the future. The appearance of *Silver Screen* around 1989-1990, which provided affordable solid modelling on a desktop computer, was the watershed between CAD as a curiosity and CAD as a powerful tool. The University embraced it quickly and a widely-used text was produced [4]. Furthermore, research was conducted showing its utility for improving the spatial visualisation ability of students [5][6].

With the development of effective and affordable solid modelling software, there was a sharp increase in the use of CAD and, therefore, the demands on computer laboratory facilities. Accordingly, during the early 1990s, the College added a second computer laboratory and by 2000, there was a set of eight networked laboratories, workshops and classrooms [7][8].

The most striking thing about this history is that CAD education in engineering now employs, at a minimum, powerful mid-range CAD software. It has made entry-level software obsolete through a focus on user-centred design, as well as very effective learnability and usability supported by excellent online tutorials and help utilities. The best mid-range software is so powerful now that it competes with upper-level CAD and vice versa, as the high-end CAD developers have to compete with the best mid-range software's capacities in user-centred design for rapid learning and fast task performance. It is also of importance that vendors of many CAD packages have recognised the importance of providing large multi-user licenses for relatively little cost – in some cases no cost – directly to academia and students, bypassing resellers. After 5-10 hours, even first year students with no background in either CAD or mechanical drawing are building objects on screen that are often more complex than they could learn to draw manually on paper after three times as much studying in traditional graphics during the 1980s. Figure 1 displays an online, closed book CAD test that almost all students have completed successfully after as little as 10-15 hours of studying CAD.

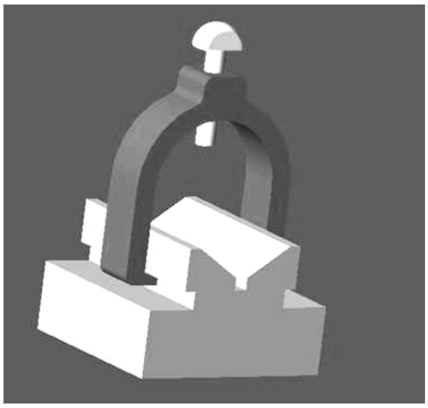

Figure 1: Real time test CAD problem.

Table 1: A history of CAD at Penn State in the first year engineering course.

Dates	Platform and Software	Notes	Curricula Presence
1983-1985	Apple II+ Networked *New Kensington CAD*-PSU	2D Local tutorial	10% CAD 30% Graphics
1985-Present	PCs Generic *CADD*	2D Local tutorial	15% CAD 30% Graphics
1987-1991	Colour PCs *CADKEY*	Wireframe 3D Local tutorial	25% CAD 25% Graphics
1992-1998	*Silver Screen*	Solid Modelling (SM) Local text	25% CAD 15% Graphics
1998-2002	*IronCAD*	Drag and Drop SM Local tutorial	25% CAD 12% Graphics
2002-Present	*Inventor*	Solid Modelling (SM) Online tutorial	25% CAD 10% Graphics sketching
2002-Present	*SolidWorks* 8-room network CEDE	Advanced SM Online tutorial	25% CAD 10% Graphics sketching
2002-Present	*Alibre Design*	Collaborative tools SM Online tutorial	25% CAD 10% Graphics sketching

Selecting CAD Software

Three different models for choosing CAD software are presented here. The most desirable is the scientific model based on a systematic assessment using objective measures. However, one lesson from history is that this approach is costly to implement when the technology changes rapidly. The second approach is to use the reviews of experts in journals and trade magazines. These are usually very subjective but are up-to-date, and reveal important information about the functionality, cost and availability of the latest software and its upgrades. The reviews also reveal information about adoptions, that is, about the assessments of others who commit resources to it. The third approach is the stakeholder model and this is the one most used by the College in the past although trade publications are certainly followed.

The Scientific Model

Despite the similarities in the capabilities of mid-level CAD packages, differences do exist in their functionality, performance, Graphical User Interfaces (GUI), learning curve, etc. Thus, one needs to carefully study alternative packages and choose the best to satisfy the needs of students and the curriculum. However, before the selection can be made, the selection roadmap and criteria should be clear. Accordingly, the literature on CAD software rating, criteria, and comparison has been studied. A summary of these findings is presented here.

Previous studies on comparing solid modelling software include: a CAD expert offering his/her review comments for various products without providing an established set of criteria; rating a software using a predetermined set of criteria; comparing several similar software packages using predetermined criteria. For example, one can find solid modeller review and ratings in *Professional Engineer* and *CADENCE* (now *CADALYST*) magazines. Several examples can be listed here. The January 1993 issue of *Professional Engineer* includes a review on four different low-cost CAD offerings by a CAD expert, where no particular review criteria are provided [9]. The October 2003 issue of *CADENCE* contains a review of *CATIA V5 R11*. After its review, ratings are provided for the criteria including installation and set-up, interface/ease of use, features/functionality, expandability/ customisation, interoperability/Web awareness, support/help, speed, operating systems, and innovation [10]. However, there are several problems with this type of rating scheme. For example, it is not possible to compare the ratings of two different software packages completed by different experts, because the way that the experts have interpreted the criteria might be different. Even when the same person has evaluated a number of different software packages, the potential bias the evaluator may have towards one application is very hard to eliminate – especially if the reviewer uses one of the reviewed packages in his/her work. In fact, this problem was brought up by Martin and Martin, and studied using published reviews and the expertise of reviewers [11].

It is possible, however, to eliminate the potential bias one can have towards one package by introducing expert users to the comparison. For example, Martin and Martin, as well as Kurland, invited various vendors to supply operators to partake in separate comparison studies [11][12]. In this manner, potential biases due to partiality towards one software over the other, or differences between software operators in terms of their skill levels, were eliminated. However, in this case, it is not clear if the solid modelling package can be utilised by any user as effectively as the expert user partaking in the studies after an adequate learning period. In other words, experimenting with an expert user cannot yield broader conclusions because the GUI of the modeller can be interpreted differently by different users. Therefore, the GUI is the primary determinant of the overall usability of the modelling package and the productivity of the user [13].

In the 1980s, the introduction of icons and small pictures, as well as the incorporation of a desktop mouse as an input mechanism, changed the Human-Computer Interaction (HCI) [14]. The implementation of the GUI takes advantage of the human capability to recognise and process graphical images quickly, and has become a universal HCI standard. Accordingly, most solid modellers use it today. However, the development of interfaces is a concern for software developers because it might be a barrier in solid modelling education and engineering practice [15]. It is believed that the layout of GUI elements influences the way that the user can interpret them [16]. While the user's correct mental model of the interface can help with his/her productivity, a false image of the interface might mislead them and limit their ability to work with the software effectively [17]. Therefore, it is clear that differences in the user's mental models of GUIs are expected and thus productivity differences may arise. This point makes it clear that any comparative study of solid modellers should involve multiple users being tested under similar circumstances.

Accordingly, Okudan studied the student performance in an experiment where they were asked to complete two solid modelling test problems using two different modellers: *Inventor* and *SolidWorks* [18]. Two performance measures were used in this experimentation as follows:

- The correctness and completeness of the solid modelling drawing (assessed by a performance grade between 0-1);
- The time taken to complete the drawing in minutes.

For both test problems, students were asked to build the solid models, create standard multiviews and an isometric view, and complete the dimensioning. During the their work on test problems, students were not allowed to ask questions or talk to each other; they did use identical computers in the same computer laboratory.

Using *Minitab*™ Release 13.1, differences of sample averages for user performance and completion time for both test problems were tested for their significance. The P values for all four of the two-sample t-tests, differences in the sample means were not found to be statistically significant. This means that for the functions that were the subject of comparison, both software deliver similar results with a similar average time for students to complete the same problems. Moreover, variance tests were conducted for the completion time of test problems. When the hypothesis test for the equality of variances between the two samples for test problem 1 using an F-test was completed, the sample variances were found to be significantly different. The significant difference in sample variances indicated a more homogeneous user performance data for one of the software packages.

A follow up study by Okudan proposed the Solid Modeler Evaluation and Comparison Cycle (SMECC), which utilises the Analytic Hierarchy Process to model the software selection problem in a comprehensive fashion where user performance, environment and cost issues were considered as comparison criteria [19].

Ultimately, however, the scientific model is most useful for redesigning the next generation of CAD software. It can rarely produce enough definite results in a timely manner to help with acquisition decisions. That data reported here, however, are useful.

The Trade Expert Model

The less scientific approach of the expert testimony questioned above is nevertheless widely used and exemplified by the expert commentary available online. There are many good sources for this, like TechniCom, CADInfo, CAD User, CAD-Portal, CADwire and *CADD* Primer, which are actually promoting the name but have very good links [20-25]. These are invaluable, if risky, sources of information on a rapidly changing world. They provide critical insights on a subject that will be returned to later, ie functionality. In this regard, scientific studies cannot meet the need for that sort of information when making decisions about which CAD package to use as they are rarely comprehensive. As Martin noted in his review of competing Autodesk products, *Revit* and *ADT 2004*, *We now have a problem that we have to face in the CAD business time and time again—where do we invest our time and money?* [3].

The Stakeholder Model

In deciding what factors to consider in making a package selection decision, a stakeholder model has been developed since it embraces a broader view than just that of whomever makes the purchasing decision (see also ref. [26]). In such a model, even software performance is embedded as just another, albeit important, criterion. The criteria listed below have been roughly ranked and contain some commentary according to experience and some survey data. The authors explain this model fully since it has, at least in hindsight, been used by them extensively.

The administrative criteria are as follows:

- Cost to university: the College has been very successful in paying little to nothing for the CAD software used over almost 25 years, and only locally produced or online tutorials have been used. The unavoidable costs are, of course, associated with implementation, maintenance and training;
- Infrequency of upgrades/long-lived educational platform: one online source listed 17 CAD upgrades, and this was a weekly publication [27]. It has been a particular problem with one of the CAD systems used that upgrades easily on individual computers but was very inconvenient on the networked system used by the College for instruction;
- Ease of installation and maintenance in a networked environment;
- Stability of software (no lost files or crashed software);
- Well received by students.

The student perspective is as follows:

- Cost to students: this is very important, but students have never been required to own their own copies of the software. Several of the CAD packages have used have offered inexpensive purchase options or free, limited-duration license (eg 150-day or *while registered as a student*). For example, *Alibre* has been provided free to the entire Penn State community;
- Personal ownership: this is also very important since it allows for students to work on their own computers and enhances their ability to use the CAD application for other productive purposes;
- Access to computer laboratories: this again very important if students do not own a copy of the software. At Penn State, it took some time to get *SolidWorks* available in most student laboratories other than the initial ones;
- Software efficacy: ease of learning and use, and functionally powerful;
- Stability of software and good file management;
- Reuse in other subsequent courses: there are currently requests to use *SolidWorks* from one department and *AutoCAD* from another; and this contributes to the need to offer two different courses. It does not look as though this will proliferate any time soon;
- Value in the professional world: some students use CAD during their summer internships as soon as at the end of their first year.

The instructor criteria with regard to software quality are as follows:

- Learnability (a quick learning curve is good);
- Intuitive with fast task performance;
- Comprehensive array of functions;
- Clarity: minimising student problems;
- Good online tutorials and help;
- Good resources, such as a parts library;
- Good integration with related tools, such as FEA;
- A defensible choice within the professional community.

The instructor criteria regarding curricula relevance are as follows:

- What do students need to know and why? Are students being trained as CAD experts or design engineers? Which idea is the driver?
- Should the focus be on one CAD software package only or is the idea that students will have to be versatile and use many CAD packages? Wiebe, for example, has studied transferable elements, such as high level modelling strategies [28]. One option is to show students how to do things in more than one CAD package. At least one such experience could make sense to show students how solid modelling skills learned on one package are transferred to another package. Students should avoid *package fixation*, which can occur due to a potential employer requesting familiarity with one package or another. Indeed, industry designers often use more than one CAD software package at a time. An example of this is the *Battle of the Bands: a 3d CAD Software Shootout* [29];
- In what courses will students subsequently require CAD: what are the needs of that course and will the same CAD package be available? If the next course is two years later, will students have forgotten how to use it? Will the software have changed?
- Are all the essential needs for CAD/computer graphics being met? This question is beginning to attract attention. Some graphics topics have been moved to the CAD

curriculum at Penn State and sketching is used for the others. But as more design is taught, the need for new tools is apparent during the conceptual design stage when most CAD packages are more than what is needed and manual sketches have to be scanned or photographed to get into the database for reports [30][31]. Manual sketches, therefore, are in a cumbersome mode for iteration and also lack colour. The College is experimenting with digital ink technologies like pens and tablet PCs. Similarly, the value of feature-based representation is being acknowledged where complex details are left blocked out and simplified with a text description, and the use of edited photographs and videos are appealing.

Industry Criteria

In a two-year curriculum where students may go to work in local companies, the industry use of CAD could influence the decision about what to teach. For example, *AutoCAD* is often chosen because of its use in many types of small-to-medium-sized companies. But in a four-year curriculum, there may be no such choice available in courses that teach students who enter a wide array of engineering fields. In this market, *Inventor* by AutoDesk may be a better choice. At the capstone level, there may be a tendency to use a particular CAD package in a particular discipline of engineering.

Overall, the governing assumptions are that industry is characterised by change with most companies use more than one CAD package at any given time, and that learning one CAD package makes learning the next one much faster. Thus, most of the time in a four-year curriculum, learning one or more good CAD packages may be more important and relevant than which ones. It is also important for students to learn what the functions and operations of CAD are and this is the core curriculum regardless of what software is used.

The Student Perspective: Report of a Survey

Data is presented below that was collected in an exploratory study that is serving mainly to start a new assessment process for the role for CAD in the engineering curriculum. The study and its analysis should trigger further inquiry yielding questions that will be targeted for examination and reporting in the future.

A short, online questionnaire was constructed and given to students in the first year engineering course (EDSGN 100). In fact, 80% of the 155 students who took the questionnaire were 1^{st}, 2^{nd} or 3^{rd} semesters, so it is not just first year students who take this first year course. Basic descriptive data was collected, such as semester standing, gender, intended major and if the students had CAD or mechanical drawing experience prior to attending Penn State. The remainder of the survey consisted of measures of student satisfaction using a Likert scale with the software for learning, using and access/owning. A subset of 119 responses were used coming from six sections that used two instructors. Each instructor taught two classes with *SolidWorks* and one class with *Alibre Design*. This experimental design provided the controls for the instructor. However, the study was viewed as a way to begin a new examination of what is being done with CAD and the data did not change how the authors felt about the two software packages used. They were both very good and both functionally different in ways that were considered important. It is not a big data set and only satisfaction data was looked at and not performance data. Indeed, it is hoped that this will lead to better questions and ideas for evaluation methodologies.

The Data

The data are reported in Figure 2. They were collected using a 5-point Likert scale where 5 is *strongly agree*. A few questions were stated in a negative manner to reduce response bias. Note that one question below was negative: agreement with the difficulty of file management.

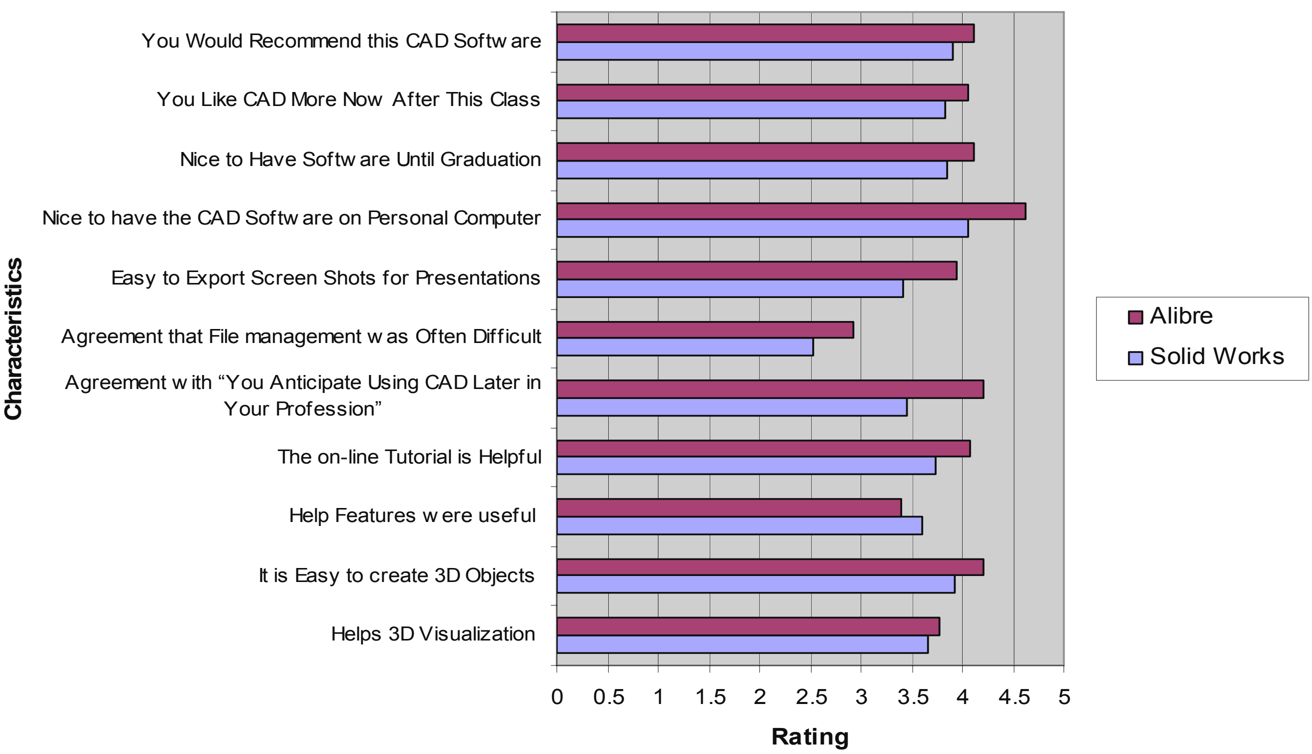

Figure 2: Student ratings of two CAD software (*Alibre* vs. *SolidWorks*).

The data reveal that *Alibre*, by a new company, performs very well against the most popular mid-range CAD software; this confirms the view that the choice for CAD literacy is not very important from a student's perspective. There are many good choices at the entry level, and *Silver Screen*, *IronCAD* and *Inventor* have also been tried with good results. Other stakeholders, of course, have different considerations, such as the Department of Mechanical Engineering choosing *SolidWorks* for its upper division design courses.

The initial analysis of the data provided the following observations. The intended major does not show much effect except a tendency for chemical engineering students to show less interest than students in other majors. Gender also had few effects. Prior study of mechanical drawing regularly correlated with valuing CAD more. Most of the data confirmed views of the software and what is important to students. The only result not understood was why *Alibre* use correlated strongly with anticipating using CAD later professionally. This is a potentially significant metric of the impact of CAD that may be worth looking at more closely. Overall, given how powerful and well designed these CAD packages are, it is thought that better overall levels of satisfaction should have been achieved. What was found was a *good* response (except for file management) to the CAD software from the students, but why was it not *very good*? Perhaps history gives a perspective to the instructors that the students did not have: this is all they know.

How the Decisions Are Being Made

Although there are sensibilities about almost all the items on the stakeholder list, a few criteria have always been important: functionality, cost and performance.

Functionality

Online reviews of software are supplemented by commentary of industry adoptions. Such adoptions almost universally refer to the functional relevance of the software for, say, surface modelling, Product Lifecycle Management (PLM), or drawing management features, and for applications from naval architecture to powertrains [29].

Both of the CAD software packages discussed here are of very good quality. *SolidWorks* is considered one of the best, if not the best, mid-range-plus CAD software with excellent reviews and some features, such as a parts library and an animation capacity that *Alibre* did not yet have at the time of the assessment. *Alibre* has been under development and prone to more upgrades that occasionally trigger problems, but the upgrade frequency is slowing down and *SolidWorks* has not been entirely problem free. *Alibre* is equally well received by students and still offers a very competitive low cost option in industry. *Alibre*'s learning curve and task performance look particularly good, so this is one question that might be pursued: how to measure the learning curve and obtain good performance data? Perhaps this is an area for the development of a metric that would allow more use of the scientific model for decision making.

Alibre has excellent peer-to-peer collaborative tools that allow imports from almost any other CAD software and a shared resource environment on *Alibre*'s servers. Since cross-national teams are part of the University's global design initiatives, this is one reason why *Alibre* has been used in several classes.

Cost to the University and the Student

Although acquisition and support cost to the department/ university are important, the cost to acquire personal copies has always been of concern because students often wish to use it on their personal computers, which allows for work outside of the computer laboratories. It should be noted that, when a student owns the software, it is used more heavily in the course, as well as far more likely get used again after the course is over. Additionally, in the few engineering courses that require CAD but do not teach a specific package (eg capstone design courses), which CAD software is used may not be an issue as long as it is good and this seems to be well assured now. *Alibre Design* has been free until graduation – and now beyond – and *SolidWorks* has been providing free 150-day licenses. Placing copies of software in students' hands has become an area of intense competition among CAD software companies, and rightly so. It is believed that Penn State was one of the very first to do this with *CADKEY* in 1985.

Performance

Neither faculty nor students wish to waste time with poor-performing CAD software. It must be easy to learn and to use. However, measures of this are needed that can be used to assess the merits of software for these factors, even though one might be unsure that there is much of an issue here with so many good options on the market.

Curricula Relevance

In the first year course, the engineering design process is used as the driver. There has been a move steadily into design over the last 15 years [32]. The first year course is now considered to be a design course and CAD is taught as a tool for the design process [33][34]. This actually does not change things much except that it can be arranged to have CAD (and graphics) needs in design projects that help contextualise their learning in the course, such as in drawing concepts and fabricating small rapid prototype models (see Table 2).

Table 2: CAD use in the phases of the engineering design process.

Concept Generation Stage	Solution & Analysis Stage	Testing & Prototyping Stage	Implementation Stage
CAD features used: 2D sketching 3D modelling of solid parts Assemblies of parts Online collaboration (available with *Alibre Design*, also in *SolidWorks* but not in student version)	*CAD features used:* Assemblies of parts Animation of assemblies FEA analysis of solid parts (*SolidWorks* only) Online collaboration (*Alibre Design* only)	*CAD features used:* Assemblies of parts Animation of assemblies FEA analysis of solid parts (*SolidWorks* only) 3D printing (rapid prototyping) Online collaboration (*Alibre Design* only)	*CAD features used:* Complete working drawings Building BOMs 3D printing (rapid prototyping) Online collaboration (*Alibre Design* only)

Next Generation CAD Features

While not disavowing the assessment criteria discussed above, there are some other important factors that could help facilitate the next generation decisions for both the choice and use of CAD software in CAD education. The suggestion is to examine end-use criteria more closely and stay focused on the changing professional context. There are three dimensions that interest us at present, namely:

- CAD for co-located teams, or for distributed, virtual teams. Messenger software is used and Adobe *Connect* for global design teams, but there is not a common ground for CAD;
- CAD for innovative conceptual design that supports the entirely different needs of conceptual design communication [30][31];
- CAD for engineering design or CAD (surface modellers) for industrial product design.

If engineers can expect their work environments to be increasingly characterised by global, mobile and virtual work, then CAD software that readily allows such collaborations and which may be readily integrated with other tools of the workplace would be the better choice. In this regard, peer-to-peer (P2P) software like *Alibre* are worth a closer look, but they will not always get that unless they are viewed as having comparable functionality for other features. Web-based software, such as Google SketchUp, wikis and spreadsheets, also seem destined to grow in quality and significance. Finally, new digital ink software is emerging, particularly for tablet PCs, as the importance of conceptual design in mobile environments grows.

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11th Baltic Region Seminar on Engineering Education: Seminar Proceedings

edited by Zenon J. Pudlowski

The yearly *11th Baltic Region Seminar on Engineering Education* was organised by the UNESCO International Centre for Engineering Education (UICEE) and held Tallinn, Estonia, between 18 and 20 June 2007. The Seminar attracted participants from 10 countries worldwide. Almost 40 papers have been published in this Volume of Proceedings, which grossly document and present academic contributions to the Seminar. All of these published papers present a diverse scope of important issues that currently affect on engineering and technology education locally, regionally and internationally.

The principal objective of this Seminar was to bring together educators from the Baltic Region to continue dialogue about common problems in engineering and technology education under the umbrella of the UICEE. To consider and debate the impact of globalisation on engineering and technology education within the context of the recent economic changes in the Baltic Region, as well as in relation to the strong revival of the sea economy. Moreover, the other important objectives were to discuss the need for innovation and entrepreneurship in engineering and technology education, and to establish new links and foster existing contacts, collaboration and friendships already established in the region through the leadership of the UICEE.

The papers incorporated in these Proceedings reflect on the international debate regarding the processes and structure of current engineering education. They are grouped under the following broad topics:

- Opening address
- Education and training for engineering entrepreneurship
- Innovation and alternatives in engineering education
- New developments and technologies in engineering education
- Quality issues and improvements in engineering education
- New trends and approaches to engineering education
- Simulation, multimedia and the Internet in engineering education

It should be noted that all of the papers published in this volume have undergone an international formal peer review process, as is the case with all UICEE publications. As such, it is envisaged that these Proceedings will contribute to the international debate in engineering education and become a valuable source of information and reference on research and development in engineering education.

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A multidisciplinary education framework that enables people from different disciplines to work together with community-based organisations on real-world projects

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ABSTRACT: In this article, the authors review research relating to multidisciplinary education, provide a commentary on current research, and describe a collaborative education programme developed by the Faculty of Design, Architecture and Building, the Faculty of Engineering and UTS Shopfront at the University of Technology, Sydney in Sydney, Australia. The authors discuss theoretical approaches, methodology and mechanisms for evaluation and improvement. It is hoped that this article will be of interest to researchers and professionals who have interests in workplace learning and multidisciplinary education research.

INTRODUCTION

The theoretical framework presented here is twofold. Firstly, it is a philosophy of *learning through experience*, where learners develop generic and technical professional skills while working together in multidisciplinary teams on community-based projects. Secondly, it is the philosophy of *scholarship of engagement*, where two-way interaction occurs between the university and the community – both work together in a manner that mutually benefits students, the university and the community.

The underpinnings of the first of these philosophies stem from work done by Mezirow, Rogers, Kolb, Dewey and Vygotsky [1-4]. Dewey held that education, in order to accomplish objectives both for the individual learner and for society, must be based upon experience. He wrote that although *all genuine education comes about through experience ... experience and education cannot be directly equated to each other* [4]. An appreciation of the relationship between learning and experience has frequently taken a significant role in the formation of programmes designed to develop professional expertise, and is particularly important for the Faculty of Design, Architecture and Building, the Faculty of Engineering, and UTS Shopfront at the University of Technology, Sydney in Sydney, Australia (UTS Shopfront is a University-wide non-profit programme that provides an essential component of the framework by which community groups link to, and interact with, students and staff).

The framework is also underpinned by the philosophy of *scholarship of engagement*. Several significant and influential schools of thought embody the central concept of scholarship of engagement, but refer to the concept using different terminology, such as *service scholarship*, *professional service* and *outreach*. It arises from a recognition that work of the university should relate to the world beyond the campus. This approach is exemplified by Boyer's observation that if universities cannot help students to better understand the interdependent nature of the world, *each new generation's capacity to live responsibly will be dangerously diminished* [5]. A related philosophy of integrated learning and community service is that of *service-learning*, where, as Kendall said, *both the server and those served teach, and both learn*, and where there is *a sense of mutual responsibility and respect between individuals in the service-learning exchange* [6]. Jacoby describes the concept as students engaging in activities designed to promote students learning and development while addressing human and community needs [7].

With these two underlying philosophies in mind, the authors are particularly interested in the development of learning activities that are focused on students, a principle that is affirmed by Biggs, who held that educational objectives should be concerned with students' learning activities, not teachers' teaching activities [8]. Such learning outcomes are expressed by statements such as: *as a result of this project I will be able to* ..., as opposed to *in doing this project I will cover* ... Learning outcomes of this type are intended to be realistic and achievable, and might include general objectives such as:

- Work together on community-based projects in multidisciplinary teams;
- Develop skills and competences relevant to professional practice and research;
- Develop greater awareness of relevant research and gain experience in discovering their own resources;
- Develop a greater awareness of multicultural, gender, indigenous and other diverse perspectives;
- Engage with community groups regarding scope, requirements and design;
- Perform work that relates to the world beyond the campus;
- Engage in a manner that is mutually beneficial.

COLLABORATIVE STRUCTURE

A collaboration between the Faculty of Design, Architecture and Building, the Faculty of Engineering, and UTS Shopfront has led to the development of a structure whereby students, community groups and staff participate in activities that are aligned with the principles of learning through experience and scholarship of engagement. Students from each Faculty jointly form multidisciplinary project teams that enable cross-disciplinary engagement and provide mutual benefits for the students and community groups involved. The collaborative nature of the joint-Faculty teams is intended to encourage the development of multidisciplinary competences in a context beyond that which could be achieved by either discipline in isolation.

The programme employed the following strategies for achieving the broad philosophical aims (being learning through experience and scholarship of engagement):

- Specific community projects are linked to multi-disciplinary groups of four to five students, together with staff from each Faculty;
- The focus of each project and the learning activities encourages students to develop greater awareness of current best-practice and relevant research, and to gain experience in discovering their own resources;
- The assessment tasks are structured in a way that encourages students to develop professionally-relevant generic skills and technical competencies – for assessment, the programme adopts an approach advocated by Ramsden: assessment tasks should focus first on learning, then on encouraging effort, and lastly on grading [9];
- A collaborative environment is established and supported where students, community groups and staff engage together in scholarly activities.

The students from the Faculty of Design, Architecture and Building are primarily drawn from Visual Communications, whereas the Faculty of Engineering students are primarily final year research-project students. Early in the process, expectations are negotiated with students, a time-plan is discussed, and engineering students are required to produce a detailed proposal of what is to be achieved and how. Members of each community group act as the liaison for student contact, provide ongoing feedback and direction, attend presentations and evaluate the outcomes relating to each project.

MECHANISM FOR EVALUATION

There exist many approaches for evaluating programmes such as this. Previous research that was concerned with the impact of service-learning on critical thinking, personal and interpersonal development, engagement, curiosity and reflective practice includes that of Astin and Sax, and Eyler and Giles [10][11].

One approach is to longitudinally track how people's perceptions of their abilities change with time. This approach can be relatively resource intensive, as it requires students to be re-tested at different stages of their education. Notwithstanding, assuming that the testing instrument has an acceptable level of test-retest reliability, the approach allows changes in perceptions to be tracked. However, educational programmes employing this approach are relatively rare, partly because it is often considerably more difficult to locate the same respondents on two or more occasions than it is to administer a test to respondents on a single occasion. A promising cross-sectional approach to studying students' perceptions about the importance of various graduate attributes at different stages of their course has been attempted within the Faculty of Engineering, but the method is yet to be validated [12].

The authors' review of the literature suggests that it might be best to evaluate such programmes using information from multiple sources; in this case, data was included from face-to-face sessions with students that occurred before, during and at the conclusion of each project. Part of the evaluation of the programme relies on information obtained through written self-reporting. The authors do, however, take into account previously documented limitations of this approach. For example, scores on self reporting when using measuring instruments, such as the Approaches to Studying Inventory, vary with age [13]. Older respondents tend to score more highly on items that relate to deep learning, whereas younger respondents tend to score more highly on items that relate to surface learning [14]. Others have also raised questions concerning the validity of self-reporting – Ross and Conway describe a study where students reported that a course that they had attended was beneficial to them, even after it was demonstrated in a debriefing that their academic performance was no better than students who had not taken the course [15].

In evaluating the programme, the authors engaged in activities informed by:

- Each of the authors' respective roles, experiences, values and beliefs;
- The philosophy of the programme;
- Research in the field of education;
- Professional practice in each of their respective disciplines.

In seeking to discover whether the methods are appropriate to the goals, the authors looked at the programme as a whole, and then each sub-task to assess the extent to which each appears to be aligned with one or both of the two broad aims.

The authors also sought to discover whether the programme facilitates deep learning, as opposed to surface learning. Surface learning is where students learn isolated facts, and treat items independently of each other and what the task is about. Deep learning *requires a sound foundation of relevant prior knowledge, so students needing to know will naturally try to learn the details, as well as making sure they understand* [8].

Some of the considerations for evaluating the programme included the following:

- Feedback surveys are completed by students;
- *Discussion board* communications are reviewed by staff and issues relevant to the programme are noted;
- Most students provide group presentations that describe the development stages of their thought processes and how the design decisions were made, and students show that they have searched for examples of current best practice for the community group's sector; engineering students write a literature review – examples of work that appear to indicate objectives being achieved or missed (eg surface learning as opposed to deep learning) are noted by staff during assessment;

- The students' design is to reflect their awareness of multicultural, gender, indigenous and other diverse perspectives, and the extent to which this appears to have been achieved is noted by staff during the presentations; engineering students' awareness of these perspectives is discussed during face-to-face sessions with staff and noted;
- Staff and students speak about the learning outcomes with an emphasis on the context of professional development; students provide feedback about the workings of their groups during these face-to-face sessions with staff and issues that relate to the evaluation of the programme are noted;
- UTS Shopfront staff maintain regular communication with community groups throughout the life of the project; e-mails and other aspects of the communication are reviewed and issues relevant to the evaluation of the programme are noted;
- Members of the community groups attend the design presentations and provide feedback, which is noted; some members of community groups also (voluntarily) provide feedback by e-mail, which is then collated.

Another central question is the extent to which the programme contributes to students' professional formation, especially with respect to the ability to relate theory and methodology to professional practice. Even though it seems likely that grounding the programme in the principles of learning through experience and the scholarship of engagement is *a good thing to do*, the authors genuinely question the programme's alignment with these principles, and try to understand the impact of the programme on all who are involved. Attempting to evaluate the learning outcomes of non-classroom activities is an important issue for professions where competence is developed through both classroom activities and internships – professions such as architecture, design, education, engineering, law, nursing, psychology and social work.

The authors are mindful of recent research aimed at furthering knowledge about non-classroom learning, such as Rowley, Smith, Falconer and Pettigrew, and Powell, Mayson and de Lange [16-19]. The authors are also informed by their own previous efforts directed towards evaluating educational issues relating to non-classroom remote laboratories and methods for evaluating educational outcomes relating to online blended groups [20-22].

A noteworthy aspect arising from prior research is the proportion of learning that professionals attribute to sources other than the classroom. For example, an analysis by Baker of a study by Garth and Martin indicated that law graduates reported law school as being the primary source of only 25% of their total learning [23][24]. Canale, Cates and Duwart described a study of Northeastern University students who attributed about 44% of their development to the classroom, 46% to internships and 11% to other sources [25]. The findings for UTS engineering students are similar (see Table 1). Such results suggest that the classroom is not as significant a source of learning as might be expected.

Another consideration is the possibility that international students are less (or more) prone to response bias than other groups. However, prior research suggests that this is not likely to be a significant factor. For example, Grim and Church indicated that response bias was stable across cultures [26]. A related issue concerns whether the participants interpret written statements as intended – face-to-face meetings are thus a primary source of the information that have been used to evaluate the programme.

One of the challenges for educators who seek to evaluate the impact of non-classroom activities on learning is to develop methods that are sensitive to the wide and varied outcomes, yet sufficiently specific to demonstrate whether such outcomes are directly attributable to the programme, as opposed to other extraneous factors. Specially-developed methods for computerised confidential peer assessment used within the Faculties of Design, Architecture and Building, and the Faculties of Engineering have been used for those students involved in community projects [27][28]. Information about student learning outcomes, which is yielded from the processes by which the students involved are assessed, is a key input for evaluating the programme.

CONCLUDING REMARKS

Programmes such as this require relatively high levels of staffing resources. However, it seems that the authors' experiences are not unique in that they feel that such programmes can effectively enable activities that develop understanding and capacity while building on the strengths and expertise of the community groups, the University and students.

Firstly, the capacity of the community groups seems to be strengthened by the scholarly interaction and sharing of knowledge and skills, and a greater awareness of sources of expertise within, and external to, each organisation. The framework seems to be suitable for enabling the community organisations involved to benefit from the sharing of knowledge and know-how, and the value of the deliverable outputs of the projects.

The capacity of the University is developed through engaging in multidisciplinary work situated within the local community, and the University benefits from providing a stimulating learning environment for staff and students. Members of staff benefit from the multidisciplinary aspects of the programme, and it has been have found that being involved with the programme is a rewarding and enjoyable experience.

Table 1: Findings for UTS engineering students.

Issue	Workplace	Classroom	Other
The ability to design and conduct experiments, as well as to analyse and interpret data	36	56	8
The ability to function on multidisciplinary teams	46	48	6
An understanding of professional and ethical responsibilities	51	42	7
The ability to design a system, component or process to meet desired needs	51	43	7
The ability to communicate effectively	53	35	12

The framework appears to be suitable for enabling a form of practice-based learning that facilitates reflective practice, professional development, contributes to personal growth and has socially relevant outcomes. Students develop cultural sensitivity through respectful, responsible and professional interactions with community groups.

Students also benefit as indicated by the results of student feedback surveys, and comments such as those of an engineering student who, after working in a group with Visual Communication students, said *I'd like to learn more about design theory*. Regarding learning outcomes, the student said *a lot that I can't describe – liaising, organising, planning ... other project things*. Such comments illustrate that curiosity and motivation is aroused by the experience, and that they value the generic competences that the framework enables them to develop.

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Engineering education reform: the imperatives for ensuring its quality and outcomes

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ABSTRACT: Leading scholars, researches and educators have been involved in discussions concerning the need for reforming engineering education in accordance with the changes and needs of industry, business, commerce and public services. The recognition of the rapid expansion of scientific and technical knowledge caused by the development of information and communication technologies, as well as the vast opportunities to study, work and live anywhere in the globe, are the driving forces for re-evaluating the basic concepts of engineering education. It is important to emphasise that the idea behind this reformation initiatives is to define the rational goals of engineering education, identify and assess the outcomes and level of proficiency, and to develop a unified curriculum. Such a curriculum would be easy to customise according to the specific educational needs and provide the quality of education by improving engineering pedagogy, including teaching approaches, methods and techniques. The growing concern about the quality of engineering education stimulates the efforts by many initiative groups to remedy the situation and those efforts are encouraged by industry and government. Some attempts to contribute to the reform of engineering education are described and discussed in this article.

INTRODUCTION

Those who follow relevant scientific publications and research concerning engineering education would agree that the idea of engineering education reform has been advocated for some time now, and is long overdue. Particularly stressed is the necessity to bridge the gap between engineering education and engineering practice. In other words, it is the effort to re-evaluate the goals and objectives of engineering education, develop a curriculum compatible with the industry needs and implement the strategy to achieve the required level of proficiency within the defined outcomes, so that any graduate could make a significant and influential contribution to the engineering practice of the 21st Century.

Moreover, the continued accreditation of educational programmes and university ranking processes complement the process of ensuring the quality of engineering and technology education, thus providing equal opportunities for engineering graduates. For engineering education, it is the time of ferment and argument, as well as the development and evolution. It is the time for the innovative minds in engineering education to change their paradigm by building a framework of revised theory, research and implementation.

SIGNIFICANT INITIATIVES OR GREAT REFORMERS

All the initiatives to reform higher education should be viewed against the backdrop of the global changes and needs in industry, business, commerce and the public services. The globalisation process brings about the dominating idea of unifying educational systems and standards without losing the quality of education.

In 1999, Ministers of Education from 29 European countries signed the document called the *Bologna Declaration*, which marked the beginning of the reformation of the European higher education area. In the Declaration, several important objectives have been specified as follows:

- The adoption of a common framework of readable and comparable degrees, *also through the implementation of the Diploma Supplement*;
- The introduction of undergraduate and postgraduate levels in all countries, with first degrees no shorter than three years and relevant to the labour market;
- ECTS-compatible credit systems that also cover life-long learning activities;
- A European dimension in quality assurance with comparable criteria and methods;
- The elimination of the remaining obstacles to the free mobility of students (as well as trainees and graduates) and teachers (as well as researchers and higher education administrators) [1].

It looks like the whole idea of that reform is about unifying the structure of higher education and increasing mobility because there should be *a common European answer to common European problems*. It is also said in the document that *the fundamental principles of autonomy and diversity are respected* [1].

The major concern about this initiative is the deficit of information about the outcomes, especially statistical data and analyses of success and failures. One of the examples is the situation in Greece, where the government met strong opposition on the part of students as a reaction to massive and radical reforms in the education sector in accordance with the *Bologna Declaration*. This social tension was the reflection of the younger generation of graduates on the perspective to be unemployed due to being part of a *flexible labour force*. Therefore, they carried the slogans *Public and Free Education* and *We Want Jobs, Not Unemployment* [2]. This situation shows that in order to meet the goals of the *Bologna*

Declaration, some governments may blindly sacrifice peace and stability in the social sector.

Furthermore, the unification of the organisational structure of European institutions with their preserved identity will hardly make it possible to provide education of the same quality. If the question is in recognising the level of proficiency, then this reformation process should probably be more about developing standards and providing quality.

The Accreditation Board for Engineering and Technology (ABET) in the USA has provided leadership and quality assurance in higher education for over 70 years. It is the most widely recognised accrediting organisation for assuring that an education programme meets the quality standards established by the profession for which it prepares its students. The ABET quality standards are set collaboratively by many different professional and technical societies working together through ABET in order to develop those standards and provide an evaluation of whether the programmes meet the ABET's standards [3].

Another key initiative, known as CDIO (Conceive - Design - Implement - Operate), emerged in October 2000 in order to improve engineering education worldwide. The name of this international collaboration group is derived from the product/ system lifecycle definition, which reflects the whole idea of the contemporary engineering education rationale as follows:

> *Graduating engineers should be able to conceive-design-implement-operate complex value-added engineering systems in a modern team-based environment* [4].

A simple statement that *engineers engineer,* ie *they build systems and products for the betterment of humanity*, was justified by the CDIO Initiative as the main principle to build their research upon and develop the CDIO Syllabus content [5].

As shown in Figure 1, engineering students are expected to have the knowledge, skills and attitudes necessary to *Conceive – Design - Implement - Operate*. It is believed that the *Personal and Professional Skills* component is central to engineering practice. The appropriate *Technical Knowledge and Reasoning* element in the portfolio of an engineering graduate should give him/her freedom to develop complex value-added engineering systems. The *Interpersonal Skills* part of teamwork and communications are essential for working in a modern team-based environment. Finally, it is important that students understand the principles of conceiving, designing, implementing and operating systems in the enterprise and societal context [5].

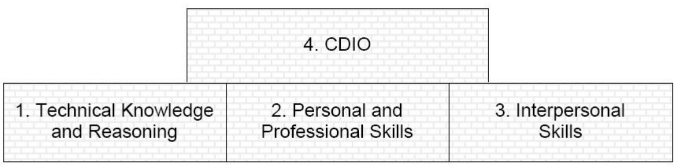

Figure 1: The building blocks of knowledge, skills and attitudes necessary to conceive, design, implement and operate systems in the enterprise and societal context [5].

The CDIO Syllabus is a *codification of contemporary engineering knowledge and attitudes* that correlates strongly with the ABET Criteria EC2000, as presented in Table 1 [6].

Table 1: The ABET 2000 Requirements correlated with the CDIO Syllabus [6].

CDIO Syllabus Sub-section	ABET Criteria Met										
	a	b	c	d	e	f	g	h	i	j	k
1.1	●										
1.2	●										
1.3	□										●
2.1					●						□
2.2		●									
2.3			□								
2.4									●		
2.5						●					□
3.1				●							
3.2							●				
4.1								●		●	
4.2											
4.3			●								
4.4			●								
4.5			●								
4.6			●								
● Strong Correlation						□ Good Correlation					

By the look of this correlation and comparison, it can be concluded that the CDIO Syllabus is even more comprehensive and explicit. The CDIO Syllabus is not merely descriptive, ie is pointing out certain outcomes, but it has several explanatory levels that gradually lead to the topical version of the Syllabus content. Such a detailed organisation of the Syllabus makes it flexible for the customisation according to the stakeholders' specific needs.

It should also be noted that, in order to translate the list of topics and skills into learning objectives and adapt the Syllabus to a degree programme, it is required to conduct a survey determining the desired level of proficiency in the designated skills [6].

A comparative study of expected student proficiency was carried out by four universities, the original developers of the CDIO Initiative, namely Chalmers University of Technology, the Royal Institute of Technology and Linköping University, all in Sweden, as well as Massachusetts Institute of Technology in the USA. The survey was conducted among four constituencies: faculty, senior industry leaders, young alumni (average age 25) and older alumni (average age 35). After comparing the results, it was concluded as follows:

> *The survey indicates that the skills for which the proficiency expectations are the highest include engineering reasoning, personal attributes, communications, and design. These four skills are consistently among those cited as most important in a young engineer. At the Swedish universities, the expected proficiency in Communications in Foreign Languages also was high* [5].

What is really welcoming about the CDIO Initiative is the transparency and openness. All the information about the reform itself, approaches, surveys, outcomes, publications and even the contact details of the people involved in this project, are available free of charge from the CDIO Web site [7]. The essence of globalisation is in its openness, freedoms and flexibility. Hence, if the idea is to re-evaluate and improve engineering education globally, it has to be openly provided and supported with information, research-based findings and expertise.

FROM RADICAL IDEAS TO REAL PRACTICES

The immediate and more distant future of university graduates is to be fully and professionally engaged in global society, enterprise and commerce. The quality of education that they obtained will impact directly on their recruitment drive, and the capacity to further develop professionally and achieve high living standards. Hence, the understanding of these challenges creates the tendency for educational institutions to revisit, re-evaluate and reform the educational programmes that they offer. International initiatives contribute to this process a lot by providing education quality standards and expertise.

ABET currently accredits some 2,700 programmes at over 550 colleges and universities, both nationwide and worldwide. According to the ABET statistical data, as displayed in Table 2, it can be stated that there is a large number of institutions involved in the accreditation process and the number is growing each year [3].

The accreditation of engineering programmes by ABET is voluntary. The programme of an institution, which seeks accreditation, is assigned to one of four accreditation commissions within ABET, specifically the Applied Science Accreditation Commission (ASAC), Computing Accreditation Commission (CAC), Engineering Accreditation Commission (EAC) or Technology Accreditation Commission (TAC). Each Commission has different accreditation criteria.

It can be observed from the ABET statistics data listed in Table 2 that the EAC is very heavily loaded with the number of programmes and institutions that seek accreditation. It is also presented in Figure 2 that the number of programmes assigned to the EAC is still growing [3]. It demonstrates the awareness of society about the importance of engineering education for its welfare and development, as well as highlights the growing concern about the quality of engineering programmes and the intention to grasp the reality of global needs.

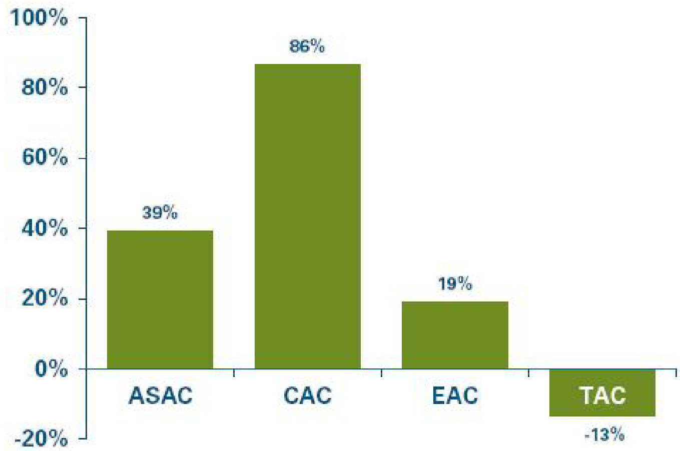

Figure 2: The increase/decrease in the number of accredited programmes (1996-2006) sorted by the Commissions [3].

As far as the CDIO Initiative is concerned, it is quickly gaining momentum. It complements the efforts of accreditation bodies in changing the face of engineering education for the better. There are 24 collaborating schools on board the CDIO Initiative. As it is stated on the CDIO Web site:

> *The CDIO™ Initiative was developed with input from academics, industry, engineers and students. It is universally adaptable for all engineering schools. CDIO™ Initiative collaborators throughout the world have adopted CDIO™ as the framework of their curricular planning and outcome–based assessment. The CDIO™ Initiative is an innovative educational framework for producing the next generation of engineers* [7].

The recognition of the necessity to incorporate the enhancement of global competences into engineering curricula has become a reality and is well accepted. There are a number of national initiatives that work together on improving the quality of education to better prepare engineering graduates for global practice. Lohmann et al recognise the fact that:

> *While many aspects of society and commerce have become internationalized, it cannot yet be said for many university curricula that they prepare students to live and work in a global community, especially engineers. Incorporating international preparation into engineering curricula, however, has proven to be a major challenge* [8].

Table 2: Number of programmes accredited by ABET and institutions with accredited programmes, 1996-2006 [3].

	ASAC		CAC		EAC		TAC		All	
Year	Programs	Institutions	Programs	Institutions	Programs	Institutions	Programs	Institutions	Programs	Institutions
1996	51	36	140	136	1,502	312	774	249	2,467	541
1997	55	39	144	139	1,531	315	771	250	2,501	545
1998	59	44	149	144	1,539	317	776	248	2,523	548
1999	58	45	155	150	1,552	320	730	238	2,495	544
2000	59	45	163	158	1,581	323	718	238	2,521	549
2001	60	45	169	164	1,618	332	711	239	2,558	557
2002	62	47	181	171	1,664	341	694	237	2,601	561
2003	66	48	197	181	1,700	343	679	226	2,642	554
2004	70	51	215	193	1,750	350	702	230	2,737	562
2005	66	50	239	204	1,759	357	664	220	2,728	571
2006	71	54	261	220	1,787	364	670	226	2,789	587

They go on to say that in the USA, several universities have developed programmes designed to prepare students to perform their professional activities on the global scene, as follows:

> *These programs fall into four categories: co-majors or dual majors (e.g. Pennsylvania State University, Iowa State University and University of Rhode Island), minors or certificates (e.g. Iowa State University, Purdue University, University of Illinois, University of Michigan and University of Pittsburgh), international internships or projects (e.g. Worcester Polytechnic University and Pennsylvania State University) or study abroad (e.g. University of Minnesota)* [8].

There appears to be a lot of support for, and contribution to, the research, development and implementation of modern engineering curricula, which have to be designed as a common model, and are easy to be customised and adapted to specific engineering needs.

A FOREIGN LANGUAGE FOR ENGINEERS IS NOT A LUXURY BUT A MUST

Living in the global context of the 21st Century is challenging as it does not only require a young engineering graduate to be technically adept, but also have the knowledge and skills to function efficiently in a transnational engineering environment. It places great emphasis on the acquisition of language and communication skills. Some important considerations on improving the acquisition of communication skills by engineers have been discussed elsewhere [9].

It should be recognised by universities that there is still not enough attention being paid to incorporating language skills into engineering curricula. Yet people who have science and technology subjects in combination with languages are particularly sought after by employers because any serious business or enterprise today is a part of the global economy.

In this context, it is surprising to see that the MIT did not even include foreign languages when conducting the survey for the CDIO project on the levels of proficiency [5]. It is seen to be odd due to the fact that in the 1960s, Noam Chomsky and his MIT colleagues were at the theoretical forefront of applied linguistics. The authors are puzzled by the fact that those outstanding linguistic scientists and scholars with enormous achievements and reputation had no influence over this process.

The myth that English is a *lingua franca* has been busted by the presented statistic figures which show that 75% of the world's population do not speak English at all [10]. Moreover, the statistics show that only 5% of the world's population use English as their first language [11].

According to the survey carried out by Hobsons Agency, the English-speaking world faces such difficulties as a shortage of native English speakers for jobs at all levels. Only a third of UK graduates have the confidence to go abroad to find work. Two thirds of their continental colleagues feel that they are able to do this and venture into the global job market [12].

This deficiency in education is of great concern to some educational institutions that find their way to incorporate foreign languages and communication skills development into their curricula. Lohman et al state the following:

> *The University of Rhode Island offers a five year dual degree in engineering and language (German, French or Spanish). In addition to meeting the requirements for the language and engineering degrees, students spend an academic year outside the USA, either on an internship, studying at an exchange university or undertaking a combination of study and internship. Among all universities reviewed, the Rhode Island program provides the most extensive language study, study of another culture (through advanced language courses) and the longest period of study overseas* [8].

It should be noted that the International Engineering Program (IEP) at the University of Rhode Island was launched in 1987 and, since then, it has been functioning successfully. Initially, the IEP was limited in terms of the offered language to German only. In order to instil the second degree into the engineering programme, the duration of the IEP had to be expanded to five years. Another basic element of the IEP was an internship in a company in a German-speaking country for the duration of six months in the fourth year [13]. Today, in addition to the German course, the IEP also offers the second degree in French and Spanish, as well as in other languages, for example Chinese, which has emerged together with the international expansion of the US trade market.

In evaluating the success of the programme, J.M. Grandin, the IEP Director, stated the following:

> *The program boasts a 100% placement rate and, frankly, cannot keep pace with the worldwide need for engineers with cross-cultural communication skills* [14].

It seems that the necessity of incorporating foreign language competences into engineering curricula as one of the important outcomes cannot be regarded as a tribute to globalisation fashion but a necessity dictated by international businesses and trading activities. It was one of the reasons why, from the very beginning of the project, the IEP received a wide acceptance, as well as significant support and willingness to help from companies and governmental organisations [13].

The same goals and objectives are being pursued by the American Council on the Teaching of Foreign Languages (ACTFL), which is committed to building language proficiency, and which has the following notion in its mission statement:

> *ACTFL is the only national organization dedicated to the improvement and expansion of the teaching and learning of all languages at all levels of instruction throughout the US* [15].

It also provides expertise, advocacy, resources and standards concerning the level of language proficiency.

Another quite successful programme called Communication across Curriculum (CxC) appeared as a means to reinforce communication strategies and integrate communication into existing engineering curricula. It was basically a response to one of the ABET Criteria 2000 requirements, which states that the engineering graduate should demonstrate the ability to communicate effectively. There are several universities that contribute to the effort of addressing this issue in practice;

among them are Louisiana Sate University, USA, the University of Pittsburgh, USA, and others.

The National Centre for Languages (CILT) was created in the UK in order to promote the true value of the languages at workplace. According to the survey by the CILT:

> *… one in five UK companies involved in export or import is losing business because of language and cultural barriers. There is evidence from CILT surveys that employees need language skills throughout the organisation, and this is very often in the frontline – the first point of customer contact* [16].

The Languages National Steering Group in the UK makes a considerable input into the development of the strategy to transform the country's capability in languages. The Group has worked out the language strategy for England, which outlines the Government's plan concerning the language acquisition and gives an insight into the initiatives to *broaden and enrich the opportunities for language learning at school and beyond* [17].

CONCLUSIONS

It is a widely recognised fact that being a part of the global economy, a lot of changes are being brought to the social and professional environments, as well as many challenges evoked within the education system in order to keep the momentum and provide high quality education. It should also be understood that foreign languages and communication skills, although not primarily engineering skills, should not be neglected in curricula.

This is especially important when taking into account that linguistics develop other skills such as risk taking, thinking flexibility, dealing with the unexpected and working across communication boundaries. Moreover, the motivation of students to learn foreign languages could be boosted when demonstrating to them the statistics from recruitment agencies, which state that salaries for those using languages at work can be much higher by 8% to 20%, when compared with those without such skills, depending on how central languages are to the role [16].

Research carried out so far has found that there are many international initiatives and programmes with the objectives to contribute to the changing paradigm of engineering education. Their principles and undertaken efforts may differ in some aspects but the main objectives are similar. Most of the initiatives endeavour to develop universal curricula through which to raise proficiency standards in order to allow engineering graduates to gain the requisite knowledge, skills and attitudes progressively as their careers advance.

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Conference Proceedings of the
10th UICEE Annual Conference on Engineering Education
under the theme:
Reinforcing Partnerships in Engineering Education

edited by Zenon J. Pudlowski

The *10th UICEE Annual Conference on Engineering Education*, held under the theme of *Reinforcing Partnerships in Engineering Education*, was organised by the UNESCO International Centre for Engineering Education (UICEE) and was staged in Bangkok, Thailand, between 19 and 23 March 2007, at the Menam Riverside Hotel.

This volume of Proceedings covers a wide selection of various papers submitted to this Conference, which detail a range of important international approaches to engineering education research and development related to the Conference theme, as well as other specific activities.

The 64 published papers from authors representing 25 countries offer an excellent collection that focus on fundamental issues, concepts and the achievements of individual researchers. The papers have been organised into the following sections:

- Opening Addresses
- Keynote Addresses
- Innovation and alternatives in engineering education
- New approaches to engineering education
- International examples of engineering education and training
- Current issues and trends in engineering education
- UICEE Special Session
- Multimedia and the Internet in engineering education
- Important issues and challenges in engineering education
- Case studies
- Effective methods in engineering education
- Quality issues and improvements in engineering education
- Research and development activities in engineering education at the ECUST

The diversity of subjects, concepts, ideas and international backgrounds in this volume of Proceedings demonstrate the global nature of UICEE-run Conferences, as well as its relevance within the worldwide affairs regarding engineering and technology education.

Importantly, all of the papers have undergone assessment by independent international peer referees and have been professionally edited in order to ensure the high quality and value of the Proceedings into the future. As such, it is anticipated that this volume will become a useful source of information on research and development activities in the dynamic and evolving field of engineering and technology education.

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Monash University's Gippsland Campus' innovative *going green*-based system for infrastructures education with environmental cultural change applications

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ABSTRACT: Higher education across the world has adopted the movement towards *going green*. Many universities and colleges are in various stages of organising for sustainability. However, no evidence is seen in the literature that one exists for utilising its own university campus as an environmental-learning laboratory for a civil and environmental engineering degree programme. The Gippsland Campus of Monash University in Australia has become an actual sustainability-learning laboratory for its Bachelor of Civil and Environmental Engineering programme. Through this unique relationship between the Gippsland Campus' Bachelor of Civil and Environmental Engineering and the Campus' Facilities and Services Division, students are exposed to the environmental projects undertaken on Gippsland Campus from their concept through to completion, and can evaluate and measure the environmental impact as a result, creating a sense of ownership to the significant improvements on campus, consequently adding to the students' experience while they study for their degrees. The outcomes are greening the Bachelor of Civil and Environmental Engineering, greening Monash University Gippsland Campus and fostering cultural changes on campus.

TALLOIRES DECLARATION

Composed in 1990 at an international conference in Talloires, France, this is the first official statement made by university administrators of a commitment to environmental sustainability in higher education. The Talloires Declaration is an international, voluntary 10-point agreement that focuses on universities' obligations to promote awareness and understanding of sustainability issues through teaching, research and community engagement [1][2]. The 10 points include *Increase awareness of environmentally sustainable development*; *Create an institutional culture of sustainability*; *Educate for environmentally responsible citizenship*; *Foster environmental literacy for all*; *Practice institutional ecology*; *Collaborate for interdisciplinary approaches and maintain the movement.* Monash University in Australia officially signed the Declaration. When the Declaration was initiated in 1990, there were 31 signatories; there are now over 350 signatories worldwide signed by university presidents, vice-chancellors and chancellors in over 40 countries.

UNITED NATIONS RESOLUTION

In December 2002, the United Nations (UN) General Assembly adopted resolution 57/254 on the United Nations Decade of Education for Sustainable Development (2005-2014). The resolution was introduced by Japan and cosponsored by 46 countries. Resolution 57/254 named the United Nations Educational, Scientific and Cultural Organization (UNESCO) as the lead UN agency responsible for the Decade of Education for Sustainable Development [3]. The goal of Education for Sustainable Development (ESD), which is the focus of the present paper, is to reorient education in all forms, so that we collectively consider the long-term future of the economy, ecology and equity of all communities in the decisions and actions we make and take. Internationally, it is recognised that education is the primary vehicle to increase the ability of people to proceed along a path of sustainability. In order to take the necessary steps, education, in all its make-ups, must foster the capacity of individuals to shift their values, behaviour and lifestyles towards one that supports a sustainable future. Higher education across the world has adopted the movement towards sustainability. Many universities and colleges are in various stages of organising for sustainability [4]. Monash University's Gippsland Campus is at the forefront of such a sustainability thrust as shown in the present paper, which is an innovative advanced application to the Talloires Declaration and UN resolution 57/254.

GOING GREEN

The words *sustainability* or *going green* for any given university campus has, in the context of the present paper, the following basic components: improving and maintaining economic efficiency; shielding and reinstating ecological systems; and enhancing the well-being of humankind.

APPLIED *GOING GREEN* CAMPUS

In this article, the authors define applied *going green* campus initiatives as the programme that applies all the above campus *going green* components to change the Campus to be sustainable, educate students on sustainability and realise cultural changes. An applied *going green* campus here means specifically changes in the way we think, act and educate students. The way that grounds are maintained, buildings constructed, research performed, teach into the Bachelor of Civil and Environmental Engineering, offered at the Gippsland Campus of Monash University, taught [5], and sustainability cultural change aspects implemented. It is believed that the educational side of an applied *going green* campus is an investment in the future. The green investment in the education of students on infrastructures sustainability has a long-term benefit. These students will eventually become leaders in their community and bring with them the important concepts of sustainability. Campus-applied *going green* has allowed students in the Bachelor of Civil and Environmental Engineering to learn the required curriculum while applying what they learn to real world Campus problems as their big environmental laboratory. This learning model is very well suited to a rural campus environment like the Gippsland Campus and is the way to integrate a knowledge base with local requirements and applications.

GIPPSLAND CAMPUS AS A SUSTAINABILITY LAB

In this article, the authors show that the Monash University's Gippsland Campus has become an actual sustainability-learning laboratory for the Bachelor of Civil and Environmental Engineering. For example, take Monash's energy guide, available for students on the Internet and as distributed booklets [6]. Another example, students are made aware of the how Monash University, Australia, adopted the movement toward sustainability (UN resolution 57/254) by recently announcing the University's commitment to reduce the energy consumption of all Australian campuses, including the Gippsland Campus, by 20% from 2005-2010. This is the largest energy reduction plan sought by any of Australia's universities and an extremely ambitious challenge. Such a plan places Monash at the forefront of Australian universities as a leader in the global commitment to addressing climate change [7]. Monash University's target has two components: a 10% reduction to be achieved through infrastructural improvements and a further 10% reduction from cultural change. The University is encouraging everyone to be more aware of how their office and environment use energy and to help reduce this, while the University will continue to pursue greener alternatives and improve infrastructure. The above measures will help the University achieve its target to reduce energy by a fifth over five years. The Gippsland Campus is leading Monash University in meeting the target among other Monash University campuses. In fact, the Gippsland Campus has total energy savings to date of 11.7% and total additional energy savings expected by the end 2007 of 4.8%, meeting comfortably the University target.

At Monash University's Gippsland Campus, a unique strategic alliance was formed between the Campus' Facilities and Services Division, and the Bachelor of Civil and Environmental Engineering [5][8]. This includes, for example, having the Campus' Facilities and Services Manager as a guest speaker for the infrastructures units of the Bachelor of Civil and Environmental Engineering. The educational rationale of this alliance is to engage students with the Campus' ongoing environmental achievements aiming at the following educational objectives for the benefit of Bachelor of Civil and Environmental Engineering students:

- To develop the skills and knowledge for the design and management of sustainable civil and environmental engineering infrastructure and solutions;
- To develop an ability to carry out such engineering activities in a manner that minimises or eliminates negative environmental impacts;
- To equip students with the knowledge and skills base to identify and implement civil and environmental engineering sustainability changes;
- To develop an appreciation and knowledge of engineering sustainability strategies for identifying and mitigating any negative environmental impacts;
- To develop the appropriate skills in analysis, synthesis, design, project coordination and evaluation of environmental impact assessments;
- To develop students' environmental engineering communication skills for convincing others, by persuasion and by examples, of the necessity for environmental cultural change as applied to the Campus community in the first instance, and the environmental international community at large.

ECOLOGICALLY SUSTAINABLE CAMPUS PLAN

Sustainable design is the method of design civil and environmental engineering projects that comply with the principles of economic, social and ecological sustainability, and includes factors such as sustainable sites, water efficiency, energy and atmosphere, materials and resources, indoor environmental quality and innovative design process. The goals of the sustainable ecological Campus plan include:

- Creating an excellent learning environment based on an international and sustainable competitive campus;
- Applying green buildings and sustainable plan concepts to structure the Campus for a green cultural and green educational environment;
- Reviewing the overall Campus and environment of the community to establish the Campus to be a springboard for green growth.

As an actual teaching illustrative example, students are taught ecologically sustainable design utilising the Campus' new auditorium building. The $5.5 million new auditorium, currently under construction, set to be completed in June 2008, has been designed to incorporate the above-mentioned environmentally sustainable design elements (see Figure 1).

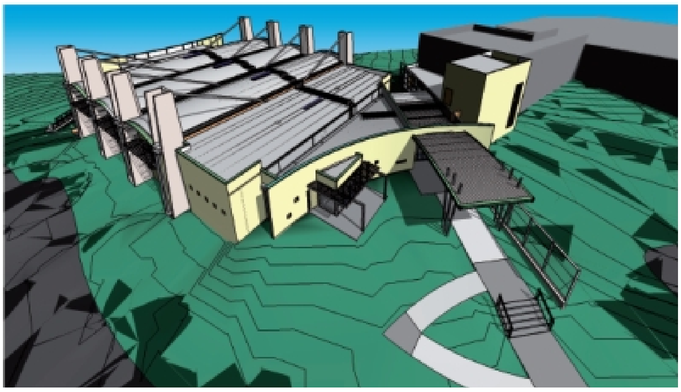

Figure 1: The Gippsland Campus' new auditorium building expected to be completed in June 2008.

The auditorium space has been designed as a multipurpose venue with the operable walls allowing for flexible room sizes that vary from 100 m² to 750 m². The auditorium's environmental sustainable design features studied by students include:

- A high level of acoustic insulation to ensure that rain noise is minimised and acoustic panels on the ceiling to reduce reverberation;
- Rainwater will be harvested in large tanks located in the basement; this water will be used for landscape irrigation;
- Waterless urinals will be used to minimise water consumption;
- Solar preheating for domestic hot water;

- Skylights in the central corridor zone with motorised louvers for black out/brown out;
- Energy efficient T5 lamps with electronic ballasts used in all fittings;
- Flexible lighting with sensor controls to ensure the maximum utilisation of natural light;
- Ultra-low brightness diffusers used to minimise glare;
- Roof-top ventilation cowls and low speed fans to allow the economy cycle to be operational when external temperature conditions are suitable;
- Independent controlled air conditioning in each separate space to ensure units are only used when areas are occupied;
- A Variable Refrigeration Flow (VRF) mechanical system comprising fan coil units serves each room connected to central heat recovery air-cooled condensing units. Each space is controlled by a separate unit to provide maximum flexibility and ensure that units are only operating when rooms are in use. VRF fan coil units will provide adequate noise attenuation for classrooms and auditorium functions.

CAMPUS ENERGY MANAGEMENT

Students are taught and quizzed in relation to Figure 2, which shows the breakdown of the Gippsland Campus' energy usage. The pie chart diagram guides students to think how to save energy effectively on the Campus by looking further at the Campus' air conditioning and lighting. Students are taught examples of such savings and how the Campus' preheating/ cooling has been rescheduled to operate an hour before occupation rather than two hours. Also, the heating/cooling for teaching areas on campus is scheduled only when classes are held, rather than the whole day. Consequently, the Campus' operation of heaters and air conditioning systems will be improved, resulting in a considerable saving of energy and greenhouse gases. Therefore, a 3% energy saving is expected at the Gippsland Campus or 126,000 tonnes of greenhouse gases saved annually. Another Campus *going green* example explained to students is that 10% of the Campus' power needs are purchased from renewable sources. This has reduced the emission of approximately 600 tonnes of greenhouse gases per year. Further energy savings examples taught to students include:

- The Campus' external lighting has been upgraded, resulting in energy reductions of 21,000 kW per annum or 31 tonnes of greenhouse gases. This has resulted in improved safety for students, staff and visitors;
- Additional saving is also accumulated by knowing that the Campus' sports field lighting is only turned on when required while the sports field is in use. Students are asked to come up with additional energy saving measures;
- The installation of motion detectors to operate standalone air conditioning in offices by end 2007;
- The installation of light level sensors in the Campus library by end 2007;
- Ad hoc after hours room bookings: areas/rooms are allocated, with minimum energy use areas taking priority;
- Lighting efficiency: de-lamping hallways and replacing lamps with energy efficient T5 tubes is expected to achieve an energy saving of approx 376,200 kW or a reduction of 543 tonnes of greenhouse gases per year;
- Heating systems: all electric hydronic calorifier heating systems on campus have been replaced by gas-fired boilers with an estimated energy savings of 710,000 kWh or a reduction of 1,025 tonnes of green house gases;
- Programme dual set point for heating and cooling by the end of 2007: heating is set on 21° Celsius while cooling is set on 23.5° Celsius;
- Students' attention is brought to the Campus's energy savings pilot programmes for further study, such as solar hot water to be installed in the cafeteria by end 2007;
- Investigation of the operation of boiling hot water units and hot water services to improve efficiency by end 2007;
- The Campus cafeteria kitchen equipment has been upgraded to more efficient gas operations;
- Further water conservation is achieved by refurbishing the obsolete 140,000-litre electric heating tank, which will complement existing water savings on campus.

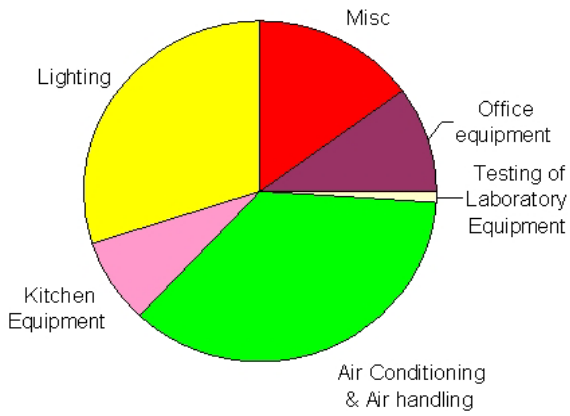

Figure 2: Breakdown of the Campus' energy usage.

CAMPUS WATER MANAGEMENT

Water is the world's most precious resource. Water conservation and management are among the University's top priorities [9]. The University policy on water is discussed with students, including water conservation in the above-mentioned new Campus auditorium building. Students are taught additional Campus measures of saving water such as:

- Flow restriction valves have been installed to all taps throughout the Campus;
- Installation of a 9,000 litre water tank for the washing of fleet and grounds vehicles. This is also used for the washing of all air handling and air conditioning unit filters;
- Harvest of storm water: storm water is being collected and used for toilet flushmeters and other purposes in numerous buildings on campus. A saving of 4.28 million litres of water is expected per annum.

CAMPUS EROSION MANAGEMENT

One of the many teaching examples that students are exposed to is the successful development of Eel Hole Creek Ponds on the Campus (see Figure 3). The project has led to:

- Reduction of erosion;
- Minimisation of nutrient flow downstream;
- Subsequent reduction of blue-green algae outbreaks on downstream water bodies;
- Litter elimination by installing a litter trap.

The Gippsland Campus is located in Churchill. The wider community of Churchill has also benefited through the development of this project.

Figure 3: The Eel Hole Creek Ponds ecology project.

LAND FOR WILDLIFE CAMPUS ACCREDITATION

Students are actively involved in the Gippsland Campus' environmental cultural changes, eg the reestablishment of wildlife on campus under supervision. An extensive native planting programme, focusing on the installation of plants endemic to the Churchill area, encourages birds and wildlife to inhabit the Campus. This programme has resulted in the Campus being awarded *land for wildlife* accreditation.

CAMPUS GREEN PURCHASING

Students are exposed to green purchasing examples such as:

- As part of the green fleet agreement, 1,462 trees are planted *annually* on behalf of Gippsland Campus;
- Hybrid electric/petrol and diesel fuelled vehicles have been purchased as Campus pool vehicles;
- The Campus has applied for additional funding for energy savings and environmental projects in minor works submissions for 2008.

CAMPUS WASTE MANAGEMENT

Students are exposed to recycling examples, for example:

- A garden waste recycling programme has been installed that incorporates an industrial mulching machine. Garden refuse is now recycled as mulch for use on garden beds around the Campus. Mulch breaks down into compost to provide nutrients for plants and saves considerable watering;
- Recycled paper is separated at each workstation;
- Replacement of paper hand towels with energy efficient electric hand dryers in toilets has reduced 1.5 million lineal metres of Campus hand towels going into landfill.

ONGOING CAMPUS NEW SUSTAINABILITY IDEAS

Students are asked to come up with new Campus living sustainability ideas modelled on the following Gippsland Campus initiative: existing external ashtrays have been replaced with environmentally friendly smokers' poles.

DISCUSSION

Because of the Talloires Declaration and UN resolution 57/254, the environmental awareness on college and university campuses around the globe has gained momentum with environmental action on teaching, research, policy formation and efforts to make specific environmental improvements on campuses. Many *stories* have emerged since then [10]. However, the applied *going green* educational technology of the present article emphasises the following message:

> *When teaching* going green *practices, a university should practice as it preaches. In addition,* going green *technology on campus gives students live examples of the very systems they are learning* [10].

This message has been innovatively applied in the present article through the above-mentioned unique relationship between the Campus' Facilities and Services Division, and Civil and Environmental Engineering. Students are exposed to the environmental projects undertaken on the Gippsland Campus from their concept through to completion. Students can readily evaluate and measure the environmental impact, thereby creating a sense of ownership to the significant improvements of the Campus' green identity, adding to students' experiences while studying for their degrees [11][12].

CONCLUSIONS

Monash University's *going green* practice within the Bachelor of Civil and Environmental Engineering allows unique links to be forged between the teaching of the degree programme and the actual *going green* practice of Monash University. This connection results in enormous opportunities for mutual benefits leading to the greening of the Bachelor of Civil and Environmental Engineering, the greening of Monash University's Gippsland Campus, and the greening of cultural changes. This is in line with the vision of the American Society of Civil Engineers of future civil engineering in 2025 [13].

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The effect of the blended Problem-Based Learning method on the acquisition of content-specific knowledge in mechanical engineering

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ABSTRACT: Problem-Based Learning (PBL) on its own has not been very successful in ensuring the learning of content-specific knowledge in engineering. The purpose of this study was to determine the effect of blending PBL and conventional teaching methods on students' achievements in mechanical engineering. The quasi-experimental design method was used with two classes of first year mechanical engineering students who registered for the *Fluid Mechanics I* course at Tun Hussein Onn University of Malaysia in Johor Darul Takzim, Malaysia. The experimental group (n=28) was prescribed the blended PBL method while the control group (n=52) used the conventional method for completing group tasks. A pre-test and two post-tests on selected topics in *Fluid Mechanics I* were administered to both groups before the study in weeks 4 and 11, respectively. The results showed that the mean scores on the achievement tests of the blended PBL group was statistically significantly higher than the conventional group in both instances (weeks 4 and 11) with the effect sizes ranging from 0.56 to 1.1. It was concluded that blended PBL is better at developing content-specific knowledge compared to the conventional method.

INTRODUCTION

It is well accepted that engineers of the future need to develop additional skills to be able to cope with the continuously changing, technologically advanced, socially and politically complex working environments. Thus, besides having a good grasp of basic engineering principles, engineers also need to have additional attributes to be:

- Good communicators;
- Innovative;
- Creative;
- Able to manage people as well as systems;
- Life-long learners;
- Adaptable [1].

Therefore, there is an urgent need for teaching and learning innovations in engineering education to achieve the goals of future engineering education that support not only the need to acquire content-specific knowledge, but also the development of the broad knowledge and skills that are demanded of future engineers. As such the emphasis on Subject-Based Learning (SBL), with the teacher being the centre of learning process, is being replaced or complemented with a more appropriate learning approach.

PROBLEM-BASED LEARNING

Problem-Based Learning (PBL), where the problem is an important element in the learning process, has been attracting much interest from engineering educators' recently due to its potential in promoting the development of wholesome engineers of the future. The PBL method is based on constructivism, which proposes that learning is a process wherein the learner actively constructs knowledge. Learning results from a learner's actions; instruction plays a role only to the extent that it enables and fosters constructive activities [2].

According to constructivist theory, learning occurs as a result of a process where students actively construct their own knowledge from their experiences. Learning occurs when students are able to make connections of new information with knowledge and experiences that they have already assimilated. Learning becomes an act of discovery as students examine the problem, research its background, analyse possible solutions, develop a proposal, and produce a final result.

Knowing about knowing or metacognition, which refers to the ability of knowing how one knows or learns, affects learning. Good students can detect when they understand – or do not understand – new information, and know when to use different strategies to make sense of new knowledge and experiences. They are able to judge the difficulty of problems and assess their own progress in resolving them.

Social and cultural factors affect learning and, therefore, the emphasis is on learning within a context to ensure greater understanding by making connections between learning materials and real-life applications. In PBL, students are dealing with problems that are designed to be as close to real-life situations as possible. The social interaction imposed through PBL (working in groups) is not only instrumental in ensuring that learning occurs, but probably helps in the longer retention of knowledge. In one such study on medical students, the author found that PBL improved learning with effect sizes as high as 0.5; not only that, he also found that medical students who used PBL still retained their knowledge even as long as two years after it was learned [3]. In general, the characteristics of the PBL method appear to provide the right learning experiences that have the potential to develop excellent analytical skills and the ability to deal with complex engineering problems.

In PBL, students learn about contents through challenges in the form of problems relevant to their future practice [4]. This is the opposite of the conventional teaching method that teaches content to help students solve problems. PBL uses the problem to challenge, motivate, focus and initiate learning [5]. In the PBL method, real-life problems that are not defined in engineering terms are posed to students. Therefore, problem analysis, definition and formulation in engineering terms are the critical prerequisites of the problem-solving process [6].

According to Woods, the fundamental difference between PBL and content-based learning or Subject-Based Learning (SBL) is in the starting point of the learning cycle [7]. In PBL, the learning process starts when students are given a problem following which they identify what they need to know in order to solve the problem. In SBL, students are given what they need to know to solve a problem following which they are given the problem.

PROBLEM STATEMENT

Although much support has been found for the efficacy of PBL in developing generic skills, its effect on the learning of content-specific knowledge is not as positive [8]. PBL has caused some students to feel ... *unsure how much self directed study to do and what information is relevant and useful* [9]. Learning the course content was found to be the main challenge and students perceived that they learnt less content in PBL compared to learning in a traditional course [10].

The student-centred nature of the PBL method has also caused frustrations among some students, who have strongly believed that the only way to learn is by … *attending lectures and by listening to faculty* [10]. This study also found that students who were new to PBL required longer periods of orientation to solve problems compared to those students using the conventional method and who received more inputs from their lecturers. Most students tended to have the opinion that the lecturer is the source of knowledge, thus the change from teacher-dependent to self-directed learning requires a change of paradigm which is not something that is easily acquired.

On top of the demand for increased students' efforts to acquire new knowledge and skills, students also need to develop self-assessment skills to monitor their own progress. The inadequacy of PBL in promoting content knowledge developments has been further supported by Kirschner, Sweller and Clark, who provided the theoretical foundations on why minimal guidance as provided in PBL is not effective in learning content-specific knowledge or problem solving [11].

Therefore, according to Savin-Baden, a blended PBL method, where some components of the conventional method are retained, would be more appropriate, especially with learners who are new to PBL where the goal of teaching and learning is to develop competent applications of knowledge in problem solving [12][13]. One such model has been proposed by Fink where conventional components (lectures, tutorials and experiments (laboratory assignments)), are blended with the following PBL components, namely:

- Problem analysis;
- Literature reviews;
- Field studies;
- Group work;
- Problem-solving;
- Reporting [6].

The purpose of this study is to determine the effectiveness of Fink's PBL model on the achievements among mechanical engineering students. The null hypothesis given below was formulated to guide the study:

- Ho: There was no statistically significant difference in the means of test scores between the PBL and the control group.

The independent variable is the teaching method (PBL or conventional teaching method) and the dependent variable is the learning gain operationalised as the score on the achievement test in the *Fluid Mechanics I* course offered at Tun Hussein Onn University of Malaysia in Johor Darul Takzim, Malaysia. The conceptual framework for the study is shown in Figure 1.

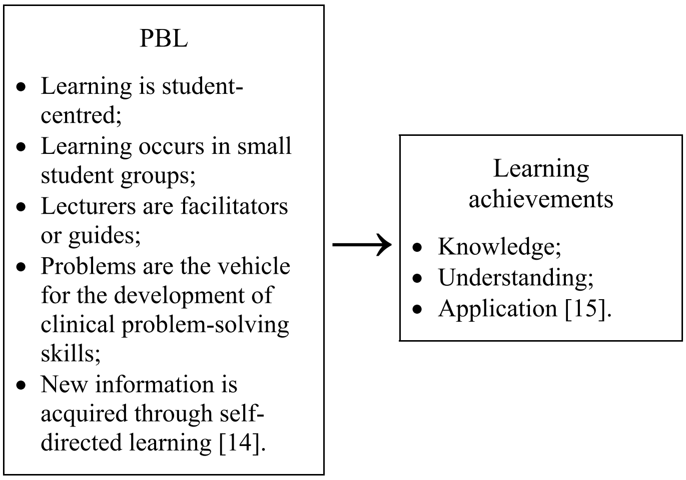

Figure 1: The conceptual framework.

METHODOLOGY

Research Design

The quasi-experimental design method was used with two classes of first year students from the Mechanical Engineering programme at Tun Hussein Onn University of Malaysia who registered for the *Fluid Mechanics I* course as the samples. One group was asked to use a prescribed PBL method (n=28) to complete their group assignments while the other group used the conventional group method (n=52). The two classes were taught by experienced but different lecturers.

Instruments

Three achievement tests, namely pre-test, Test 1 and Test 2, were used to gather data on students' content-specific knowledge of *Fluid Mechanics I*. The items in these tests were designed at the knowledge, understanding and application levels based on Bloom's taxonomy of learning in the cognitive domain [14].

The pre-test consisted of 13 items on the topics of fluids in equilibrium, Test 1 had six items on the same topic and Test 2 consisted of three items on basic equations in fluid mechanics, which is the last topic in the *Fluid Mechanics I* syllabus. These achievement tests were developed by two subject matter experts. A table of specifications was constructed as a planning tool to ensure content validity and standardised marking schemes were developed in order to ensure intra-scorer and inter-scorer reliability.

Procedure

The study was carried out over 11 weeks in duration. Both groups were pre-tested before the intervention to determine their baseline knowledge and skills. Both groups were asked to complete three group tasks: Task 1, Task 2 and Task 3. The pre-test was administered before Task 1. Test 1 was conducted after Task 1 (at four weeks into the semester) and Test 2 after Task 3 (at 11 weeks into the semester).

For the PBL group, the tasks were completed using the following steps:

- Respond to the problems (triggers) – FILA table;
- Generate hypothesis;
- Research – KND chart;
- Problem solving;
- Presentation;
- Documentation;
- Assessment.

The time given for students to complete their tasks was one week for each task. An orientation session was provided to help students familiarise themselves with the PBL method. Students worked in groups of four or five with members of their choice.

The same tasks were also given to the conventional group that worked in groups of four or five members of their choice. The favoured working strategy for the conventional group was to divide a given task among group members and combine their efforts later before submission.

RESULTS

Group Equivalence

The Welch *t*-test was used to compare the means on the pre-test because the samples had an unequal variance as shown by the Levene's test results in Table 3. The pre-test scores of the PBL group ($\bar{x}$=8.77, s=5.92) and the conventional group ($\bar{x}$=8.73, s=3.34) were very similar and not statistically significant at the 0.05 level (p>0.975) as shown in Table 1. Therefore, it can be concluded that at the start of the study, the two groups were equivalent with respect to their cognitive skills.

Table 1: Results of the Welch *t*-test on the pre-test means.

Levene's test		*Welch t*-test		
F	*p*	*t*	*df*	*p*
5.805	0.018	0.032	39.88	0.975

The Effect of PBL on Cognitive Skills

The results of the independent *t*-test on the difference between the mean scores in Test 1 are shown in Table 2. The obtained *p*-value was smaller than 0.05; therefore, the null hypothesis of no difference was rejected. This means there was a statistically significant difference between the mean scores, with the PBL group scoring higher than the control group on Test 1.

An effect size of d=1.113 was obtained using the Cohen method [15]. It was found that 86% of the students in the control group obtained scores below the mean of the PBL group.

Table 2: Results of the t-test based on Test 1.

Group	$\bar{x}$	s	*t*	*df*	*p*
PBL	18.7 (62.3%)	4.80	4.68	78	0.000
Control	13.6 (45.2%)	4.60			

The results of the independent *t*-test on the difference between the mean scores in Test 2 are shown in Table 3. The obtained *p*-value was smaller than 0.05; therefore, the null hypothesis of no difference was again rejected. This means that there is a statistically significant difference between the mean scores, with the PBL group scoring higher than the control group for Test 2.

Table 3: Results of the t-test on long-term learning.

Group	$\bar{x}$	S	*t*	*df*	*p*
PBL	11.2 (56.1%)	5.10	2.29	78	0.025
Control	8.7 (43.4%)	4.50			

The effect size was 0.56 for Test 2. Although smaller in size compared to the effect size in Test 1, according to ref. [16], a size of above 0.50 is considered to be moderately significant. The effect size value of 0.56 shows that the mean of the PBL group is at the 71st percentile of the control group.

DISCUSSION

The consistently higher achievements obtained by the PBL group on cognitive skills is in contrast with Glew and Wood [8][9]. The differing results may be explained in terms of the specific PBL model used in the current study. In the current study, the PBL method was not used to replace the existing method, but rather to complement it. The existing conventional teaching and learning method, namely lectures, laboratory assignments, etc, were still used hand-in-hand with the PBL method.

Such an introduction to the PBL method probably reduces the *cultural shock* that students have often faced when using the PBL method for the first time. Furthermore, the current PBL model may provide greater opportunities to meet students' varied learning preferences. This could be the reason why the students in the PBL group obtained better results on the achievement tests as compared to the conventional group. The meeting of learning style needs is still a hypothesis that remains to be tested in the future.

The effect of novelty is a common problem in teaching and learning studies. Nevertheless, such an effect in some aspects is good, as stated by Hawthorn (in Cohen and Manion): *Put people in a novel situation and observe them and they will work harder (for a time)* [16]. This means any *new item* in teaching and learning will attract attention and become a catalyst for a better result even though only for a short period. However, if the increased achievements in the PBL group were the result of novelty, then the level would have declined steeply after the initial excitement was over, which is not so in this case. The PBL group was still better at week 11, while the conventional group remained at the previous level. This could mean that the PBL method is indeed more effective than the conventional method.

Another major finding from this study is that the learning obtained is not only statistically significant, but also academically significant as the effect size was consistently large (0.56 and 1.11). The large effect size (d>1.0) is not only an indication of the effectiveness of the PBL method, but also indirectly a reflection of how poorly the outcome of the conventional method is because if the conventional group had done better, the observed effect size (d=1.113) would not have been possible. In medical education, for example, where students' performance is generally very good, the effect size obtained rarely reaches above 0.8 [3].

CONCLUSION

In this research, the authors set out to determine if learning effectiveness in engineering can be enhanced by complementing the conventional teaching method with PBL. The data generated supported the conclusion that the learning effectiveness of engineering subject matter content can be enhanced when PBL is used to complement the current teaching method. The findings were not only statistically significant, but also academically significant meaning that the results obtained were worth the effort.

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Humanitarian engineering programme: conceptual challenges

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ABSTRACT: Colorado School of Mines (CSM) in Golden, USA, has created a minor programme in humanitarian engineering. Numerous challenges have surfaced as the programme is being developed. The first and most basic challenge was to define the terminology *humanitarian* engineering and understand the possible implications of the name. One of the early criticisms of the Humanitarian Engineering programme at the proposal stage was the question: *Is not all engineering humanitarian?* The authors believe that specific considerations and awareness are required of the humanitarian engineer that are not generally included and developed within traditional engineering education. An investigation of past humanitarian and humanitarian engineering efforts has revealed that social and cultural constraints are at least as (and perhaps more) important as the technical constraints. The balance of this paper is aimed at supporting these arguments.

INTRODUCTION

The National Academy of Engineers report, *The Engineer of 2020*, calls for educators to prepare engineers for the future *who are broadly educated, who see themselves as global citizens, who can be leaders in business and public service, and who are ethically grounded* [1]. An entire chapter in the report addresses societal, global and professional contexts of engineering. Along with the requirement for firm technical knowledge and skills, the engineer of today and the future must respond to society.

ABET 2000 requires engineering schools to provide a means for students to attain the following:

- *An understanding of professional and ethical responsibility*;
- *The broad education necessary to understand the importance of engineering solutions in a global, economic, environmental and social context*;
- *A knowledge of contemporary issues* [2].

Cooperation with the liberal arts, social science, or humanities sections of universities with the engineering sections is essential to attain the goals. Numerous universities throughout the world work to provide students with a social or cultural context for their engineering education. Examples include the University of Manitoba, Canada [3], Monash University, Australia [4], the University of Porto, Portugal [5], Nihon University, Japan [6], and the University of São Paulo, Brazil [7]. Some universities have taken an additional step, such as Worcester Polytechnic Institute in the UK, which offers a degree programme in Liberal Arts and Engineering [8]. Katehi and Ross, and Lyman summarise the challenge to integrate non-technical skills with technical competences for engineering students [9][10]. Working together in an interdisciplinary environment is essential. At Colorado School of Mines (CSM) in Golden, USA, educators have developed a minor programme in humanitarian engineering as part of their solution to the challenge of forming an engineer for our times. In this article, the authors describe this programme and some of the challenges that have been encountered in the development of this programme.

HUMANITARIAN ENGINEERING AT THE CSM

Colorado School of Mines (CSM) is one of nine universities participating in the Engineering Schools of the West Initiative (ESWI), generously sponsored by the William and Flora Hewlett Foundation. The goal of the Engineering Schools of the West Initiative is to improve the quality of undergraduate education in engineering and increase the number of engineering graduates. The major objective of the CSM project under the ESWI is to create a minor programme in humanitarian engineering. The long-term goals of this Humanitarian Engineering programme are to:

- Create a culture of acceptance, and a value of community and international service activities at the CSM;
- Increase the number of CSM engineering graduates who enter occupations that have a community or international service emphasis;
- Increase the recruitment of women and minority students to the engineering programme at the CSM;
- Increase the number of engineering students who enter internships in community or international service;
- Enhance the social and cultural sensitivity of engineering graduates;
- Attract students with strong aptitudes in mathematics and science, and also a strong interest in working with people (these might not have otherwise considered engineering as a career) [11].

Progress towards these goals, especially in the area of gender diversity, has been made [12][13]. The programme allows students to gain a minor in humanitarian engineering by the completion of a set of liberal arts and humanities classes, a set of humanitarian-designated engineering classes, and a year-long capstone humanitarian engineering senior design project [14][15].

CHALLENGES IN THE ACCEPTANCE OF THE HUMANITARIAN ENGINEERING PROGRAMME

Numerous challenges have surfaced as the programme is being developed. The first and most basic challenge was to define the terminology *humanitarian* engineering. A team of faculty from the CSM Division of Liberal Arts and International Studies, the Division of Engineering and the Engineering Physics Department have developed a working definition and continue to be engaged in further characterising the *humanitarian engineer*:

- *Humanitarian*: to promote the present and future wellbeing for the direct benefit of underserved populations;
- *Engineering*: design under physical, political, cultural, ethical, legal, environmental and economic constraints;
- *Humanitarian Engineering*: design under constraints to directly improve the wellbeing of underserved populations.

The term humanitarian engineering incorporates many of the concepts contained within sustainable development, although sustainable development has broader connotations. There is a new movement to include engineering in sustainable development, as is evidenced at many conferences and a recent book edited by Mulder [16].

Indeed, the multi-departmental faculty team has remained actively engaged in trying to understand the terminology from a historical and societal context. Numerous books and articles have been studied and discussed that provide a history of humanitarianism [17][18]. In addition, the documentation of the experiences of the late Frederick Cuny provides one of the best examples of the modern humanitarian engineer [19]. After his initial experiences as a relief supply pilot, Cuny became absorbed in using his skills and leadership towards helping people in crisis, wherever that might be in the world. He eventually disappeared in Chechnya in August 1995 while trying to help the refugees displaced by the civil war there [20].

In his book, Cuny identified three environments of operation for the humanitarian engineer [19]. The first is *response to emergency*. The words *humanitarian aid* connotes to many a response to help refugees displaced by a natural disaster or armed conflict. However, he also referred to *developmental response* to help meet the basic human needs of the underserved. He also cited *transitional response*, which is an effort he recognised in between the emergency and developmental responses. Cuny claimed that an effective design in emergency response could enhance the progress of the refugee towards an efficient developmental path.

Although it is not the authors' intention to provide a practicum for students in emergency response projects, as this is clearly a task for professionals, it has become clear that if one is working in developmental response, a certain level of trust is developed between the humanitarian engineer and the people he/she is working to help. In the event of an emergency, the engineer will likely be called upon to render assistance [21]. Therefore, the student humanitarian engineer should be prepared, at least through coursework, to face emergency response-type challenges.

Much of what is written about the history of humanitarianism is depressing. At best, there have been failures in delivering aid. At worst, the aid benefits only the wealthy or the unscrupulous [18]. In addition, sustainable development is hard work; it requires significant time, awareness, patience, strong will, knowledge of a foreign language, plus knowledge of the social, cultural and political climate. In addition, the rewards system for faculty to be involved with these types of activities are not generally in place, nor is there appropriate infrastructure within the university to carry on this type of work. One can easily get discouraged and feel isolated or that it is hopeless to have any positive impact.

However, there is reason to be optimistic. For example, Hawken describes the millions of organisations throughout the world where people from all walks of life are working towards a better world [22]. Collaborative opportunities with Non-Governmental Organisations (NGOs) exist to aid the university faculty and students in a project's realisation. Undoubtedly, mistakes will be made, but in the process, people will learn to communicate with one another, yielding renewed hope for a better world.

One of the early criticisms of the Humanitarian Engineering programme that was asked during the proposal phase within the University's Undergraduate Council is encapsulated in the question, *Is not all engineering humanitarian?* This is an important question that has required an education in the history of humanitarianism and engineering to achieve a practical understanding. General faculty acceptance of the idea may indeed hinge on the ability to answer this question.

Historically, engineers have developed infrastructural systems and machines to meet a broad range of needs for the industrialised local human society in which they lived [23]. In fact, there is growing concern about the specialised engineer working within a compartmentalised environment creating technology with little consideration for the impact on humanity as a whole [24]. Within a globalised world, this type of compartmentalisation will not likely contribute to sustainable solutions for our increasingly complex, interdisciplinary problems. Additionally, the humanitarian engineer who works to directly meet basic human needs will necessarily encounter issues of social justice and human rights. Most engineering education is inadequate to prepare students for this type of environment. There are no ethical guidelines to aid the engineer working within this environment. Indeed, significant work remains to prepare students who wish to pursue a career as humanitarian engineers.

CONCLUSIONS AND FUTURE DIRECTIONS

The goals of the Humanitarian Engineering minor programme at Colorado School of Mines have been established and are presented above. The formation of this unique minor programme has resulted in unanticipated challenges that in turn have led to interesting questions. The definition and public recognition of the name, humanitarian engineering, connotes an emergency response, but also includes latitude for sustainable development work and, indeed, the transitional work that may occur between these two activities.

With regard to the question, *Is all of engineering humanitarian?*, the answer is no as the word *humanitarian* refers to one who works towards improving the lives of underserved populations in need of emergency or developmental assistance. The field of engineering is much broader than this. As much as we might like to believe this were the case, there is nothing within the ethical code of engineering that guarantees that justice prevails or that human rights are maintained.

In preparation for the future, the faculty from both the Liberal Arts/Social Sciences and Engineering departments involved with the Humanitarian Engineering programme will seek to develop coursework that helps to prepare students for the emergency response situation, as it is likely that they will be called upon to provide assistance to a disaster.

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Project-Based Learning – analysis and synthesis of mechanisms for awning window linkages

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ABSTRACT: In this article, the authors describe the project-based approach to teaching in the final year of a degree programme at the French Military Academy de St-Cyr in Coëtquidan, France. A project is the usual requirement in the final year of any degree programme in engineering. Since the Academy's training programme combines engineering education with military training, the cadets' preparation for their final year is different to that of students in a non-military university. In the normal system, a typical scenario of a *capstone* final year project is that it should require from the student an element of synthesis to combine knowledge from a few, or several courses in order to solve a particular engineering problem. However, in the case of cadets from the French Military Academy, the demand is not only on the project itself, but also on acquiring the necessary knowledge not covered in taught courses. The authors describe such an experience based on a project carried out by a student from the French Military Academy de St-Cyr in the Department of Mechanical Engineering at the University of Botswana in Gaborone, Botswana. The authors also describe the curriculum of an engineering programme at the French Military Academy de St-Cyr.

INTRODUCTION

A project is the most typical and fundamental requirement in the final year of any degree programme in engineering. It is sometimes called a *capstone* as it should require from the student an element of synthesis to combine knowledge from a few or several subjects in order to solve a particular engineering problem. Normally, it should be a design project or at least should have an element of design. Such a project is a typical requirement for the accreditation of an engineering programme.

However, is such a final year project really Project-Based Learning (PBL)? Although it carries certain elements characteristic of PBL, in reality, it is not full PBL. Students carrying out such final year projects are normally applying knowledge from different areas or courses that they have studied in their curriculum; but do they really acquire new knowledge through performing the project? If they do, then it is quite limited; they normally acquire some additional information on topics they have already studied.

A project is also part of the degree programme offered at the French Military Academy de Saint-Cyr (in full École Spéciale Militaire De Saint-Cyr). This well-known military school was founded in Fontainebleau in 1803 by Napoleon Bonaparte. In 1808, Napoleon moved it to the town of Saint-Cyr-l'École near Versailles. The buildings at Saint-Cyr-l'École were destroyed in 1944 during World War II, and after the war, the Academy was transferred to Coëtquidan in Brittany. Throughout most of its history, Saint-Cyr has prepared officers for the infantry and cavalry, as well as for staff positions within those services, while the École Polytechnique in Paris trained engineers, artillerymen and other technical officers. After World War II, however, the French Military Academy de St-Cyr took over the training of most technical officers.

CURRICULUM AT THE FRENCH MILITARY ACADEMY

The Academy's training programme meets the demands of the classic profile of the St-Cyr officer: to be leaders for the future [1]. The training is based on four tiers: general knowledge, values and beliefs, leadership potential and professional skills. General military training is the basis of officer training and focuses on three areas that are all complementary and interconnected: military conduct training, interdisciplinary academic training, and military and sports training. Interdisciplinary academic training has two distinctive elements: a detailed study of basic subjects that offer an educational background and general training, which provides the key to understanding the current environment. This general training includes subjects from the common core syllabus (like military history, history of international relations, French contemporary society, public law and communication) and specialised subjects depending on the background of each officer (for example human science and law for students in science, economics, statistics for science students).

The normal entry requirement is the completion of the preparatory school or the DES competitive examination. For such candidates, the programme consists of six semesters at the Academy, four based on academic training and two focusing on professional training. Semesters 3 and 4 constitute the elements required for a professional degree – specialised and optional courses in the chosen field of study. The training at the French Military Academy is as follows:

- Semester 1: integration;
- Semester 2: general training;
- Semester 3: specialised courses;
- Semester 4: optional courses;
- Semester 5: international placement;
- Semester 6: autonomy warfare training.

The training courses for cadet officers are recognised on an international level. All cadet officers from the Academy are awarded the St-Cyr Masters degree as cadet officers specialising in science in an engineering degree.

There are three academic departments that offer academic training programmes: the Department of International Relations, Department of Management of Organisations & People and Department of Engineering Science. The academic training programme forms a common core of the military training programme. Courses are taught jointly by the academic department and the Department of Military Techniques and Instruction, and also by outside professionals, a feature that underscores the all-rounded nature of the programme. This includes the following:

- Semester 2 focuses on basic and general knowledge courses that figure in all programmes in the three departments;
- Semester 3 concentrates on each respective specialisation;
- Semester 4 comprises advanced courses/optional courses of study or supplementary courses of study;
- Semester 5 is taken up by the work-placement abroad (duration 12 weeks), as well as preparation work and the completion of the thesis (four weeks).

The academic semester is made up of a 30-hour week. The remainder of the time is given over to sport and unscheduled courses. A 30-hour week (semesters 2 and 4) on average includes 20-24 contact hours plus personal research and self-study time, which brings the total number of hours up to 30.

The cadet officer who graduates in engineering science should possess excellent knowledge in science, be fluent in at least one foreign language (English) and have some experience in an international dimension. There are three specialisations: engineering physics, computing and simulations, and electronics and electromagnetism. Courses in the above streams provide the basis for the engineering project to be initiated in the 4th semester and completed in the 5th semester during the 12-week work-placement abroad. The core and stream courses are presented in Table 1.

THE PROJECT IN THE ENGINEERING CURRICULUM

An engineering project is initiated in the 4th semester and completed in the 5th semester during the 12-week work-placement abroad. The objectives are as follows:

- Involvement in research activities;
- Development of awareness of foreign cultures;
- Improvement of language skills.

The placement takes place in an academic establishment (normally a university or military academy). The work placement abroad takes an estimated 420 hours (considered as contact hours) plus 150 hours for work-placement preparation and completion of the report (considered as personal research and study). As the total number of contact hours for academic courses in the three-year programme is 2,065 (of which 1,347 hrs – 65.2% is dedicated to engineering courses), the project takes 14.5% of the total number of hours and 22.3% of engineering courses hours. That emphasises the importance of the project.

Another indicator of the importance of the project is the fact that its assessment constitutes 15% of the total mark for the programme. The above values of the percentage of time and component of the total assessment for the project is much higher than in ordinary engineering programmes at other universities. Hence, the question arises: why has so much credit been put into the engineering project?

Table 1: Curriculum at the French Military Academy.

Semester	Core Courses	Stream Courses		
		Computing & Simulations	Engineering Physics & Energy	Electronics: Communication & Detection
2	Mathematics (72 h) Physics (75 h). Engineering Physics (39 h) Electronics (31,5 h) Computing (34.5 h)			
3	Mathematics (39 h) Engineering Physics (70.5 h) Computing (75 h) Electronics (85.5 h)	Database design (24.5 h) Object-oriented Programming (49.5 h) Unix (46 h)	Mathematics (30 h) Analytical Engineering Science (40 h) Continuous Media & Theory of Elasticity (30 h) Thermodynamics (20 h)	Mathematics (30 h) Component Physics (22.5 h) Applied Physics Project (30 h) Controls of Electronic Systems (37.5 h)
4		Mathematics (30 h) Networks (30 h) Artificial Intelligence (24 h) Object-oriented Programming (70 h) Database and Project (50,5 h) Information Processing (60 h) Operational Research (34.5 h) Security of Information Systems (76 h)	Resistance of Material (65 h) Method of Finite Elements (60 h) Theory of Machines (70 h) Propulsion (45 h) Ballistics (45 h) Detonics (45 h)	High Frequencies & Antennae (55.5 h) Signal Processing (51 h) Signals & Systems of Communication (72 h) Radio Electric & Optic Connections (45 h) Radar (45 h) Optics, Laser Imaging (69 h) Research Project (37,5 h)

In order to answer the above question, it is necessary to look at the courses taught at the French Military Academy and their duration, and compare them with other engineering degree programmes. The normal strategy in an engineering curriculum is that the primary concern of engineering courses taught during the junior years is to provide students with a thorough understanding of the fundamentals. These courses should normally have strong applied mathematical and engineering science components. Moreover, after a good understanding of the basic principles and laws has been gained, the application of these fundamental principles for the design and analysis of practical problems should be introduced. Design should be introduced in small doses throughout the junior year. In their senior year, students should be heavily exposed to design. The design experience culminates in the capstone design courses in the final year.

How does the above relate to the engineering curriculum in the French Military Academy? The fundamental courses in engineering certainly have the attributes of a normal engineering curriculum. In some cases, the names of the courses may be a bit confusing (the names are quoted from the official documentation of the Academy in English), for example *Engineering Physics* in semester 2 and 4 (see Table 1) should rather be called *Engineering Mechanics* as it combines statics, dynamics, solid mechanics and fluid mechanics. Also course *Theory of Machines* in Semester 4 is actually a course equivalent to *Thermodynamics II* in an ordinary engineering degree programme. Irrespective of the nomenclature and the names of the courses, the fundamentals of engineering science are covered in the programme offered. However, what is really missing from the programme is the students' exposure to design. As the programme is rather short, there is simply no time to allow for design experience. The substitute for this is the engineering project carried out during the work-placement abroad.

EXAMPLE OF A PROJECT

A project with the final title *Analysis and Synthesis of Mechanisms for Awning Windows Linkages* was undertaken by a student from the French Military Academy at the Department of Mechanical Engineering, University of Botswana, from September to December 2006 [2]. The aim of this project was to find the best mechanisms that satisfy the production requirement of awning windows (horizontally opening windows) in Botswana. In order to determine the type and dimension of these mechanisms, different linkages were studied using analysis and synthesis by mathematical and graphical methods, and by the application of two professional software: *Robert's Animator* and *Watt Mechanism Design Tool* (both by Heron Technologies). The linkages for awning windows were compared using three criteria: the existence of toggle positions, the value of the transmission angle and the mechanical advantage. These criteria made it possible to classify the linkage from the mechanical point of view. The costs of production were also considered and finally chosen as the critical criterion in the selection of the mechanism.

Project Statement

The main system of windows used in Botswana is the vertical opening mechanism. This type of window is not the most suitable for Botswana because of the climatic conditions. The normal rainfall in Botswana is a short and very strong storm with a high rainfall in a short period of time. It is also normally accompanied by strong winds. In such conditions, vertical windows allow for rain water to enter inside and they have to support heavy loads due to winds. They also do not allow for the proper use of blinds. A much better solution in such conditions would be an awning window system because it is a horizontally opening mechanism. Currently, such windows are not available on the Botswana market, although they are the most popular type of windows in North America (over 5 million are sold annually in the USA and Canada). The aim of the project was to find an opening linkage that would have good mechanical properties and be easy and cheap to manufacture.

Awning Window

Awning windows are windows with a horizontal opening system where the window stays completely outside while it is opened. Usually, the window is composed of two linkages (one on the left and another on the right) and a lifting system to help the operator. When this type of window is used on a vertical wall, the main advantage is the protection of the room against bad weather and dust. Secondly, when these windows are used on roofs, the advantage is the simplicity of opening and closing. An example of an awning window is shown in Figure 1.

Figure 1: An awning window.

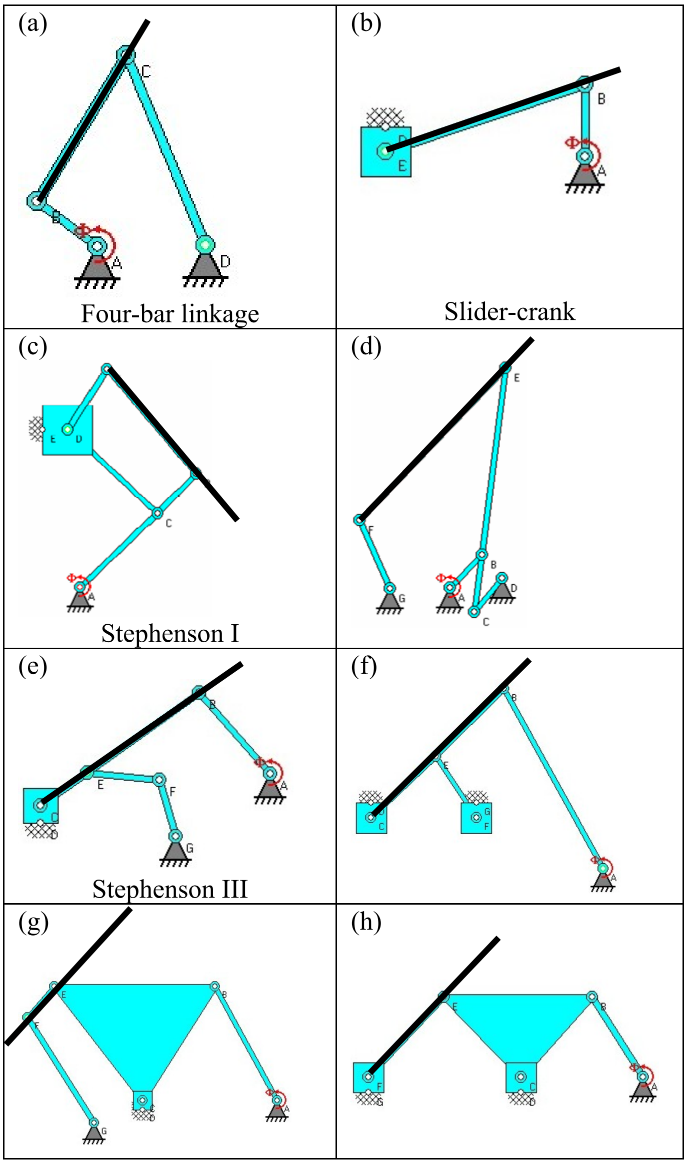
Design Constraints

For the purpose of the project, the only constraints considered were those concerning the linkages as follows:

- The window must open more than 45° from the sill;
- The end of the sash must slide in order to allow for washing on both sides of the window from the inside;
- The linkages must have one degree of freedom;
- The transmission angle of a new hinge must be between 40° and 140°.

Linkages must be as simple as possible due to economic considerations (pin and slider joints are preferred over gear and cam connections). Originally, there were eight linkages considered for the window mechanism. They are presented in Table 2 (the black solid lines indicate the position of the window sash). All had one degree of freedom with either four or six links. Based on the preliminary analysis, the last four mechanisms were discarded mainly because they would be difficult to manufacture. The remaining four linkages were designed in order to satisfy the window requirements. For simpler mechanisms (four-bar and slider-crank), the *MATLAB* procedure for the motion generation was developed based on an analytical method [3][4]. For the more complicated linkages (Stephenson I and Stephenson III), the synthesis was achieved using *Watt* software [5].

Table 2: Possible solutions for the window mechanism.



Synthesis Results

The designed linkages were compared in terms of their transmission angles, mechanical advantage, the existence of the toggle point and the force index.

The example of the results for transmission angle is presented in Figure 2 and the mechanical advantage in Table 3. The analysis of the mechanism was carried out using *Robert's Animator* [5].

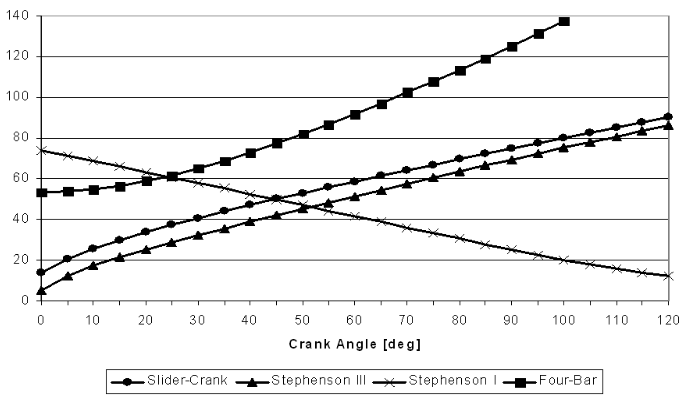


Figure 2: Transmission angle of the selected mechanisms.

Table 3: Mechanical advantage of the selected mechanism.

Crank Angle	Mechanical Advantage			
	Slider-Crank	Four-Bar	Stephenson III	Stephenson I
5°	7.16	1.82	2.68	1.68
20°	1.68	1.19	1.68	0.94
40°	0.84	0.34	1.25	0.95
60°	0.87	0.33	1.09	
90°		1.25	1	

From the mechanical point of view, the best mechanism is the Stephenson III; it has no toggle position, and the value of the transmission angle is always between 50° and 115°, which is the best range of the four mechanisms [6][7]. Finally, the value of the transmission angle in the mechanism is between 1.61 and 3.79, which shows that for a given input force, the output force is always greater. The second mechanism is the Stephenson I. Its advantage is a useful toggle position when the window is closed. The range of the transmission angle and the mechanical advantage are less suitable. The third mechanism is the slider crank. This mechanism has a useful toggle position that will lock the window. The values of the mechanical advantage is just less than the Stephenson I when the window is open at an angle of more than 40°. The least suitable is the four-bar linkage because of the very low values of mechanical advantage.

However, as the aim of the project was to find the best design for an awning window for production in Botswana, a compromise between mechanical performance, simplicity and cost of production had to be found. Therefore, the Stephenson I and III were discarded as not suitable for production in Botswana as they are more complicated in terms of manufacturing compared to the simple four-bar or slider-crank mechanism. Of the remaining two simple mechanisms, a slider-crank has been selected as the better of the two from the point of view of its mechanical properties. Also, since the slider could move along the sill, it would, therefore, support the weight of the window [8]. However, there are some restrictions on the use of this mechanism for awning windows; firstly there would still be a torque required on the sash to close it from a 90° position. Also the crank (link AB) could not be used effectively as an input link since the transmission angle is 0° in the open position. The slider (link BE) would also not be suitable as an input link since the transmission angle is 0° in the closed position. Therefore, the only solution would be to use the sash as the input link.

Stress Analysis

The stress analysis for the slider-crank linkages used as a window mechanism was carried out using the finite elements method. The software used was *RDM 6*, which gave the value of the Von Mises stress in the sections of each link. Three different types of materials were used in the stress analysis: copper, steel 335 and AU4G aluminium.

Figure 3 shows window in the 60° opened position; it is considered that the window and the links do not move. The size of the element for the window frame was assumed to be 10 mm x 10 mm (element A1B1). It shows also the stress distribution in the frame and in element A1B1 for steel 335. The analysis proved that both aluminium alloy AU4G and steel 335 can be used for the window mechanism as the maximum stresses in both cases were lower than the elastic limit of both materials.

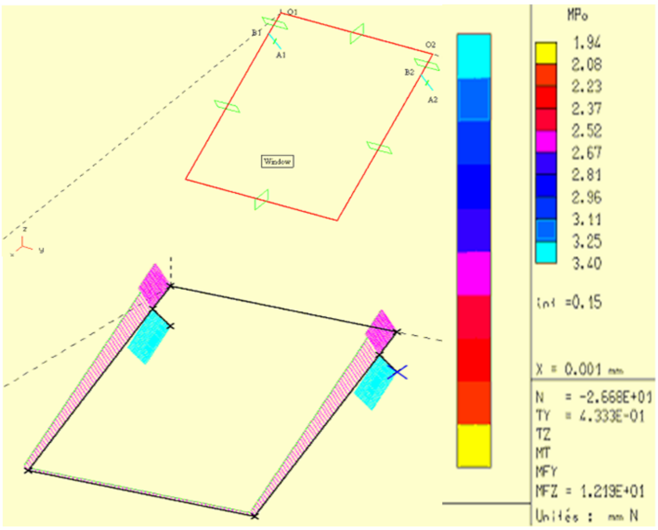


Figure 3: Stress analysis in the window.

Due to the climatic conditions in Botswana with high temperatures in summer and high humidity during the rain season, the aluminium alloy would be the ideal material for the window frames. The only factor that could lead one to choose steel rather than AU4G is the manufacturing cost, as steel is five times cheaper than aluminium.

Project Findings

Five linkages were originally compared using three criteria in order to establish which one would be the best design for an awning window from a mechanical point of view. The criteria for comparison were toggle positions, transmission angle and mechanical advantage.

Based on these three criteria, the mechanisms under consideration were classified in order to find the best of them. After considering the costs of production, the best mechanism from the mechanical point of view was not selected because of its complexity to manufacture. Instead, two less efficient but easy to manufacture mechanisms were chosen. Then, the calculation of the transmission of the external force applied to the window was carried out so as to determine the quality of these mechanisms. Finally, a stress analysis was conducted using the finite element method to determine the required strengths of the elements.

CONCLUSIONS

Project-Based Learning (PBL) is to be an efficient method to acquire new knowledge. It requires students to utilise all of their skills in order to answer driving questions. They must research, collect data, interview and adapt information in order to present a possible solution to the presented problem. It helps students to gain a proper understanding and remember new information as students tend to remember things that they have experienced or had to research on their own, because it feels like it is their own question, not just one presented during class [9].

The following are primary features of PBL:

- It is student-centred in that the topic of the project is an authentic assignment from the discipline, which would be relevant and meaningful to students' interests;
- Teaching through skills: students learn the content as they try to address a project;
- It is process-centred (more than product-centred) as the ultimate goal of learning is not about finding the best answer to a question but rather to train students to learn through the process of problem solving, ie thinking steps, research topics, development plans, etc;
- It is group-based in that the majority of the learning process takes place in groups or teams;
- It is experiential as students experience what it is like to think as a practitioner of a particular discipline.

Without doubt, all the projects undertaken by students at the French Military Academy in semester 5 during their international placement fulfil all but one of the features of PBL. The only feature of PBL not fully satisfied in the project was the fact that it was not group-based. However, even that feature had been addressed to some extent, mainly because of the specifics of the international placement. Since students are placed in different institutions in different countries, there are normally only a few of them allocated to the particular organisation, thereby creating a natural group of students who normally discuss projects between themselves. The other features of PBL are addressed through the realisation of the project. In the particular case of the awning window design, the student was allocated a practical and authentic assignment in an area of mechanical engineering that he was not very familiar with. Through that context, he had to study and learn analysis and synthesis of planar linkages, use that knowledge to design a mechanism for particular needs, and analyse it in terms of positions, kinematics and also kinetostatics. The above was achieved using graphical and analytical methods and also with the help of software that the student had to learn. He also learnt how to perform a stress analysis using the particular finite element software.

The goal of the project was always to train the student in certain aspects of mechanical engineering and not to find the best overall design for the mechanism. The latter was a secondary goal to fulfil the student's own satisfaction.

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10th Baltic Region Seminar on Engineering Education: Seminar Proceedings

edited by Zenon J. Pudlowski

The successful *10th Baltic Region Seminar on Engineering Education* was conducted at the University of Szczecin, Szczecin, Poland, between 4 and 6 September 2006. The Seminar attracted participants from 18 countries worldwide. Just under 40 papers have been published in this Volume of Proceedings, which include an informative Opening Address about the UICEE European Headquarters and its involvement with European engineering education, plus various Lead Papers. All of these published papers present a diverse scope of important issues that currently affect on engineering and technology education at the national, regional and international levels.

The paramount objective of this Seminar was to bring together educators from the Baltic region to continue dialogue about common problems in engineering and technology education under the umbrella of the UICEE. To consider and debate the impact of globalisation on engineering and technology education within the context of the recent economic changes in the Baltic region, as well as the increasing importance placed on fostering students' entrepreneurship skills, were also important objectives of this Seminar. Moreover, the other important objectives were to discuss the need for innovation in engineering and technology education, and to establish new links and foster existing contacts, collaboration and friendships already generated in the region through the leadership of the UICEE.

The papers incorporated in these Proceedings reflect on the international debate regarding the processes and structure of current engineering education. They are grouped under the following broad topics:

- Opening address
- New trends and approaches to engineering education
- Specific engineering education programmes
- Simulation, multimedia and the Internet in engineering education
- Education and training for engineering entrepreneurship
- Innovation and alternatives in engineering education
- New developments and technologies in engineering education
- Quality issues and improvements in engineering education

It should be noted that all of the papers published in this volume were subject to an international formal peer review process, as is the case with all UICEE publications. As such, it is hoped that these Proceedings will contribute to the international debate in engineering education and will become a source of information and reference on research and development in engineering education.

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Applying the dynamics of the pendulum to the design of a playground swing

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ABSTRACT: In teaching mechanics courses, it is common practice to neglect nonlinear terms that arise in derivations. The reason used to justify this is that such approximations are adequate for small deformations. However, it is seldom clear how small is *small* or how large the maximum error is likely to be. The errors incurred by neglecting such terms are illustrated in this paper by taking the results of the dynamics of the pendulum and applying them to the design of a playground swing in a city park. The dynamic forces that arise during the operation of a swing are determined under the conditions of small angles and under those of large angles. The resulting forces are compared to see the effect of nonlinearity. Forces in the cables that support the seat of the swing are shown to be smaller when computed using the linearised equation of motion than those obtained from the nonlinear equation itself and the discrepancy between the two results increases with the magnitude of the initial angle that is given to the swing. The effect of this discrepancy on design is that the moments and forces used to design the beam and fasteners that hold the seat of the swing in place are underestimated significantly by linearising the driving force. The extent to which these forces are underestimated is quantified.

INTRODUCTION

The motion of a pendulum is studied in many college courses. These include college physics, ordinary differential equations, dynamics, controls, vibrations and acoustics. However, in all these cases, the differential equation that describes this motion is linearised by assuming that the amplitude of oscillation is small. As a consequence, students do not see how the oscillation of a pendulum is affected by large amplitudes of motion; nor do they know the limits of applicability of the linearised solution they have studied. It turns out that, up to angles of 30°, the period of oscillation obtained from the linearised equation is accurate to within 5%. However, in order to achieve this same accuracy, the angles of swing obtained from solving the linearised equation must be kept below 10° [1].

Observations of children in local city parks revealed that a child on a swing can cause it to move through angles that can be as large 90° from the vertical. Thus, to be realistic, the design of a swing requires the consideration of a nonlinear effect because the angles of swing involved exceed those that are required to make the linearisation of the equation of motion valid.

Oscillations of a pendulum that include large amplitudes have been studied for the purpose of comparing them to those for small amplitudes [1]. It is known that in both cases, the angle of a swing is a periodic function of time. For small angular displacements, the period of oscillation is a constant and the ensuing angle of swing can be represented accurately by means of circular functions. However, for large amplitudes, the period is represented by Jacobi's complete elliptic integral of the first kind and varies with the initial amplitude, while the corresponding angle of swing is represented by elliptic functions of Jacobi. It was demonstrated that the period of the linearised motion is always smaller than, or equal to, that from the nonlinear motion and that, as a general rule, it is inaccurate to use the magnitude of the error made in approximating $\sin\theta$ with θ as an estimate of the accuracy on how well the linearised solution approximates the exact motion [1].

In this article, oscillations of a swing are used to compute the forces that arise during the operation of a swing under conditions of small angles and those of large angles. The results are then compared in order to assess the errors induced in the magnitude of the forces by neglecting the nonlinear effects.

THE BASIC EQUATIONS

Consider a rigid body that is suspended from a point O about which it oscillates freely in the vertical plane. Let the angular displacement about the vertical axis be denoted by θ, measured in radians. After applying Newton's second law of motion in polar coordinates, we obtain two equations of motion. Using the equation of motion in the tangential direction, we find that the angle θ can be obtained by solving the equation [1]

$$\ddot{\theta} + \omega_n^2 \sin(\theta) = 0. \tag{1}$$

In general, the conditions at the starting time, $t = t_s$, are given by [1]:

$$t = t_s, \theta(t_s) \equiv \theta_s, \dot{\theta}(t_s) \equiv \dot{\theta}_s. \tag{1a}$$

In these equations, the dots represent differentiation with respect to time t and the quantity ω_n, which has units of rad/s, is related to the natural frequency of the system.

As an example, for a compound pendulum swinging in the vertical plane about a horizontal axis that goes through point O,

$$\omega_n \equiv \sqrt{\frac{m_{total} g d}{J_0}} \tag{1b}$$

where, m_{total} is the total mass of the pendulum; g is the acceleration of gravity; d is the distance between point O and the centre of mass of the pendulum; and J_0 is the (polar) mass moment of inertia of the body about point O. It can be seen that ω_n is a physical parameter that is independent of time [1].

By applying Newton's second law of motion in the radial direction, the force of tension in each cable that connects the seat of the swing to its support is found to be given by:

$$T = \frac{mg}{2}(\cos\theta + \frac{1}{\omega_n^2}\dot{\theta}^2)$$

When the pendulum is at rest, each tension is equal to half the weight of the child using the swing. In order to be able to compare the dynamic tension to this static tension, one uses a dimensionless ratio of the two forces, as shown below.

$$\frac{T}{\left(\frac{mg}{2}\right)} = \cos\theta + \left(\frac{\dot{\theta}}{\omega_n}\right)^2 \tag{1c}$$

The objective is to solve Eq. (1) by assuming small angular displacements and again by assuming displacements of arbitrary size. Then, by using the results so obtained to compute and compare how the force of tension expressed in Eq. (1c) is affected by the magnitude of the initial displacement of the pendulum, one obtains a means for determining the effect of linearising the differential equation on the force that is actually applied to the supports that hold the swing in place.

THE CASE OF SMALL ANGLES OF SWING

For small amplitudes, it is conventional to linearise Eq. (1) by expanding the sin θ into a power series as shown below.

$$\sin(\theta) = \theta - \frac{\theta^3}{3!} + \frac{\theta^5}{5!} - \frac{\theta^7}{7!} + \cdots + \frac{(-1)^n \theta^{2n+1}}{(2n+1)!} + \cdots \tag{2}$$

and replacing the sin θ with θ, the first term in that series.

Doing so gives:

$$\ddot{\theta} + \omega_n^2 \theta = 0 \tag{3}$$

This is the equation that is used in all the courses mentioned above**.** Its solution is:

$$\theta(t) = A\sin(\omega_n t) + B\cos(\omega_n t) \tag{4}$$

In this case, ω_n is the circular frequency of the motion expressed in radians per second.

After the initial conditions given in Eq. (1a) are used in Eq. (4), the constants A and B are found to be given, respectively, by:

$$\begin{aligned} A &= \theta_s \sin(\omega_n t_s) + \tfrac{\dot{\theta}_s}{\omega_n}\cos(\omega_n t_s) \\ B &= \theta_s \cos(\omega_n t_s) - \tfrac{\dot{\theta}_s}{\omega_n}\sin(\omega_n t_s) \end{aligned} \tag{5}$$

However, in order to obtain a solution with a simple mathematical form, it is conventional to let α be the maximum amplitude of oscillation and set $t_s \equiv 0, \theta_s \equiv 0, \dot{\theta}_s \equiv \omega_n \alpha$. Incorporating these assumptions into Eq. (5) leads to $A = \alpha$ and $B = 0$; and Eq. (4) becomes:

$$\theta(t) = \alpha\sin(\omega_n t) \; . \tag{6}$$

Here, the period of oscillation, τ_n, is related to the circular frequency, ω_n, by:

$$\tau_n = \frac{2\pi}{\omega_n} \tag{6a}$$

Using Eq. (6), the tension in the swing cable expressed in Eq. (1c) becomes:

$$\frac{T}{\left(\frac{mg}{2}\right)} = \cos\theta(1 + \alpha^2\cos\theta) \cdot \tag{6b}$$

THE GENERAL CASE OF ANY ANGLE

When swinging angles may be large, Eq. (1) is transformed into Jacobi's elliptic integral of the first kind by two successive integrations and a change of variables [1]. The exact solution to Eq. (1) is found to be [1]:

$$\theta(t) = 2\,Arc\sin\left[\sin\left(\frac{\alpha}{2}\right) sn(\omega t)\right], \tag{7}$$

where sn(ωt) denotes the sine amplitude of ωt, a Jacobi's elliptic function with the elliptic modulus suppressed [4-9].

The elliptic functions of Jacobi are defined as inverses of Jacobi's elliptic integral of the first kind [4-9]. Thus, if one writes:

$$u = \int_0^{\phi} \frac{d\phi}{\sqrt{1 - k^2\sin^2(\phi)}},$$

then, for example, the sine amplitude $sn(u,k) = \sin(\phi)$, the cosine amplitude is $cn(u,k) = \cos(\phi)$, and the delta amplitude is $dn(u,k) = \sqrt{1 - k^2\sin^2(\phi)}$, where the parameter k is related to the maximum angle of swing by $k^2 \equiv \sin^2\left(\frac{\alpha}{2}\right)$.

It will be necessary to incorporate Eq. (7) into Eq. (1c) in order to obtain a general expression for the tension in the swing cable. This process requires finding the derivative of Eq. (7).

The derivative of the function θ(t) with respect to time is obtained using the following standard results from differential calculus [2-9]:

$$\frac{d}{dt}\sin^{-1} u = \frac{1}{\sqrt{1-u^2}}\frac{du}{dt}, -\frac{\pi}{2} < \sin^{-1} u < \frac{\pi}{2}$$

and

$$\frac{d}{dx} sn(x) = cn(x)dn(x)$$

With the aid of these results, it is easy to verify that the instantaneous angular speed of the pendulum is given by:

$$\frac{d\theta}{dt} = \frac{2\omega \sin\left(\frac{\alpha}{2}\right) cn(\omega t) dn(\omega t)}{\sqrt{1-\sin^2\left(\frac{\alpha}{2}\right) sn^2(\omega t)}}, -\frac{\pi}{2} < \sin^{-1} u < \frac{\pi}{2}. \quad (8)$$

Using the results of Eqs. (7) and (8) into Eq. (1c), the general expression for the tension in each cable that holds the seat becomes:

$$\frac{T}{\left(\frac{mg}{2}\right)} = \cos\left\{2 Arc\sin\left[\sin\left(\frac{\alpha}{2}\right) sn(\omega t)\right]\right\} + \left[2\sin\left(\frac{\alpha}{2}\right) \frac{cn(\omega t) dn(\omega t)}{\sqrt{1-\sin^2\left(\frac{\alpha}{2}\right) sn^2(\omega t)}}\right]^2 \quad (9)$$

COMPARING THE ANGLES OF SWING

A graphical comparison of the angles of swing obtained, respectively, from the nonlinear and linear equations is shown in Figure 1. Six starting angles were chosen; and, for each, a solution was obtained using the linearised equation and another with the nonlinear equation. The initial angles used were α ≈ 10°, 30°, 60°, 90°, 120° and 150°. Plots of the corresponding variations of the angular positions of the pendulum with time are shown, with the solid lines representing the linear solution and the dashed lines the nonlinear (exact) solution [1][10][11].

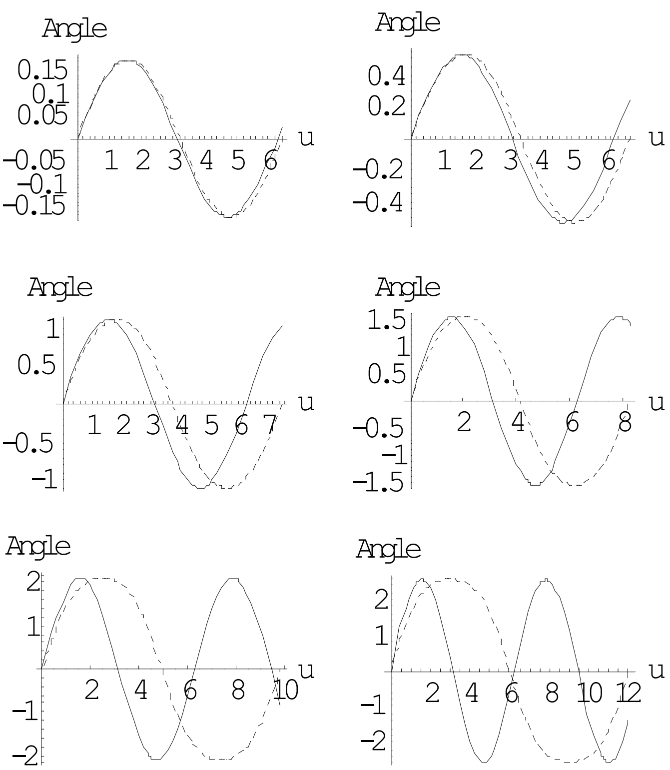

Figure 1: Swing angle vs. time, for α =10°, 30°, 60°, 90°, 120° and 150°. Solid lines show the approximate solution), while dashed lines show the exact solution [1].

COMPARING THE FORCES IN THE CABLE

Variations of the forces in the cable with the position of the pendulum were obtained from the nonlinear and linear equations, respectively, and are compared graphically in Figure 2 by using six starting angles: $\alpha = \frac{\pi}{6}, \frac{\pi}{4}, \frac{\pi}{3}, \frac{5\pi}{12}, \frac{\pi}{2}, \frac{7\pi}{12}$, where the solid lines represent the *linear* (approximate) solution and the dashed lines the *nonlinear* (exact) solution.

From Figure 2, it can be seen that, as the initial amplitude α increases, so too does the discrepancy between the corresponding periods of motion and tensions in the cables that hold the seat.

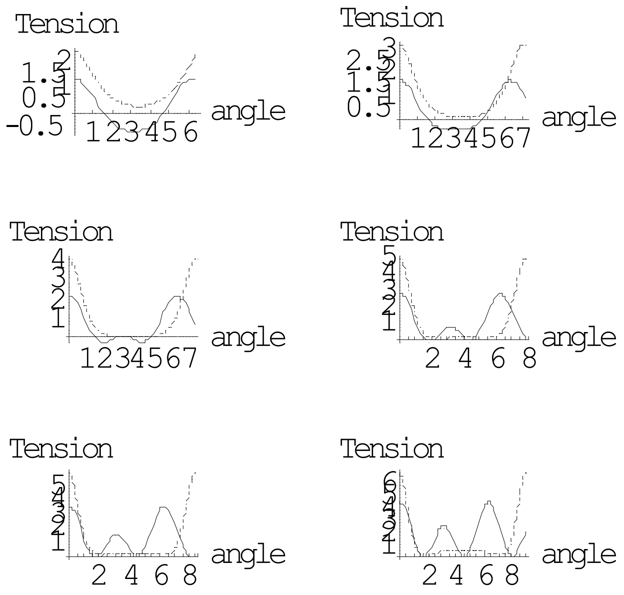

Figure 2: The tension in each cable that holds the seat. Eq. (6b, solid line) and Eq. (9, dashed line) are plotted over one complete cycle of the nonlinear solution. The initial angle α is a parameter ($\alpha = \frac{\pi}{6}, \frac{\pi}{4}, \frac{\pi}{3}, \frac{5\pi}{12}, \frac{\pi}{2}, \frac{7\pi}{12}$, respectively).

Furthermore, for any initial angle, the maximum tension in each cable is reached when the swing hangs vertically under its supports (θ = 0). From Figure 2, it is clear that the linearised equation of motion underestimates the maximum tension in the cable at this point. The maximum tensions at θ = 0 were compared by computing their ratios as a function of the starting angle α.

The tension from Eq. (9) was divided by that obtained from Eq. (6b) and the result is illustrated in Figure 3. It is evident that the linearised equation underestimates the maximum tension in the cable and that it can do so by as much as 95%.

To demonstrate that, generally, underestimation of the magnitude of tension is a pattern that holds true for many positions of the swing besides θ =0, the ratio of the tensions is computed at a variety of locations of the pendulum. The results are plotted in Figure 4, for different positions of the pendulum.

It can be seen that each ratio is larger than unity, indicating that the tension from the nonlinear equation is larger than that from the linear equation. It can also be noted that, while all maximum tensions occur at one specific location of the pendulum, such is not the case for the ratio of tensions.

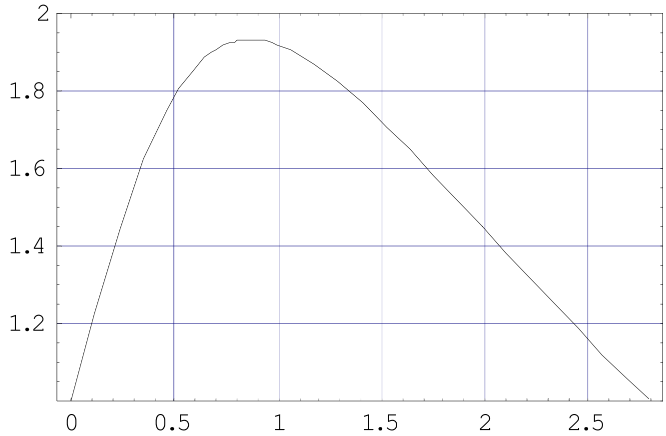

Figure 3: The ratio of maximum tensions in each cable was computed using Eq. (6b) and Eq. (9). Its variation with the initial angle α is plotted here. The maximum ratio was found to be 1.95 and occurred when the initial angle was α = 0.85 radian.

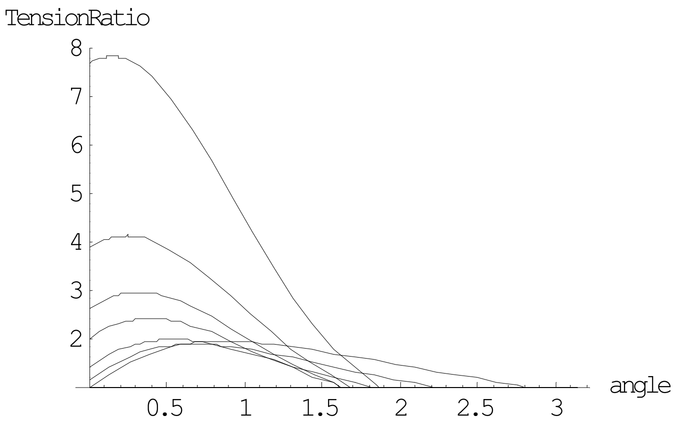

Figure 4: Each curve is a plot of the ratios of tensions in the cable, computed by dividing Eq. (9) by Eq. (6b), vs the initial angle α, assuming a fixed position of the pendulum. The positions used are: $\omega_n t = 0, \frac{\pi}{6}, \frac{\pi}{4}, \frac{\pi}{3}, \frac{4.5\pi}{12}, \frac{5\pi}{12}, \frac{5.5\pi}{12}$.

CONCLUSIONS

It has been shown that the approximation $\sin\theta \approx \theta$, which is used to linearise the differential equation for the motion of the pendulum, introduces the following three kinds of errors in the kinematics of the motion:

- The magnitude of the period of oscillation;
- The magnitude of the swing angle;
- The phase of motion of the pendulum.

These errors were determined exactly and represented graphically [1].

A fourth error that is related to the dynamics of motion is identified in this paper and its magnitude estimated. The dynamic forces that arise in the supporting cables during the operation of a swing are determined under conditions of small angles and under those of large angles.

When the results are compared, one finds that the forces in the supporting cables that are computed based upon the linearised equation of motion are smaller than those obtained using the nonlinear equation itself and that the corresponding discrepancy increases with the magnitude of the initial angle given to the swing.

The effect of this discrepancy on design for strength and reliability is that the moments and forces that are used to design the beam and bolts that hold the seat of the swing are underestimated significantly when the driving force is linearised. Numerical experimentation indicates that, as a rule of thumb in design, forces computed using linearised motion must be increased by 100% in order to account for the effects of errors introduced by the linearisation of the governing differential equation of motion.

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Developing the research aptitude in senior year manufacturing engineering students

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ABSTRACT: This article chronicles experiences with individual research-paper projects in teaching a senior level course on *Polymer Properties and Processing* to manufacturing engineering majors. The course exposes students to current trends in the plastics and composites industry as a means of preparing them for graduate study. Accordingly, in this course, rather than assigning team-based projects, research paper topics were assigned on an individual basis. Independent research activity develops the research aptitude early in the career, prepares students for graduate studies, develops independent thinking, and makes students responsible for their learning. Students were systematically prepared for taking up this research paper activity by means of a proper selection of topics, research laboratory demonstrations and plant tours. Students prepared a 10-12-page research paper and delivered a 10-minute presentation. The output of this activity has been very encouraging. Out of 10 students, three have accepted jobs at Toyota, Chrysler and Boeing, and are committed to graduate studies. One student is working as a research assistant and has co-authored two conference papers in the bio-based composites area. In this article, the authors detail the pedagogy and the research paper activity.

INTRODUCTION

Manufacturing Engineering is a relatively new and small programme that started in 2000 at the School of Engineering at Texas State University, San Marcos, USA (see Table 1). The *hands-on* curriculum includes laboratory experiences in Computer-Aided Design (CAD), Rapid Prototyping (RP), robotics, microelectronics manufacturing and computer integrated manufacturing. The Manufacturing Engineering programme is scheduled to undergo ABET accreditation in autumn 2008. Companies such as Toyota, Chrysler, Northrop Grumman, Boeing, National Instruments, etc, have hired graduates from this programme.

Table 1: The enrolments and number of graduates in the BS in Manufacturing Engineering at Texas State University.

	2006	2005	2004
Enrolments	93	75	79
No. of Graduates	18	17	14

Although the curriculum emphasises *hands-on* and team-based learning, it does little formally by way of preparing students for graduate studies. The School is in the process of collecting data pertaining to the number of students enrolled for graduate studies, but this number is very small. Secondly, the major thrust in the present manufacturing curriculum is towards metallic materials and processes. Majors in manufacturing engineering have very limited knowledge of plastics and composites. This fact was revealed while teaching other courses like Computer-Aided Engineering [1].

The course of *Polymer Properties and Processing* was offered for the first time in spring 2006. In this course, rather than assigning team-based projects, research paper topics were assigned on an individual basis. The intent of the research paper was that it would serve as a major learning tool. The students were systematically prepared for taking up this activity. Demonstrations were organised in the chemistry laboratory on polymer characterisation techniques, including Gel Permeation Chromatography (GPC), Thermal Gravimetric Analysis (TGA) and Dynamic Mechanical Analysis (DMA). Plant tours were organised to expose students to different plastics and composite manufacturing processes.

Manufacturing Engineering majors are required to take two electives from the manufacturing processes group, which contains five courses. The *Polymer Properties and Processing* course is one of those five options. Ten students enrolled for the course. Considering the total enrolment in the Manufacturing Engineering programme and the fact that the course was offered for the first time, 10 students constituted a good enrolment. Students had the prerequisite knowledge gained from the *Materials Engineering* and *Materials Selection and Processes* courses. Topics in the course were selected so that they would help students in their research papers. The topics in the course were selected from two different texts and are as follows:

- Polymer Materials – Molecular Structures, Microstructures and Polymerisation;
- Characterisation, Applications and Manufacturing of:
    - Thermoplastics;
    - Thermosets;
    - Polymer Matrix Composites (PMC).
- Environmental Aspects of Plastics and Composites;
- Introduction to Bio-Based Composites and Nanocomposites [2][3].

TEACHING STRATEGY

This course was taught twice a week for one hour and 15 minutes. It was a combination of lectures, videos, plant tours and research laboratory visits. Three plant tours and one research laboratory visit was organised. Ten videos were shown and discussed in the class.

The following polymer characterisation techniques were demonstrated in the Polymer Chemistry laboratory; these techniques were briefly explained in the class prior to the visit:

- Dynamic Mechanical Analysis (DMA) for the viscoelastic behaviour of polymers;
- Gel Permeation Chromatography (GPC) for the evaluation of molecular weight;
- Thermal Gravimetric Analysis (TGA) for evaluating mass loss.

The three plant tours were organised in the local industry in San Marcos, specifically:

- Stellar Plastics: injection moulds and injection moulding [4];
- Flex-Tech Hose & Tubing: extrusion [5];
- CFAN: manufacturing of *carbon/epoxy composite fan blades* for jet engines [6].

For better understanding, videos on manufacturing processes were showed in the class. These videos have been prepared by the Society of Manufacturing Engineers. Detailed notes were provided before showing a particular video. Students were asked to read through these notes before watching the videos. By this method, students would watch each video carefully and not divert their attention by writing notes. Table 2 explains the schedule on a weekly basis pertaining to teaching, plant tours, laboratory visits and research paper activities.

PLANT TOURS

Plant tours were regarded as a major learning source for the research paper activity. Students had the opportunity to talk to researchers, engineers and management personnel in order to understand the importance of a research aptitude in their career. All the plants visited engaged themselves in solving challenging problems and were not merely production shops.

Research Laboratory Visit: Institute of Environmental and Industrial Science (IEIS)

The Institute of Environmental and Industrial Science (IEIS) at Texas State University has a state-of-the-art laboratory for polymer characterisation consisting of DMA, TGA and GPC [7]. Students were demonstrated DMA, TGA and GPC techniques. Also, some of the current research activities in the IEIS, such as bullet-proof, self-healing polymers; polymer nanocomposites; and bio-based resins, were discussed. Students were inspired by watching graduate students and researchers in action.

Plant Tour 1: Stellar Plastics

Stellar Plastics develops specialty injection moulds for reputed firms such as Dell and Toyota [4]. The President and Vice-President of the company accompanied students during their tour. They provided insights on designing with plastics components. Many challenging injection moulds were exhibited. Stellar Plastics also engages in the regular production of injection-moulded parts. Students were able to watch the entire cycle of part production on injection-moulding machines.

Table 2: The schedule of activities on a weekly basis.

Lecture Topics	Video	Plant Tour	Research Paper
Stage I: Polymer Properties and Characterisation (weeks 1-3)			
1. Polymer materials: molecular structures, microstructures and polymerisation 2. Mechanical, chemical and physical properties 3. Basics of polymer characterisation: DMA, GPC and TGA	1. Introduction to plastics	1. Research laboratory: demonstrations of DMA, GPC and TGA	1. Introduction to research paper activity: 3rd week
Stage II: Thermoplastics, Thermosets and Polymeric Composites: Materials and Applications (weeks 4-8)			
4. Commodity thermoplastics 5. Engineering thermoplastics 6. Thermosets 7. Composite materials, basics 8. Constituent materials: properties and applications	2. Polymer production techniques 3. Composite materials 4. Plastics injection moulding 5. Plastics extrusion	2. Stellar Plastics 3. Flex-Tech Hose and Tubing Company	1. Details about research paper activity: 7th week 2. Topic finalisation: 8th week
Stage III: Thermoplastics, Thermosets and Polymeric Composites: Processing (weeks 9-12)			
9. Injection moulding 10. Extrusion 11. Blow moulding 12. Plastics machining and assembly 13. Manual and spray lay-up 14. Vacuum Assisted Resin Transfer Moulding (VARTM)	6. Plastics injection moulds 7. Plastics blow moulding 8. Plastics machining and assembly 9. Manual lay-up and spray lay-up 10 Filament winding	4. CFAN Company	3. Discussions on research paper resources and samples reports: 9th week 4. 1st progress report: 11th week
Stage IV: Research Paper Examination (weeks 13-14)			
15. Final report and presentation discussions 16. Research paper final examination	-------------------	-------------------	5. 2nd progress report: 13th week 6. Final report and presentation due: 14th week

Plant Tour 2: Flex-Tech Hose and Tubing

Flex-Tech produces rigid and flexible tubes and pipes using the extrusion process [5]. Students had the opportunity to understand the entire extrusion system. They also had the chance to see the assembly of the extrusion screw and how the extrusion system is started at the beginning of production. There was also the problem of *melt fracture*, and engineers at Flex-Tech explained the reasons and troubleshooting methodology. It was a three-hour-long visit and students learned a lot that could not be explained in regular lectures.

Plant Tour 3: CFAN Company

CFAN was created by GE Aircraft Engines and SNECMA, two leading aerospace companies that manufacture very high precision parts using advanced performance composites such as jet engine fan blades [6]. Students had the opportunity to watch prepreg cutting, manipulating cut pieces of prepreg on 3D complex moulds, vacuum bagging and autoclave, and post-curing. At the end, engineers at CFAN showed a short video explaining the challenges that CFAN has to meet in producing high-precision components. This was a most exciting plant tour and students were really charged with the area of composites manufacturing.

RESEARCH PAPER ACTIVITIES

Research Paper: Introduction (3rd and 7th Week)

A brief explanation was made about the purpose of research papers; the nature of the work; and other expectations in the 3rd week. A weight of 30% was given to the research paper. At the end of 7th week, details of the research paper activity were provided. By this time, students had amassed a good understanding of basic polymer chemistry, polymer characterisation, thermoplastics, thermosets and polymeric composites' properties and applications, as well as different manufacturing techniques. The document explaining the purpose of the research paper, formats of progress reports, the final report, *PowerPoint* presentation and important due dates was circulated. Also, few sample research papers were distributed so that students had clear idea about this activity.

It was expected that students would select a topic that had current importance (such as polymer nanocomposites). Later they would collect information from different sources such as research articles, handbooks, magazines and Web sources. They were also encouraged to visit the industry and research laboratories. They were expected to compile a 10-12 page research paper and deliver a 10-minute presentation in front of the entire class. It was expected that students would have at least 15 technical references from mixed sources. It was insisted that each paper must comprise the section: Abstract, Introduction, Conclusions, Future Scope and References. Students were asked to bring their own topics in the following week. The instructor suggested few topics, such as polymer nanocomposites, bio-based composites, and polymers in Noise, Vibration and Harshness (NVH) applications.

Research Paper: Topic Finalisation (8th Week)

Research paper topics were finalised in the 8th week. The majority of the topics were related to polymeric composites. The instructor helped students to narrow broad-based topics into focused topics (such as polymer nanocomposites for high-temperature applications). Students brought all their collected material when meeting with the instructor. Some of the final topics were as follows:

- Polymer nanocomposites for high-temperature applications;
- Carbon fibre reinforced composites in aircraft applications (case studies on fuselage, wings and fan blades);
- Recent trends in polymers and composites in automotive applications;
- Polymers in NVH applications;
- Recycling of thermoplastics waste;
- Fibre-Reinforced Polymer (FRP)-reinforced concrete;
- Characterisation and applications of bio-based composites.

Two progress reports were expected: one after two weeks and other after four weeks from the date of the finalisation of the specific research paper topic.

Research Paper: Resources

In the 9th week, various resources for gathering information regarding research paper were discussed. The instructor had set up time with each student to discuss probable sources for the literature review. The instructor shared handbooks (eg refs [8-10]), books, magazines, research papers and personal contacts within and outside the University.

The instructor assisted students by helping them visit the Web sites of the National Composite Center (NCC) and Lightweight Structures BV [11][12]. These research organisations engage themselves in applied research. The NCC has developed composites leaf springs, pickup truck beds, FRP bridge decks, and FRP temporary runways. Lightweight Structures BV has developed a composite safety barrier, lighting columns, crash cones for trucks and truck trailers. Students were excited to see the enormous applications of composites in the real world.

The instructor demonstrated to students how to search for related research articles and how to get a full script using database sources available through the University's library Web site. The instructor's graduate research assistant also helped students in obtaining the required articles.

Research Paper: First Progress Report (11th Week)

It is very important to monitor the progress from time to time to avoid any surprises. Students were asked to come up with the outline of the paper as a first progress report. The outline would help students to narrow down the vast information they had collected. The outline of the paper was finalised for each student. The instructor discussed everybody's progress report and presentation in front of the entire class. The feedback to individual students helped others as well. They were urged to mention each and every reference, which is part of professional ethics. They were advised to use ample visual information (eg pictures, figures, tables and charts).

Research Paper: Second Progress Report (13th Week)

As a second progress report, students were asked to bring a one-page abstract, one-page introduction, conclusions in bulleted form and references. It was observed that students were more inclined to write in detail about manufacturing processes but were applying less effort in the fundamental understanding and elaboration on specific applications. This was an obvious outcome as manufacturing engineering students do not have a strong background in areas like fluid mechanics, mechanical vibrations, dynamics and the strength of materials. Some students were advised to present their information in the form of two or three case studies. Students were also asked to bring the title, introduction and conclusion slides in *PowerPoint*.

Research Paper: Final Report and Presentation (14th Week)

Students were asked to bring their final reports and final *PowerPoint* presentation. It was expected that each report would have 10-12 pages excluding the title page. Each *PowerPoint* presentation would have about 15 slides excluding the title slide. The instructor mainly provided feedback on the *PowerPoint* presentation. The feedback was focused on missing information, improper technical flow of the slides and formatting. The lecture room with a projector was made available to students for mock presentations.

Research Paper: Examination (14th Week)

Two external evaluators with broad industrial/research experience were invited to assess the performance. One of the motives of the research paper was to generate interest among undergraduate students in performing research. Therefore, it made much more sense to invite active researchers as evaluators. Their feedback would help in improving this activity. The external evaluators considered how each manufacturing engineer student comprehended the science and application of polymeric materials. The hardcopy of the final report and a softcopy of the *PowerPoint* presentation were given to these evaluators one week before the examination. Each student was expected to deliver a 10-minute presentation that was followed by a two-to-three minute question/answer session. Students were graded by the instructor and external evaluators on the basis as displayed in Table 3. The average score for written reports was 85%, whereas the average score for presentations was 66%.

Table 3: The basis for research paper evaluation.

Report
1. Creativity
2. Completeness and depth
3. Knowledge of engineering science
4. Use of appropriate engineering terminology
5. Conclusions
Each item 20 points; total out of 100
Presentation
(a) Presentation Skills
1. Speech volume, projection and pronunciation
2. Quality/clarity/quantity of visual aids
3. Use of time
(b) Questions and Answers
4. Directness and clarity of answers
5. Display of knowledge/competence
Each item 10 points; total out of 50

CONCLUSIONS

Out of 10 students, three have accepted jobs at Toyota, Chrysler and Boeing, respectively, and are committed to graduate studies. One student is working as a research assistant and has co-authored two conference papers in bio-based composites. Although these numbers do not assume statistical significance, they definitely indicate encouraging results.

External evaluators were active researchers with wide industry experience. They felt that the research paper activity would prepare undergraduate students for interdisciplinary research. They seemed to be interested in recruiting students on their active research project. This fact attests to the quality and success of the research paper activity.

Students took the initiative in revisiting the polymer research laboratory, visiting local composite manufacturing plants, visiting the library at the University of Texas at Austin, and requesting sample materials from companies. Many of them used Sci-Finder and other databases. Almost everybody used four-to-five journal article references in their report. These activities indicate that they developed a research aptitude and independent thinking.

It was also observed that students who took this course considered polymeric materials when selecting materials for their capstone project. Four students requested that this course be offered as a special topic in spring 2007. One other undergraduate student, who received the Houston-Louis Stokes Alliance for Minority Participation Scholars Program (H-SLAMP) scholarship, is working with the first author on bio-based composites research and will be participating in a student poster competition. All of these results indicate that this course has generated awareness and interest about polymeric materials.

This course will next be offered in spring 2009. Hands-on components will be added in the next cycle of teaching. The research paper activity will be continued to evaluate this particular teaching approach.

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Experiential learning and the classification of team skills in pilot education

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ABSTRACT: In this article, the author discusses a research project being undertaken by the AERO Lab that uses Crew-Centred Flight Training (CCFT) coupled with a database of behavioural markers in scenario-based Line Oriented Flight Training (LOFT) simulator sessions. The classification of team skills, using this behavioural marker database, will be developed using Artificial Intelligence (AI) classification techniques. It is hypothesised that the use of these AI classification techniques will improve the ability to distinguish between pilots with a healthy repertoire of team skills for use on the flight deck and those pilots who have a lesser repertoire of team skills. In this way, CCFT techniques can be modified to improve a student's learning of team skills. Given that it is generally accepted that the majority of aircraft accidents are caused by pilot error and that these errors are caused substantially by a breakdown in team processes, it would suggest that the experiential learning of team skills should improve error management and reduce aircraft accidents. This is especially so since situated cognition in LOFT simulator sessions makes this form of experiential learning particularly powerful.

INTRODUCTION

There is general consensus that pilot error is the major factor in aircraft accidents. There is also consensus that this error is more likely to be the result of poor team skills rather than poor technical flight skills. Flight crews have demonstrated poor team skills in the following general areas:

- Situational awareness;
- Interpersonal communication;
- Workload management and task delegation;
- Leadership;
- Decision making;
- Resource management;
- The process of building and maintaining an effective team relationship on the flight deck.

In an effort to reduce the incidence of these human factor-related events, NASA sponsored a workshop to discuss *Resource Management on the Flight Deck* in San Francisco, USA in 1979 [1]. As a consequence of this Workshop, Cockpit Resource Management (CRM) training was developed and introduced by numerous airlines represented at this workshop. Since then, there has been an evolution of CRM to include larger groups or teams. As a result, CRM has become known as Crew Resource Management to reflect the importance of crew members associated with the flight who are not members of the flight crew. The evolution of CRM training in commercial aviation is discussed by Helmreich, Merritt and Wilhelm [2].

In this article, the author briefly describes the development of CRM and outlines a methodology for embedding this in-flight training at the ab initio level through Crew Centred Flight Training (CCFT) [3]. The author also outlines a project that uses experiential learning in scenario-based flight instruction simulator sessions, termed Line Oriented Flight Training (LOFT). These scenario-based LOFT sessions will utilise a database of behavioural markers that are classified using Artificial Intelligence (AI) techniques.

THE EVOLUTION OF CRM

Helmreich et al have suggested that CRM has undergone five developmental stages from 1979 [2]. The first stage was an outcome from the *Resource Management on the Flight Deck* Workshop sponsored by NASA in 1979 [1]. The CRM training that was introduced was a version of the training used by corporations to increase managerial effectiveness and was based on the *Managerial Grid* developed by Blake and Mouton [4]. The CRM training centred around pilots determining their own managerial style and examining strategies to correct deficiencies in these styles, such as lack of assertiveness on the part of first officers and authoritarian behaviour on the part of captains. LOFT sessions were also introduced as part of the training. In these sessions, flight crews could practice the CRM techniques learnt in the classroom setting.

The second stage began around 1986 when NASA held another workshop [5]. At this workshop, the aviation industry met to discuss the current status of CRM training. It was apparent that the focus of CRM had changed in emphasis from management styles to group dynamics with a corresponding change of name from Cockpit Resource Management to Crew Resource Management. The new courses became more team-oriented and focused more on flight operations [6]. CRM concentrated on briefing strategies, team building, decision making, situation awareness and stress management [2].

The third stage began in the early 1990s when CRM training began to become specialised in areas such as human factors, aspects of the aviation system, organisational culture and flight-deck automation. At the same time, CRM training began to broaden to include other groups of personnel like flight attendants, maintenance personnel and dispatchers. Helmreich et al point out that although these modified courses of CRM filled a particular niche need as they became more specialised and accentuated the crew element of the training, they did have a tendency to diminish the focus on the primary goal: that of reducing the human error associated with air travel [2].

The fourth stage began around the mid-1990s when the Federal Aviation Administration (FAA) introduced a major change in the qualifications and training of airline flight crews [7]. The Advanced Qualification Program (AQP) is a voluntary programme that allows US airlines to develop their own specific programme to fit their needs. The FAA requirement is that the airline must integrate CRM training into the flight training and provide both CRM and LOFT training for all of their flight crews. The majority of US airlines now have AQP. Crews now undergo full flight scenarios in the simulator and are formally evaluated during these simulator sessions (Line Oriented Evaluation – LOE).

Helmreich et al argue that while the integration of CRM training into technical airline flight training (through the various AQPs) has improved the quality of flight crew training, there are some issues that still need to be addressed [2]. These issues include some flight crew members not responding well to some aspects of CRM training and the problem that flight crews may revert back to *type* after a long time interval from the last CRM session. There is the tendency that an over-regulation of CRM principles through the use of airline-specific Standard Operating Procedures (SOPs) may in fact lead to flight crews *going through the motions* rather than internalising the implied crew attitude and behaviour. Further, the research indicates that CRM and AQP training had become very culturally specific and could not be efficiently and effectively transferred from one airline to another. This was especially the case when programmes were transferred from the USA to another country [8].

As a consequence Helmreich et al argue that the fifth stage of CRM development has returned to the original proposition of reducing the level of human error [2]. CRM has become focused on error management.

The author agrees that error management is the overarching axiom for improving aviation safety. However, the author argues that if CRM training, including error management, were introduced in an integrated manner at the very beginning of flight training rather than at the advanced level, crew-beneficial attitudes and behaviours would become well entrenched. This would alleviate some of the CRM training problems currently encountered in airline flight crews [3][9-11].

CREW-CENTRED FLIGHT TRAINING

Flight training is conducted in the very small space of the cockpit of a small light aircraft. This leads to a very close, almost intimate, educational experience for both the student and instructor. Because of this and the *one-on-one* learning experience, the student is exposed to an educational environment that is relatively unique. This form of experiential learning is very powerful in terms of learning outcomes.

As a consequence, traditional pedagogical approaches to flight instruction have achieved a high level of technical flight proficiency and have, therefore, remained relatively unchanged and unchallenged since the early days of flight instruction. The way instructors instruct has changed very little since the early *Tiger Moth days* of the Royal Air Force.

Given the multi-crew environment in modern airline operations, it is no longer sufficient for an individual to be just technically competent; it is also necessary for an individual to have learnt team skills, and acquired an ability to assess and manage errors in a way that improves overall flight safety.

As stated above, airline CRM training has addressed this. However, there is still the assumption that improvements in crew processes will come about naturally if crew members become familiar with their style of crew behaviour, and understand that there may be a need for improved communication and coordination. It should not be assumed that members of the crew possess team skills and that somehow they are innate or have been learned during ab initio flight training or elsewhere.

CRM courses that explore the relationship between individual behaviours within the crew and their associated crew outcomes may yield an understanding of group processes and team effectiveness. However, they will do relatively little to help flight crews reproduce favourable behaviours when placed in emergency flight situations. When a person is in a highly aroused condition, he/she tends to revert back to well-learnt behaviours, exhibiting whatever response is most dominant for that person in that particular situation [12]. In order for pilots to incorporate desirable team behaviours into their behavioural repertoire, or to extinguish undesirable team behaviours, they must be learnt in real team situations (by way of experiential learning) and reinforced with positive feedback from the team. The use of Line Oriented Flight Training (LOFT) sessions has proved to be a useful tool in this learning process [13].

Crew-Centred Flight Training (CCFT), devised by the author, develops a methodology that incorporates Crew Resource Management (CRM) and error management as an integral component of the educational process rather than part of the academic course content [3]. That is, a student learns CRM and error management through experiential learning sessions in the simulator and aircraft rather than by classroom teaching.

By developing a CCFT (or andragogical) approach at the more technical ab initio flight training level, an environment is created which reinforces behaviours and attitudes that are deemed to be most beneficial in group or team environments. Because these behaviours and attitudes have been learned at an early stage in a pilot's cognitive and psycho-motor development, they are likely to resist decay and are, therefore, more likely to be manifested at times of high arousal in emergency situations later on in a pilot's career.

> *The aim of Crew-Centred Flight Training (CCFT) is to provide a nurturing environment in which a pilot can learn to be safe and proficient in the technical aspects of flying, and more importantly, learn the educational and team processes, embodied in the training, which will provide a foundation for further development* [3].

The central principle of CCFT is the establishment of a student-instructor team or crew that focuses on this aim and takes responsibility for the student's learning. Traditionally, ab initio flight training has been mediated using an instructor-centred approach with the instructor focusing on the aim and taking responsibility for the student's progress. As a consequence, few students have adequately learned the educational and team processes embodied in the flight training.

The CCFT methodology will be used in scenario-based simulator sessions.

EXPERIENTIAL LEARNING: SCENARIO-BASED SIMULATOR SESSIONS

The simulator, or flight training device, will be used to conduct LOFT or full-flight missions. These will be identical to the full flight lesson that the student would normally undertake in a real aircraft. The simulator will also be used for the evaluation of the flight lesson (LOE). The simulator will be used instead of the real aircraft because of the following reasons:

- Flight training is more cost effective on the simulator because it is cheaper and safer to operate than a real aircraft;
- Flight training is more educationally effective on the simulator because the flight lesson can be stopped, reviewed and repeated.

All flight lessons will be simulated in the simulator. These include both the basic general handling exercises, which on average last between one and one and a half hours, and the navigation exercises, which last on average three and a half hours. All aspect of the flight will be simulated and, to all extents and purposes, will be identical to the real flight lesson on an aircraft. The student-instructor crew will be evaluated on their performance as a crew. Additionally, the instructor will be evaluated on their ability to deliver the flight lesson using CCFT methodology, and the extent to which they embrace and deliver the content from a crew-centred perspective. The evaluation (Line Oriented CCFT Evaluation – LOCE) of the student-instructor crew will be performed by AERO Lab trained evaluators and use a list of the behavioural markers described below.

A preliminary investigation of the education transfer from the simulator to the aircraft indicated that students who had undertaken experiential learning on the simulator prior to the aircraft generally performed better than average [14].

BEHAVIOURAL MARKERS

Behavioural markers have been utilised as a tool to evaluate flight crew performance since the mid-1990s [15]. This is essential if CRM concepts and practices are to be assessed, reinforced and used to develop further training and education requirements. The set of behavioural markers developed by Helmreich, Butler, Taggart and Wilhelm results from the evaluation of a set of observable behaviours on the flight deck using the Line/LOS checklist [15]. These behavioural markers are also closely related to the attitudes measured by a revision of the cockpit management attitude questionnaire, the Flight Management Attitudes Questionnaire (FMAQ) [16].

The behavioural markers in the Line/LOS Checklist has been modified by the author to suit the flight deck or cockpit of the flight training environment and derive naturally from the CCFT methodology described by the author in ref. [3]. Examples of these behavioural markers are as follows:

- An environment for free and open discussion is established and maintained;
- Flight briefings are technically and operationally complete. They address crew coordination. Flight tasks are clearly defined including planning for abnormal situations, ie engine failure on take-off and after take-off. Missed approach procedure is also tackled;
- Crew atmosphere is task- and operationally-specific, ie crew interact socially during times of low workload (team building) and are focused on tasks during high workload periods;
- Both the student and instructor ask questions to clarify actions and decisions made by each other, and directions and clearances from air traffic control;
- Crew members feel comfortable to express their concerns about the operation of the flight, ie they speak up and persist until they are comfortable with the situation;
- Operational decisions of the flight crew are expressed clearly and acknowledged by the other crew member. Both the student and instructor seem to have the same understanding of the situation.

There are 25 behavioural markers for use in the LOCE. Negative (0) or positive (1) outcomes of the behavioural markers are reduced to an overall score for the student-instructor crew. The 25-dimensional vector derived from the crew in the simulator will be used as an input vector to an intelligent agent. The output vector will be generated from the behavioural marker set observed in the real aircraft.

INTELLIGENT AGENT CLASSIFICATION TECHNIQUES

As outlined above, the full mission scenario-based simulator sessions will be conducted using CCFT and evaluated using a set of 25 behavioural markers (LOCE). The project will explore various Artificial Intelligence (AI) classification techniques to improve the classification of student learning of team skills and technical flight skills. The AI classification techniques under investigation are discussed below.

The author has investigated a form of a self-organising map, namely topographical mapping to see if this will aid in the classification of teams skills in student pilots [17]. Other forms of topographical mapping have been considered involving harmonic averages [17]. The author has shown that this provides a good mapping of the input data and could be useful as a classification tool.

The project will explore another type of mapping: the fuzzy cognitive map [18]. Fuzzy cognitive maps are a software emulation of the way that an expert thinks and classifies the data set. They mimic human reasoning and decision making.

The project will also explore the use of support vector machine software, which performs a mapping from the input data set onto a feature space which provides a separating hyper-plane between classification sets within the data, thus classifying the data [19].

SUMMARY

Simulator sessions will be conducted that simulate the whole flight lesson. These lessons will include basic flight skills training and advanced navigation training. The student-instructor crew will perform the flight lessons exactly as they would be performed in the aircraft. This form of experiential learning is considered to be very powerful in terms of the effectiveness of the teaching and learning.

CCFT methodology will be used to aid in the student's learning of team-beneficial behaviours and attitudes. These are considered important in the multi-crew environment on a flight deck. In order to evaluate the effectiveness of CCFT, an evaluation tool, LOCE, has been developed that comprises a set of behavioural markers which have been shown to correlate to crew behaviours and attitudes that have sound CRM concepts. AI classification techniques will be investigated to develop a tool that can be used by non-experts to evaluate the learning of team skills.

This project is in its infancy and it is hoped that the acquisition of a three-axis, full motion simulator by the AERO Lab will greatly assist in the development of this project and the learning of team skills at an early stage in a pilot's education.

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Developing new curricula for engineers' entrepreneurial education: a Romanian experience

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ABSTRACT: The article presents a Romanian experience from the standpoint of the Chair of Industrial Management at the University *Politehnica* of Bucharest (UPB) as far as developing new curricula for engineering education in the area of *management and entrepreneurship*. Following the 1999 Bologna Declaration, the European education system started a complex restructuring process (the Bologna Process). Universities in Romania (currently a new member state of the European Union (EU)) were part of this process. For technical universities, the restructuring process was particularly tough: the curricula redesign, although considering the engineers' competence system, had to proceed to a painful *cutting* of the duration of studies from five to four years, and alter the engineering education curricula accordingly. Based on the client-oriented marketing approach regarding the educational services provided, labour market surveys were conducted among employer organisations, professional associations of engineers and companies. This survey was aimed at identifying the needs of companies concerning the management and entrepreneurial profile of engineers in order to redesign curricula to fit these needs. This article focuses on the survey results of some actions taken by the UPB.

THE EUROPEAN AND ROMANIAN CONTEXT

Following to the Declaration signed in the university city of Sorbonne (1998), an unprecedented process aimed at the restructuring of the European higher education system formally commenced. One year after, in 1999, those Ministers responsible for higher education from 29 European countries signed the Bologna Declaration, which has the major objective of developing a coherent and cohesive European Higher Education Area by 2010. Other meetings followed: Prague (2001) and Berlin (2003), where 33 participant countries agreed to strengthen the initial objectives: *Europe must be the most competitive and dynamic knowledge-based economy in the world* [1]! The European reform took off.

In this article, the author does not question the rightness of the European objectives or their chances of being reached by 2010. The important thing is that Europe accepted the challenge and Romania signed up for the Bologna Process. Romania was engaged in a twofold fundamental transition: from centrally planned to a free-market economy plus the European Union (EU) accession process. Higher education reform was part of this complex process and Engineering Education (E^2) was just a component of this. An analysis of the transition strategy is not the purpose of this article either; however, it is important to understand the complexity of the circumstances in which technical universities evolved; among them the University *Politehnica* of Bucharest (UPB), the oldest and largest technical university in Romania.

MANAGEMENT AND ENTREPRENEURSHIP AT THE UPB

The Bologna Process has seriously influenced E^2; starting with the 2005-2006 academic year, the duration of engineering studies has reduced from five to four years of study and E^2 curricula were affected accordingly. The shock was painful for many UPB departments.

Earlier Start

Management subjects at the UPB were traditionally taught by professors within the Chair of Industrial Management (CIM). A core group of CIM professors, well trained in the early 1990s in North America and Western Europe, initiated the change of the old-fashioned subjects and syllabi in the management area and influenced the engineering faculties at the UPB to update their curricula. As a result, the first economics engineering specialisations were established in the Faculties of Electrical and Power Engineering (mid-1990s) with the large contribution of the CIM in the curriculum design. New subjects started to be taught along with management and marketing, such as business strategy, marketing research, human resource management, finance and accounting. Engineering Economics Education (E^3) now exists and has its own students.

The process was eased by the existence of the Center for Business Excellence (CBE), which opened its doors in 1991 following a successful cooperation programme between the UPB and US universities as a *business research laboratory* of the CIM. Its mission was to provide services (as consulting and training) to the business community and *stimulate entrepreneurship in Romania*, using academic expertise and its international vocation. As the very first centre of this kind, the CBE has considerably impacted on the business culture in Romania [2].

The year 2000 is a milestone for entrepreneurial education at the UPB with the introduction of the course *Entrepreneurship*, now taught to E^3 students since then. Consequently, 2000 is the year when Engineering Economics & Entrepreneurial Education (E^4) was born at the UPB.

In 2001, the CBE initiated the Business Plan Contest open to UPB E^3 students following the Harvard Business School model. The major objective of this contest – now in its 6th edition in 2007 – is to stimulate the entrepreneurship spirit among students.

A series of classes started to be linked to the CBE aimed at connecting the business world and academia. Networking with managers and companies revealed another urgent need: postgraduate studies in management (Master's). Thus, the same kernel of energising professors founded the School for Academic postgraduate studies in Management (SAM) in 1996. The 10^{th} promotion of managers (about half of them are engineers) just graduated and the SAM celebrated its 10^{th} anniversary while the CBE marked 15 years of activity.

In summary, the CIM, in conjunction with the CBE and SAM, has contributed to the development of new curricula at the UPB for Engineering Education (E^2) and Engineering Economics Education (E^3) aiming at E^4 (Engineering Economics & Entrepreneurial Education) – well before the start of the Bologna Process.

Curricula Reform Based on Surveys of the Needs of the Labour Market

The main benefit of reformed E^2 is the experience needed for future engineering employment in the global environment [3]. To better answer to the requirements of the Bologna Declaration and Process, the CIM was largely involved in academic curricula restructuring, always based on competence analysis. The efforts to reform E^2 were based on the concept of the *entrepreneurial university*: universities should support the development of entrepreneurial spirit and (continuous) education [4-6]. The philosophy of educational marketing assumes that the *client* of a university for educational services is not the student strictly, but rather organisations that employ the university's graduates. Consequently, the CIM has restructured the academic curricula and syllabi based on the conclusions of the labour market surveys and research conducted among professional associations of engineers, companies and managers – a research process that started back in 2001 when the first research project was designed. Significant research projects on E^3 and E^4 were completed over a period of five years (2001-2005) including the following:

- The EFWE research project (2002-2003);
- The EDUCAT research project (2002-2004);
- The IMPACT of entrepreneurial education (2003-2004);
- The ARIES research project (2004-2005).

All of the above were anticipated during the 2001-2002 academic year when a survey was conducted among E^3 senior students just before their graduation. The results have signalled that topics and teaching methods should change at the UPB. Thus, further research projects were suggested and their methodology designed and documented.

The EFWE project, which focused on the European structure for recognising the abilities acquired through work experience, was promoted by the Careers Research and Advisory Centre from the UK with the CBE acting as the Romanian project partner. The purpose of the project was to create and implement a European standard of evaluation and certification of basic competences for employing young people. The results of the survey, questioning over 150 companies, emphasised that *young employees lack the managerial and entrepreneurial skills like: customer focus and teamwork* [5].

The EDUCAT project targeted developing the entrepreneurial spirit and education based on the research of the market labour needs. This was promoted and completed by the CBE in conjunction with the CIM. The overall objectives of the project aimed to answer to these needs and contribute to: developing the entrepreneurial spirit of young E^2 graduates so that they may better meet the needs of the labour market in the current conditions of a knowledge economy; helping young E^2 graduates to adapt better and quicker to a free-market economy (single EU and global markets) as managers or entrepreneurs; helping E^2 graduates to become internationally-accepted professionals based on the European Credit Transfer System (ECTS). Three pilot studies have been carried out (in Bucharest in the field of electronics, software and IT) totalling interviews with 107 general managers and 120 managers – graduates of E^2 and even E^3. The results of the project underlined that *young engineers lack entrepreneurial skills as: pro-activity, initiative spirit, assuming the responsibility, decision-making* [5-7].

The IMPACT project was a joint Slovenian-Romanian project privately funded by a group of professors. It was aimed at evaluating the impact of the *quality of the entrepreneurship education* on students' decisions to continue their education [8].

The ARIES project, initiated by the Romanian Association of Electronics and Software Engineering (ARIES) and the CIM, targeted the following objectives: identify how E^2 graduates are perceived by the managers of the companies active in the Communication & Information Technology (C&IT) sector; and develop recommendations for reforming the curricula of E^2, based on the above to mainly electrical engineering faculties. The survey targeted 349 C&IT firms. The companies acknowledged that *certified* continuing E^2 is important as far as E^3 and E^4, even at the Master's level. Also, E^3 and E^4 should include subjects like business communication, project and team management, entrepreneurship and business planning. When hiring E^2 graduates, both for management and technical positions, practical criteria are key issues that are just as important as the prestige of the graduate's university [9].

The conclusions of all the research projects were pointed at strategic issues: E^3 and E^4 must complement engineers' technology education, and new teaching methods and tools have to be used in order to stimulate their entrepreneurial skills. Additionally, international educational and research projects should be further developed, and the reform of E^2 should be correlated and integrated in a more complex set of political and administrative strategies and measures.

All these issues, which were revealed by research, were targeted by the CIM while designing the reformed curricula (applicable since 2005-2006), developing new international exchange projects, disseminating the research results and lobbying national decision bodies.

E^2, E^3 AND E^4 CURRICULA REFORM WITHIN THE GLOBAL CONTEXT

The Romanian example (presented shortly) is not an isolated case. The role of the government in education reform is commonplace worldwide; likewise the increasing focus on changing curricula and teaching methods with C&IT in order to make engineering education more entrepreneurial. These elements are highlighted below.

The Role of Government in Management Education Reform

Education is increasingly becoming a top issue of government policy – not only in industrialised Europe but also in rapidly developing large economies (eg India and China). The importance of management education was acknowledged by the Chinese government: it played the change agent role (as a *visible hand*) to influence both the demand (companies) and supply (higher education institutions) sides of management education. This resulted in the synchronous development of the economy and management education [10].

The Role of Entrepreneurship in E^2: Technopreneurs

As high-tech industries impact greatly on the economy, high-tech entrepreneurship is an increasing focus for engineering schools and technical universities at both the undergraduate and postgraduate levels. An economy's competitiveness largely depends on the level of innovation, intrapreneurship and entrepreneurship in the engineering professions, no matter if engineers work in larger companies or for themselves.

Studies conducted in three British universities have shown that E^2 students aim to start firms, although this tends to be cited as later than that reported by other students. They also understand that enterprise skills are relevant to employment and personal development; however, *perceptions of enterprise skills development are less common than for other students (they tend to report that have enterprise skills anyway)* [11].

Studies over three generations, analysing the processes by which engineers become entrepreneurs, found that the uniqueness of the Israeli political, economic and security situations has impacted on their entrepreneurial career [12]. Although the study is based on Israeli data, the current conditions for the third generation anticipate *universal validity: to become entrepreneurs, engineers' learning process is influenced by formal learning, experience, and lifelong learning process* [12]. Similar results were obtained by Cooper: the survey of entrepreneurs in the electronics and software sector demonstrated that the number of individuals able to directly start a business is very limited and *sizeable numbers of firms are established by those in mid-career, after a significant time working as an employee,* gaining knowledge and developing skills and networks [13].

Aimed at improving E^4, interesting differences were found when comparing the entrepreneurship creativity of engineering to business Master's students in Sweden; both groups displayed high creative potential, but engineering students channelled their potential into practical and incremental efforts, while the business students had a better market focus and were more speculative [14]. The role of entrepreneurship in E^2 is demonstrated by numerous authors. It educates engineers and scientists by innovative means to become *technopreneurs*, which means *engineering entrepreneurs* [15].

Curricula Design

E^2 curricula have to be designed to ensure that graduates possess all the qualities of a generalist and all the competences of a specialist, and are capable of life-long learning [16]. At the UPB, new courses in E^2 curricula (as entrepreneurship) contributed to make it E^4. Major change in E^2 started a decade ago when E^3 curricula were designed and then implemented. Today, more than half (8 out of 13) of the UPB faculties have E^3 profiles too. UPB graduating students have not only solid E^2, but also consistent knowledge of economics and management.

Masters Programmes

Many engineers realise the need for management education by the time they reach management positions. Masters programmes (business administration, engineering management and technology management) are valid options. The best option for engineers is the one most suitable for their careers – either management or technology [17].

Curricula Implementation

The major difficulties reported in developing countries are chronic under-funding, lack of talent or the poor management of universities [18].

New Tools and Methods of Teaching

An entrepreneurial university also means that educators teach entrepreneurially. Smith used an entrepreneurial education resource inventory to create a more entrepreneurial community and shown its implications for change management in managerial practice in both the USA and globally [19].

Problem solving is essential in E^2. Souza et al described a collaborative virtual environment for *problem solving* in E^2 [20]. The implementation of a solution generates a collaborative environment in which the different knowledge or abilities of team members must merge in order to achieve the goal by way of *teamwork*. Suliman demonstrated how a *problem-based learning* philosophy can be used in E^2: during the process, E^2 students are developing the acquisition of critical knowledge, problem-solving proficiency, self-directed learning strategies and team-participation skills [21].

Group projects are effective classroom tools that relate to job performance and knowledge development during classes [22]. Students acquire *teamwork* skills while logged on to the Internet without direct personal interaction [23]. Utilising *online groups*, McLaughlin studied conceptual models of how technology and teamwork can be effectively integrated [24]. The design of support for team processes (like time planning and responsibility allocation) is essential for effective online collaboration.

Decision-making is crucial in management education and becomes more critical as systems grow more and more complex under the stress of competition and time pressures [25]. Computer-based simulations are efficient tools when teaching decision-making in large-scale systems [26].

C&IT is essentially valuable in distance e-learning. For effective and coherent teaching, integrated portal systems are important for the benefit of all stakeholders, ie students, professors and administrative staff [27]. There is also a need for curricula management to generate an efficient and effective teaching-learning environment. Syllabi should contain deliverables that are Web-researched and Web-presentable so that the student-faculty response time is minimised [28].

CONCLUSIONS

Higher education institutions cannot avoid the impact of three environmental changes: economic globalisation, the rise of knowledge economies and C&IT. The emergence of a European higher education and research area should be added for European universities [29]. Under such influences, the reform of the Romanian E^2 system was an opportunity to make it, in the case of the UPB, more entrepreneurial (E^3 and E^4).

This reform should be based on a needs analysis of the business community. Several surveys on the labour market completed by the UPB concluded that E^2 should be more entrepreneurial. Transforming the classical university into an *entrepreneurial university* does not mean changing the mission of the university, but rather changing the curricula and syllabi, teaching philosophy and methods. Besides technology knowledge, E^2 should focus on entrepreneurial and management skills development, especially decision-making, problem solving, teambuilding and teamwork.

These conclusions regarding E^2 in the UPB are also applicable to other Romanian or foreign (technical) universities.

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Incorporating a shaking table into a basic course in earthquake-oriented structural engineering

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ABSTRACT: An understanding of structural behaviour during earthquakes is important for future engineers in order to provide the proper design of buildings and avoid damages. The College of Judea and Samaria in Ariel, Israel, offers a mandatory course in the design of seismic resistant structures, and correspondingly adapted related courses in engineering mechanics, structural dynamics and reinforced concrete structures. The geophysical conditions of Israel, located on the African-Syrian fault and the current seismic codes' requirements, are also considered in the teaching process. The laboratory facilities enable the demonstration of basic structural properties, ie stiffness, ductility, dynamic strength of concrete and steel, etc. Students can also investigate the response of structures to earthquakes using a laboratory shaking table, reproducing records of real seismic motions. Teaching according to the proposed programme yields deeper understanding of a structure's physical nature and modern design techniques in earthquake engineering, and helps students to get a better *feeling* of the building. In the final stage of the course, students design buildings considering the real seismic conditions of a building site. Students in their final diploma projects further use the knowledge received during the course.

EARTHQUAKE ENGINEERING EDUCATION IN SUPPORT OF NATIONAL EARTHQUAKE PREPAREDNESS

Israel lies along the Syrian-African Fault, one of the world's major fault lines. As a result, Israel has historically experienced multiple earthquakes, sometimes causing large-scale disasters. The last major earthquake in Israel occurred in 1927 and future events are expected. Due to the growing population density in the country, the consequences of such events could be catastrophic.

Since 1999, the course of *Seismic Structural Design* has been included into the educational programme at the College of Judea and Samaria in Ariel, Israel. Teaching was based on the facilities available at the dynamic laboratory. In 2001, a small-scale shaking table was later purchased. Simultaneously, the programmes of related courses have been adapted to meet the requirements of this course. At the current stage, the course includes lectures, practical exercises, laboratory works and a course project. Based on the knowledge obtained in the course, during the diploma project, students design structures according to a certain seismic zone.

This programme is expected to serve as a national (and international) model for integrating structural dynamics and earthquake engineering into the undergraduate curriculum.

COURSES ADAPTATION

Dynamic Part of Mechanics

One of the basic disciplines required for a proper understanding of structural design to earthquakes is the *Dynamic Part of Mechanics*. Tuition of this subject is oriented to provide a possibility for applying the obtained knowledge in further studying buildings' behaviour during earthquakes. With this aim, a tutor from the Department of Civil Engineering participates in teaching the laboratory part of the course. Additionally, the laboratory works in the frame of the course are realised in the laboratory for structural dynamics. It allows for the use of elements of structures in order to study their dynamic parameters.

In the laboratory works given in this course, the main emphasis is on learning the simple oscillation processes of progressive motion and rotation. Systems with the accumulation of elastic and gravitation energy are studied. These phenomena correspond accordingly to the behaviour of simple fixed-base structures and base-isolated ones during earthquake motions. One of the laboratory works is aimed at the study of rotational stiffness. In the test, instead of traditionally-used springs, torsion bars are involved that allow for the understanding of the torsion response of structures to earthquakes.

Structural Dynamics

The course of *Structural Dynamics* was also adapted for earthquake engineering applications. The teaching process was focused on the behaviour of real structural schemes subjected to ground motions (artificial vibrations and natural earthquake records). This allows the real damped response of structural elements and their ductility factor, required for seismic design, to be obtained. In order to reproduce the records of natural earthquakes, a small-scale shaking table is used (see Figure 1). This is also applied by members of the University Consortium on Instructional Shake Tables (UCIST).

Most of the laboratory works in this course are performed using models of framed structures instead of mass spring-damper systems. One of the aspects studied is the influence of the beam's rigidity on the equivalent structural stiffness. In seismic zones, buildings are always subjected to gravitation (static) loads.

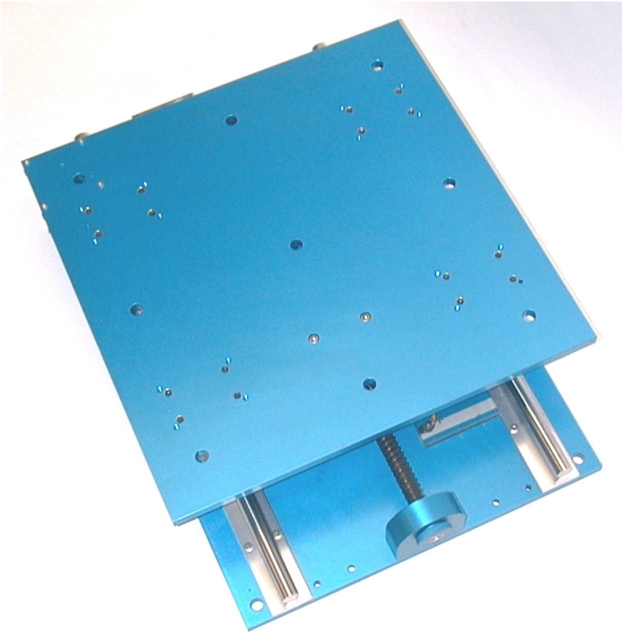

Figure 1: A small-scale shaking table used in the dynamic laboratory (general view).

In order to illustrate the influence of these loads on structural dynamic parameters, an effect of axial stresses in columns is included in the course curriculum.

Natural damping is one of the important structural dynamic properties; hence, this topic is studied intensively and forms a separate group of laboratory works. The natural damping of a framed model is obtained from a free vibration test by analysing the whole structural response record. An influence of the amplitudes on damping is studied. It is demonstrated that the damping increases according to the amplitude, which is important for the further understanding of buildings' behaviour during strong earthquakes.

Design of Seismic Resistant Structures

A series of new illustrative structural dynamics experiments were developed and integrated into the course curriculum. It extends the understanding and intuition of the undergraduate students enrolled regarding the dynamic nature of structures. It also provides them with experience in using modern engineering tools including sensors, dampers and other equipment for *hands-on* experiments.

A group of laboratory works deals with artificial damping. It includes models of structures with viscous, friction, passive and active tuned and semi-active magnetorheological dampers. The properties of these dampers are obtained and their influences on structural dynamic behaviour are demonstrated.

These tests allow for students' further understanding of the mechanism of supplemental damping and create a basis for the design of intelligent seismic resistant buildings. It also allows an effective seismic design of structures combining their own energy dissipation resources and artificial damping systems.

Other courses, such as *Pre-Stressed Concrete*, *Spatial Structures*, *Principles of Structural Design*, *Engineering Structures*, and *Foundation Analysis and Design* were also adapted to earthquake engineering aspects.

CHARACTERISTICS OF THE SHAKING TABLE

The basic component of the dynamic laboratory experiments is a typical small-scale shaking table shown in Figure 1. The shaking table is an effective unit applied in a wide variety of experiments for civil engineering structures. It is computer-controlled with a user-friendly interface and is reasonably priced for educational institutions with an interest in earthquake engineering. The main characteristics of the shaking table are given in Table 1. The shaking table software was improved by the researchers from the College in order to allow for a more exact reproduction of real earthquake records [1].

Table 1: Characteristics of the shaking table.

Specification	Value
Design payload	110 N
Peak acceleration	1 g
Operational frequency range	0 - 20 Hz
Peak velocity	50 cm/sec
Sliding table dimensions	45 x 45 cm
Stroke	15 cm
Weight of the shaking table	445 N

DESIGN OF SEISMIC RESISTANT STRUCTURES: SYLLABUS OF THE COURSE

Topics included in the course are elaborated on below.

Definition of an Earthquake

In this part, students learn about the source of the earthquake, its epicentre, the forms of waves and their distribution, the magnitude of the earthquake and available scales to measure the seismic energy. A review of the strongest earthquakes that have occurred recently and the rise in the price of buildings constructed in seismic zones are also discussed.

Vibrations of SDOF Structures under Earthquakes

This part is based on the preliminary knowledge obtained in the *Structural Dynamics* course. The difference is that instead of periodic excitations, real earthquake motions are introduced. The response of structures to impulse-type earthquakes is taught based on the non-damped and damped free vibrations theory. The forced vibrations of structures under real earthquakes are then studied.

The Response Spectra

This topic is also an extension of the knowledge obtained in the *Structural Dynamics* course. Biot has introduced the standard spectra in seismic design [1]. This idea is used for teaching the design procedure for the equivalent static and modal dynamic analysis. The Standards provisions regarding various soil conditions are also involved [2][3]. The peak response of structures and the SRSS method are introduced.

General Principles of Structural Seismic Resistance

A definition of RC sections and structural ductility is given. The definition is based on the research performed recently by Iskhakov [4]. The students get the final analytical expression for plastic energy dissipation and ductility obtained in a closed form. Other problems, such as the influence of flexible and weak storeys, masses concentration and building irregularity, are also studied.

Earthquake Conditions and Parameters

The principal parameters of a building, soil and environment (ie peak ground acceleration, soil sections, building characteristics, dominant vibration period, ductility parameter and seismic design coefficient) are studied in this part. The storey shear force capacity and limitations in infill walls are also studied. The possible types of structural analysis under seismic excitation (equivalent static analysis and modal dynamic analysis) are introduced.

Principles of Equivalent Static Equivalent Analysis

First of all, a method for the calculation of the horizontal force acting on a building is given. Then the force distribution between the storeys is explained. For regular structures, this distribution is obtained using an original close analytical solution. A next step is the force distribution between the vertical rigid elements of the floor. Additionally, the torsion and P-Δ effects are studied. This part includes a full numerical example for an equivalent static analysis of a typical residential multi-storey building [5].

Principles of Modal Dynamic Analysis

Based on the preliminary knowledge from *Structural Dynamics* on the natural vibration modes of multi-storey structures, a method for the distribution of the design of horizontal forces is introduced. Students learn the interaction of the modes including the influence of torsion and second-order effects.

Geometrical Properties of Vertical and Horizontal Diaphragms

In order to develop engineering students' intuition and feeling of structural response to earthquakes, based on the knowledge obtained from engineering mechanics, the following parameters are studied:

- Second moment of walls section;
- Centres of masses, rigidity and gravitation of the floor diaphragm.

These parameters enable the student to obtain the distribution of horizontal forces between the rigid elements of a floor.

Design of Reinforced Concrete Frames

The constructive requirements for structural and non-structural elements are first given. The specific properties of concrete and reinforcing steel desired for the effective seismic design of structural elements are emphasised. Students learn about the design peculiarities of beams and columns in seismic zones. The increase of bending moments and shear forces due to seismic loads in flexible and weak floors is also considered.

Modern Methods Improving Structural Response to Earthquakes

The effect of base isolation for seismically excited structures is introduced. As an example, a friction pendulum and an electro-metric bearing system, incorporating lead core, neoprene layers connected to steel plates, are discussed. Students acquire the principal information about different passive artificial damping systems used in modern seismic applications. Combined systems that incorporate base isolation and supplemental dampers are also introduced. Finally, the effectiveness of the above-mentioned systems and their influence on structural seismic responses (peak accelerations and displacements) is demonstrated.

Exercises

Each of the topics mentioned above is accompanied by a practical exercise. After some of the topics, students should solve a homework based on the requirements of the Israel Seismic Code [3].

Exercise 1: Seismic Coefficient Cd

This exercise includes the calculation of the following parameters required to obtain the seismic coefficient:

- Soil influence S;
- Peak ground acceleration according to a given seismic zone Z;
- Seismic force reduction coefficient K (related to the ductility parameter μ);
- Coefficient of building's importance I.

The next step is determining the natural vibration period of the structure T. According to T, the spectral intensity coefficient Ra is obtained by three methods: analytical, using appropriate tables and from the graphs available in the Code 3.

Finally, the value of Cd is calculated and verified according to the requirements of the Code.

Exercise 2: Building's Spectral Acceleration Graph

For a given building site with the known above-mentioned parameters Z, S, K and I, and for the equivalent static analysis, the building's acceleration is obtained as follows:

$$a = \text{Cd Z g} \tag{1}$$

where g is the gravity acceleration.

After that, students calculate and draw the acceleration spectrum a(T) for buildings with a natural vibration period, T, ranging between 0.1 and 2.0 seconds.

Exercise 3: Total Seismic Force FH and Floor Seismic Force Fi

For a given regular multi-storey RC plane framed building with known storey heights, storey mass, full storey live load, live load reduction coefficient kq, and for a known seismic region, the following problems should be solved:

- Obtain the natural vibration period, storey weight, total design horizontal force and base shear force;
- Determine the floor seismic force for each floor neglecting the torsion effect;
- Identify what the torsion influence coefficient is for a given structural wall;
- Identify what the floor seismic forces are in the case when the torsion effect is considered by the above-mentioned coefficient.

Exercise 4: Equivalent Static Analysis

For a multi-storey building with known geometry, elements and materials properties, the following calculations should be performed:

- Total floor shear strengths in X and Y directions;
- Design dead load, live load, floor weight and total horizontal seismic force;
- The total seismic force distribution along the building's height;
- Floor torsion moments.

Exercise 5: Modal Dynamic Analysis

For the building given in the previous exercise, a modal dynamic analysis should be performed for the first three vibration modes.

Course Final Project

In the second half of the semester, when students are familiar with the basic seismic design concepts, they are given a task for a final course project entitled *Seismic Analysis of a Regular Multistory RC Plane Frame Building*. Students obtain a cross-section and a plane of a typical building floor, required structural details, frame ductility level and characteristic live load. The data, describing the seismic zone, seismic parameters (S, K and I), seismic load direction and reduction coefficient, are also supplied.

It is necessary to undertake the following:

- Check if the building is a regular one;
- Determine the natural vibration period, spectral intensity coefficient Ra and storey self-weight;
- Perform an equivalent static analysis of the building, including the determination of the total seismic force, roof level concentrated force, horizontal design forces at each floor, shear forces at each floor Vi, and floor shear capacity V_{cd}. The relations between Vi and V_{cd} for each floor and for two adjacent floors are also to be obtained. The last step is the calculation of the torsion coefficient, increasing the floor seismic forces;
- Analyse the given RC frame structure under the seismic forces, including the increase in seismic forces, determining the bending moments, shear forces, and axial forces diagrams and displacements in columns. One column and one beam-column connection should be designed.

Seismic Design Aspects in the Diploma Project

Over the last year, all students worked on their final diploma projects. The duration of the project was extended (from one to two semesters), mostly in order to include the seismic design part. It is assumed that the buildings designed by the students will be constructed in a seismic zone. Hence, the buildings constructive schemes have to correspond to the Code requirements for seismic zones.

The design process in the diploma project involves the case of a normal building design for seismic regions. It yields an understanding of the main concepts in structural seismic design, eg preferring regular structural systems, seismic isolation, using appropriate foundation types, etc.

The design of the beams, columns and connections, as well as rigid and infill walls, is performed according to the seismic code requirements. Students can use *STRAP* software for the seismic design process.

The examination board for the diploma project defence includes experts in seismic design.

CONCLUSIONS

The importance of the understanding of buildings' responses to earthquakes by future engineers yields certain changes in the undergraduate educational programme in civil engineering.

An obligatory course, *Design of Seismic Resistant Structures*, is given at the College of Judea and Samaria, and some other disciplines are adapted to satisfy it.

The laboratory facilities enable the demonstration of basic structural properties, eg stiffness, ductility, dynamic strength of concrete and steel, etc. Students can also investigate the responses of structures to earthquakes using a small shaking table to reproduce the records of real seismic motions.

The use of shaking table experiments enable the demonstration such important aspects like the influence of natural and artificial damping on the behaviour of structures subjected to earthquakes. It also allows for the demonstration of modern methods to reduce buildings' seismic responses.

Teaching according to the proposed programme yields a deeper understanding of a structure's physical nature and helps students to gain a better *feeling* of the building, making them more familiar with existing design techniques in earthquake engineering.

Finally, students design buildings by considering real seismic zone conditions. In their diploma projects, students apply the knowledge they acquired during the whole seismic engineering educational process at the College.

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The incorporation of the AECE 4-D cycle learning system into technological and engineering education

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ABSTRACT: The purpose of this study was to propose the 4-D cycle learning system for Appreciative Environmental Consciousness Education (AECE) for technological and engineering college students, to incorporate the learning system into education and explore the effects of the learning system on students. The Appreciative Environmental Consciousness Education Questionnaire (AECEQ) was administered before and after AECE instruction. The research results showed that students' environmental consciousness improved through the incorporation of the AECE 4-D cycle learning system in technological and engineering courses. Having the knowledge of environmental education and general ecological principles, students began to appreciate their natural environment and cherish natural resources.

INTRODUCTION

The world is currently facing complex environmental problems that have resulted in environmental degradation, such as acid rain, global warming and air pollution. Many environmental problems are caused directly or indirectly by the actions of people, such as the patterns of productions in industries, increasing consumption patterns, etc. It has been shown that the most important factor affecting nature is the lack of public awareness or public concern for the environment [1]. Therefore, the shaping of people's correct attitude and concern for the environment is crucially required.

Over the last two decades, technological and engineering education has played an important role in advancing Taiwan's economic growth and in developing students' professional skills in technological, engineering and management knowledge to satisfy the demand for hi-tech personnel in Taiwan.

While focusing on instilling students' technological and engineering knowledge, universities in Taiwan do not currently pay much attention to students' environmental education. In order to raise students' environmental awareness, it is necessary to integrate appreciative environmental consciousness into school education.

The purpose of this study is as follows:

- To propose the Appreciative Environmental Consciousness Education (AECE) 4-D cycle learning system for technological and engineering college students;
- To incorporate the AECE 4-D cycle learning system into technological and engineering education;
- To explore the effects of the AECE 4-D cycle learning system on technological and engineering college students.

THE AECE 4-D CYCLE LEARNING SYSTEM

The AECE 4-D cycle learning system is a learning system that is intended to identify the best in the natural environment to build up further the vision of *what could be* in Nature. With this vision of Nature, the AECE 4-D cycle learning system has been structured to arouse students' environmental consciousness and to transform their environmental attitude to further identify the beauty of the world.

The key aspects of AECE are as follows:

- Draw on the strengths and values of students; in every class, group, society or organisation, there should be something developed that works to arouse students' appreciation of the environment;
- The focus should become the reality. That is, when the focus is on a vision of Nature's beauty, then this beauty will someday become the reality;
- The vision of Nature's beauty is created in any moment. Therefore, teachers' acts or methods of asking questions in a class, group or organisation influences the attitudes and behaviours of the group in some way;
- Teachers and students should have much more confidence and comfort to journey to the vision (the unknown beauty) if they carry forward parts of the past (the known beauty) to the vision;
- When carrying parts of the past to the future, they should be the best in the past, that is, the beauty in the past.

AECE is derived from appreciative inquiry [2]. There are four phases in the AECE 4-D cycle learning system. These are defined as follows:

- Discovery;
- Dream;

- Design;
- Delivery.

In the *discovery* phase, teachers help students mobilise the whole class to discover a positive change core for the natural environment. In the *dream* phase, teachers help students create a clear and positive result-oriented vision and discover their potential to create an ideal natural environment. In the *design* phase, focusing on the positive core, teachers help students figure out possible strategies to create their vision for Nature. In the *delivery* phase, teachers and students work together to go through the process of learning, adjustment and improvement for co-creating their vision of beautiful Nature. With the shared vision, students engaged in the AECE 4-D cycle learning system would work cooperatively to create the ideal image of Nature.

Through the facilitation of the AECE 4-D cycle of discover, dream, design and delivery, teachers endeavour to help students appreciate the beauty of the natural environment, provide students with a chance to realise the key environmental issues currently endangering the world, and further aim to minimise the negative environmental impacts.

METHOD

In order to explore the effects of the AECE 4-D cycle learning system on technological and engineering college students, two classes (66 students) were selected as the experimental sample. After the literature review, the Appreciative Environmental Consciousness Education Questionnaire (AECEQ) was developed. In order to establish the validity of the questions in the AECEQ, the initial questionnaire was read by 10 technological and engineering students to assure that students could understand the questions without ambiguity. Two questions were deleted because of a lack of clarity and ambiguity. The questionnaire was then reviewed by an expert panel consisting of three people. Based on the panel's feedback, a small revision was required to make the questions clearer. The final AECEQ was made up of 10 items rated on a 5-point Likert-type scale ranging from *strongly disagree* to *strongly agree*. In this study, Cronbach α was used to test the internal consistency reliability. The reliability of this scale was 0.82. Before the experiment, everyone had to fill out the AECEQ to obtain each student's environmental consciousness. The questionnaire was used to investigate students' consciousness of natural resources, environmental protection and their knowledge of environmental education.

After the administration of the AECEQ survey, the AECE 4-D cycle learning system was incorporated into technological and engineering education. This study took place in autumn 2006 and the experimental period was eight weeks.

After eight weeks of instruction under the AECE 4-D cycle learning system, a post-experimental AECEQ was given to the students involved in the survey. The statistical package used to analyse the quantitative data of the questionnaire was the *Statistical Packages for the Social Sciences* (*SPSS*). An independent sample t-test was used to determine whether there was any significant difference before and after the incorporation of the AECE 4-D cycle learning system into technological and engineering education.

The experimental framework of the AECE 4-cycle learning system is shown in Figure 1.

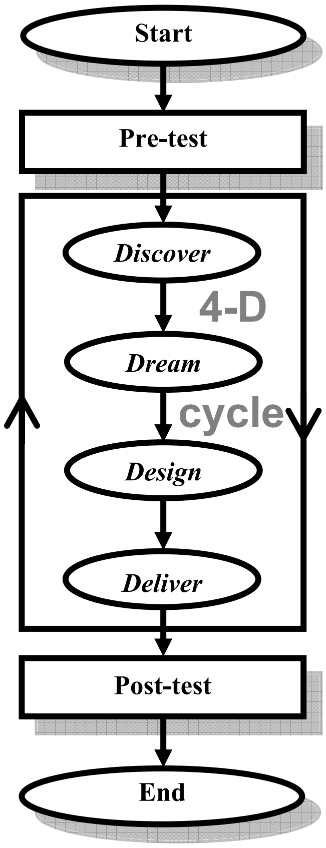

Figure 1: The experimental framework of the AECE 4-D cycle learning system.

RESULTS AND DISCUSSION

After the administration of the post-test AECEQ, the results of the survey were analysed. The research results showed that the AECE 4-D cycle learning system was effective in improving the students' environmental consciousness. The t-tests results of pre- and post-environmental consciousness are shown in Table 1. The table shows that, after the implementation of the AECE 4-D cycle learning system, students had better environmental consciousness than before.

Table 1: The results analysis of pre- and post-experimental environmental consciousness.

Item	Pre-test		Post-test		t	Sig.
	Mean	SD	Mean	SD		
1	2.91	1.03	3.70	0.63	5.816	0.000*
2	3.86	0.76	3.97	0.61	1.187	0.240
3	4.02	0.81	4.02	0.59	0.000	1.000
4	2.98	0.97	3.76	0.66	6.914	0.000*
5	3.02	0.89	3.92	0.62	8.467	0.000*
6	3.03	0.97	3.58	0.73	4.208	0.000*
7	2.77	0.94	3.61	0.68	6.563	0.000*
8	3.83	0.89	3.85	0.81	0.142	0.888
9	3.33	0.85	3.91	0.49	4.947	0.000*
10	2.03	1.02	4.01	0.62	12.778	0.000*

SD=Standard Deviation
Sig.=Significant
*p-value less than 0.01

Based on the above research purposes and data analysis, the research results show that the AECE 4-cycle learning system was effective in improving students' environmental consciousness.

While further investing the results between the pre-test and post-test, the researchers found that there were no significant differences in Items 2, 3 and 8 before and after the implementation of the AECE 4-cycle learning system. From the above results, it could be inferred that before the implementation of the learning system, although without knowledge of environmental education and general ecological principles, the students did realise the importance of environmental protection for human beings. Also they realised that the advancement of technology would cause harm to the environment, but they also had the ability to protect the natural environment. However, before the incorporation of the AECE 4-D cycle learning system into technological and engineering education, they did not have the intention to cherish natural resources and pay attention to recycling leftover food, paper, glass, plastic, etc. Moreover, they believed that human beings had the right to destroy Nature for their needs.

Through the incorporation of the AECE 4-D cycle learning system into technological and engineering courses, students' environmental consciousness can be changed. Having knowledge of environmental education and general ecological principles, students begin to appreciate the natural environment and cherish natural resources. They believe that they have the ability and can pay attention to recycling leftover food, paper, glass, plastic, etc. Besides, they realise that humans do not have the right to destroy nature for their needs but should instead protect it.

The AECE 4-D cycle learning system empowers students to envision a beautiful natural world that they value and hope for. In the discovery phase, students can begin to appreciate a variety of natural resources and the interactions between living and non-living elements in their daily lives. Once realising that the whole production process – from the extraction of resources through production, products sold and used, and the services rendered to final disposal – may endanger the beautiful natural environment. After graduation and with appreciative environmental consciousness, students can utilise their own technological and engineering expertise and knowledge to decrease the threat of the advancement of technology. For instance, they may stick to some ecological principles and do their best to prevent dust, gas, smoke and harmful chemicals being discharged and dumped into the air and rivers.

In the dream phase, after discovering the significance of environmental quality, students begin to dream and envision a positive natural environment. Instead of seeing the natural environment as a problem to be solved, students identify with some positive values in the natural environment and believe that there is a miracle in Nature that can recreate peak experiences from the past. In order to let the miracle come true, with appreciative environmental attitudes, in turn, they look upon their strengths and capacities to restore the peak moments of Nature. That is, based on the vision created in the discovery and dream phases, in order to let the vision come true, students would take some positive actions and positive change in themselves and others for the natural environment. In this stage, students do not focus on environmental problems, but rather pay attention to envisioning their hopes and aspirations for Nature, which they will keep going on into the design and delivery phases.

Based on their vision for Nature, which focuses on strengths and power, sustainable solutions can be determined in the design phase. In this phase, students can develop strategies for advancement and seek to prevent environmental degradation, while also participating in the resolution of environmental problems. For instance, based on ecological principles, these technological and engineering students can actively design some environmental protection activities or policies in advance so as to protect the natural environment. Unlike conventional environmental problem-solving education in which students are instructed to identify environmental problems and scrutinise a solution to solve them, the AECE 4-D cycle learning system focuses on preventing the causing of environmental problems in advance.

Then, in the delivery phase, students actively take action to exercise the designed environmental protection strategies or policies in order to restore Nature's beauty, such as using energy, water or other natural resources much more efficiently. With the incorporation of the AECE 4-D cycle learning system into technological and engineering education, students are empowered to actively undertake social responsibility and therefore prevent negative environmental impacts on daily lives and on Nature.

Conventional environmental education is designed for *finding and fixing* problems, which focuses on decay [3]. In this conventional environmental education, problem-solving teaching strategies are applied to help students identify environmental problems and scrutinise a solution to solve them. Conventional environmental education may leave students with an understanding of environmental issues. However, it could be possible that students may feel powerless to achieve a resolution to countering environmental degradation. Under this kind of education, students may feel powerless to undertake social responsibility for environmental protection activities. In order to motivate and empower students to develop their levels of environmental awareness and further take actions to change the world, the AECE 4-D cycle learning system was proposed.

Instruction under the AECE 4-D cycle learning system focuses on the potential of replacing conventional problem-solving instruction applied to environmental education. The basic sequence of conventional environmental problem-solving instruction is: identify key problems → analyse causes → find solutions → develop action plans [4].

This contrasts with the sequence of conventional problem-solving instruction. The cycled sequence of the AECE 4-D cycle learning system is: discover and value the best of what has been in the natural environment → dream and envision what might be in the natural environment → discuss and design what can be done to this envisioned world → construct and deliver what will be in the world.

Through the 4-D cycle of discover → dream → design → deliver, AECE implies that there is a miracle in Nature, and people, by appreciating Nature, should empower themselves with awareness and confidence to effectively protect their natural environment, and let the miracle come true. Unlike problem-solving instruction, the AECE 4-D cycle learning system looks upon nature's peak experiences in the past in order to further discuss and determine strategies to recreate those peak experiences.

To sum up, after the incorporation of the AECE 4-D cycle learning system into technological and engineering education, students can start appreciating Nature and natural resources, and through self-reflection to take action to change their environment.

CONCLUSION AND SUGGESTIONS

The research results show that the AECE 4-cycle learning system is effective in improving students' environmental consciousness. By paying attention to the vision of the future world rather than paying attention to current environmental problems, teachers deliberately create change.

In the discovery phase of the AECE 4-D cycle learning system, teachers help students mobilise the whole class to discover a positive change core for the natural environment.

In the dream phase, teachers help students create a clear and positive result-oriented vision to discover their potential to change the world or create an ideal natural environment.

In the design phase, by emphasising on the positive core, teachers help students figure out possible strategies to create their vision of the natural environment.

In the delivery phase, teachers cooperatively help students go through the processes of learning, adjustment and improvement to co-create their vision of Nature.

Through the AECE 4-D cycle of discover, dream, design and delivery, teachers help students appreciate the beauty of the natural environment. Educators can also provide students with the chance to understand the key environmental issues endangering the world today and help students recognise how they can minimise their negative impacts on the natural environment.

The key to achieving successful AECE lies in its 4-D cycle as well as good teachers. While integrating the AECE 4-D cycle learning system into technological and engineering education, teachers would definitely play an influential role in raising students' appreciative consciousness of natural resources and the environment. Moreover, while developing students' appreciative environmental consciousness, a combination of sensitive teachers with good teaching strategies and materials would result in a worthwhile interactive teaching-learning situation.

However, there are still some difficulties in implementing the learning system for technological and engineering education. For instance, while integrating the learning system into technological and engineering education, some educators may lack expertise and not know enough about their surrounding environment. Even worse, they may not know how to obtain relevant environmental information or to combine this information with the core knowledge of their course. Therefore, in order to facilitate the AECE 4-D cycle learning system, a qualified teacher is required.

However, with the incorporation of the AECE 4-D cycle learning system into technological and engineering education, students are given a chance to use what they have learned in class. After graduation, based on ecological principles, they can then utilise their own technological and engineering expertise and knowledge to develop strategies in advance to prevent the degradation of the environment or to minimise the harm that the advancement of technology brings to Nature.

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Integrated delivery in chemical engineering education

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ABSTRACT: Surveys conducted on graduating classes over the past few academic years at the Department of Chemical and Process Engineering at the Universiti Kebangsaan Malaysia (UKM), Bangi, Malaysia, found that there was a lack of integration in the delivery of chemical engineering curriculum and that students were overburdened with too many projects in a given semester. An innovative delivery approach via an integrated project was formulated and implemented in order to address the concerns raised by students. In this article, the authors discuss the formulation and implementation of the integrated project. The implementation of the integrated project successfully relates and reinforces various chemical engineering subjects to the overall chemical engineering curriculum and provides excellent opportunities for the development of soft skills such as teamwork, independent learning and communication.

INTRODUCTION

As part of the Continual Quality Improvement (CQI) process in the Engineering Faculty, Universiti Kebangsaan Malaysia (UKM), each academic programme is required to seek feedback from students and devise an action plan to improve the quality of the programme. One of the techniques employed by the Department of Chemical and Process Engineering is to conduct an exit survey of graduating students towards the end of their final semester. The objective of this exit survey is to obtain feedback regarding the learning process that the students have gone through for four years in the Department. The survey was conducted for the first time in the 2004/2005 academic year.

The results of the surveys conducted over the past three years have indicated common concerns raised by the graduating students. The more significant concerns include the following:

- A lack of integration in the delivery of the chemical engineering curriculum: each course has focused only on its own scope and no effort was made to relate subjects with other courses in the same or previous semesters;
- Students were overloaded with a number of projects in a given semester. Every semester, almost all courses that students enrol in have significant project components, thus students did not have enough time to prepare good reports for all the projects.

The only exception where students were required to integrate the knowledge that they had learned was the plant design course in the final semester of the four-year chemical and biochemical engineering programmes. Reflecting on students' feedback and the existing delivery approach, the Department's members agreed that students raised valid concerns and an innovative delivery technique was required to improve the curriculum delivery. Thus, in this article, the authors highlight the integrated delivery approach that was formulated and implemented in the Department beginning in the 2006/2007 academic year.

INTEGRATED DELIVERY

Integrated delivery was achieved via an open-ended integrated project for all chemical engineering courses in a given semester. The integrated project's components, implementation and assessment techniques are elaborated on below.

Objectives of the Integrated Project

The integrated project was formulated to address the concerns raised by students and the development of soft skills, such as communication, teamwork and independent learning. The specific objectives of the integrated project are as follows:

- Integration aspects of different courses in the chemical engineering curriculum;
- Application of basic knowledge and theories obtained from lectures in a project;
- Project work that satisfies and, at the same time, does not overburden-students;
- Application of professional chemical engineering software, such as *HYSYS*® or *SUPERPRO*®, in students' early years;
- Development of soft skills in communication, teamwork and life-long learning to obtain current and updated information on the project, as well as recognising the environmental issues.

Components of the Integrated Project

The integrated project was implemented for the first time to second year students in the first semester of the 2006/2007 academic year and who were enrolled in three of the Department's courses, namely *Chemical Process Principles*, *Chemical Engineering Thermodynamics* and *Physical Chemistry*.

An integrated project covering a wide range of topics from material and energy balances, thermodynamics and physical chemistry was formulated to ensure that these students were provided with an opportunity to apply the chemical engineering knowledge that they had already learned and, at the same time, not overburden them with too many projects. The details of the project's scope and elements for the semester 1 second year courses are presented in Table 1.

Table 1: Components of the second year integrated project in semester 1 of the 2006/2007 academic year.

Components	Details
Courses enrolled in semester	KR2313: *Chemical Process Principles*; KR2333: *Chemical Engineering Thermodynamics*; KR2353: *Physical Chemistry for Engineers*
General components	Supply and demand scenario for products, use of products, and environmental issues on waste generation and discharge limits
Chemical Process Principles	Energy and mass balance for a single component, plus energy and mass balance for multiple components
Chemical Engineering Thermodynamics	Property estimation and vapour-liquid equilibrium calculations such as dew points, bubble points and flash estimations
Physical Chemistry for Engineers	Chemical and physical properties of the components involved, plus basic chemical kinetics
Chemical engineering professional software	Simulation of the entire process and a comparison of results with those obtained from *HYSYS*® and *Superpro*® software

The second semester focused on second year students enrolled in three chemical engineering courses: *Organic Chemistry*, *Transport Phenomena 1* and *Chemical Engineering Reaction 1*. The elements of the courses in the first semester, such as property estimation (*Chemical Engineering Thermodynamics*), and energy and mass balances (*Chemical Process Principles*), were included in the project's scope. The details of the project's scope and elements for the second year courses in semester 2 are presented in Table 2.

The soft skills targeted included teamwork, communication and independent learning. For teamwork, students were divided into teams of four and the instructors decided on a team's members as suggested by Oakley et al [1]. Each group elected a team leader who was responsible for leading the team discussion and project implementation. The integrated project also required both written and oral communication. Students were required to present their findings orally and written communication was in the form of a technical report and the minutes of group meetings.

To encourage independent or active learning, in the last four weeks, students completed the integrated project with minimum supervision from the lecturers. Students planned for their group meetings and searched for the required materials in the library or on the Internet using their own initiative. The Department's lecturers were always available for consultation. In addition, the integrated project required students to use professional simulation software. This helped introduce the application of professional simulation software at an early stage, as suggested elsewhere [2][3]. Students were provided with an overview in lectures on the use of professional simulation software plus the necessary reference materials.

Table 2: Components of the second year integrated project in semester 2 of the 2006/2007 academic year.

Components	Details
Courses enrolled in semester	KR2413: *Organic Chemistry*; KR2433: *Transport Phenomena I*; KR2453: *Chemical Engineering Reaction I*
General components	Raw materials and use of products, supply and demand scenarios for products, determination of physical properties for chemicals, heat and mass balance, and process flow diagrams
Organic Chemistry	Stoichiometric equations for processes, specifying any by-product of the process and identifying separation methods of this by-product, and indicating a way to stabilise this monomers
Transport Phenomena I (momentum transfer)	Application of the Bernoulli principle to fluid flow systems, incompressible and compressible fluids, and fluid-moving machinery (pump and compressor)
Chemical Engineering Reaction I	Choice of reaction path, reactor selection, reaction kinetics and mole balance
Chemical engineering professional software	Simulation of the entire process, a case study on pump and compressor performance, generation of a pump performance curve, and a case study on reactor performance

Implementation

Students were informed about the implementation of the integrated project in the first week of the semester. The learning activities throughout the 14-week semester covered both traditional lectures by the course instructors for 10 weeks and independent study by students on the integrated project in the final four weeks. The traditional lectures for each course provided the necessary course syllabus coverage. However, the depths of topics that were covered by the project were kept to the basics. Students were expected to cover the necessary depth in the integrated project.

The project question sheet was handed to students in the third week and a constant reference was made to the integrated project in the first 10 weeks. A Web-based learning portal that all students had access to was utilised for storing the necessary documents. Students were required to submit their group report and present an oral report on the project in the last week of the semester in the presence of all the lecturers for the chemical engineering courses that the students had enrolled in for that particular semester. Students were provided feedback on their performance in completing the integrated project by the respective lecturers. The typical activities for chemical engineering courses in a given semester are listed in Table 3.

Assessment

Assessment on the integrated projects covered technical evaluation on the report submitted, oral presentations and peer assessment. The technical evaluation was carried out by the lecturers for the respective course or subject matter. Students were required to present an oral report on the project in the final week of the semester. On the day of the oral presentation, the lecturers would pick one member of the team randomly to present the report. The purpose of doing so was to ensure that every member would prepare for the oral presentation and to also allow the lecturers to test whether they had worked together

Table 3: Coursework activities.

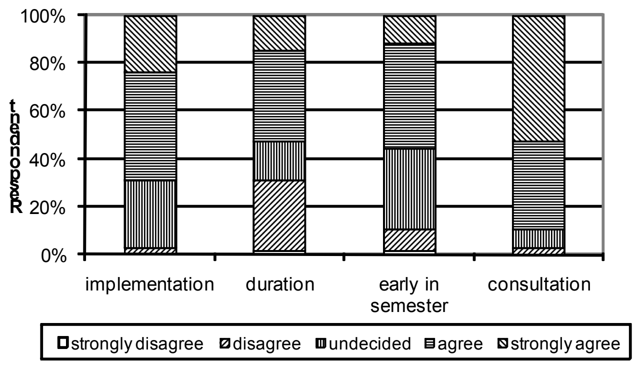
Activity	Week													
	1	2	3	4	5	6	7	8	9	10	11	12	13	14
Traditional lecture	■	■	■	■	■		■	■	■	■				
Introduction to integrated project	■													
Handing out project statement			■											
Professional chemical engineering software			■											
Industrial visit						■				■				
Completion of PFD										■				
Project work											■	■	■	■
Report submission & oral presentation														■

or otherwise by evaluating the response of the other members when answering questions from the lecturers. During the oral presentation, students were graded based on the presentation quality, ability to answer questions and professionalism. The final form of assessment was peer assessment on the performance of each team members. Since students had spent the last four weeks in a 14-week semester working together, the projects carried a 25% weight of the final grade for each course.

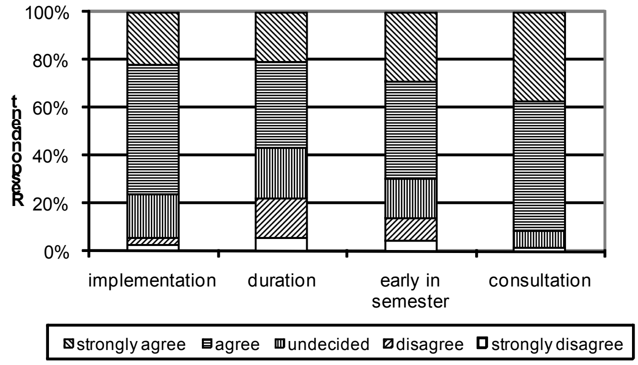
DISCUSSION

A survey was conducted at the end of the semester in order to gauge the effectiveness of the delivery technique and further improve its implementation. Feedback from students covered the aspects of integration, implementation and soft skills. Figure 1 shows students' views on the implementation in the 2006/2007 academic year. Based on students' feedback, the initial implementation of the project in the first semester of the 2006/2007 year required improvement. With the improvement that was incorporated, the majority of students agreed that the integrated project was implemented smoothly in the second semester of the 2006/2007 academic year. This figure shows that for both semesters, most students agreed that despite lacking formal lectures in the last four weeks of the semester, the lecturers were readily available for consultation and students were provided with the adequate guidance to carry out the project. The survey results indicate that the majority of students agreed that handing over the project statement to students at the beginning benefited them. However, only slightly more than half of students agreed that four weeks was adequate for completing the project. An improvement on the project scope was incorporated in the second semester of the 2006/2007 academic year, but students' opinions remained the same. The results imply that either the open-ended integrated project failed to address the issue related to students being overburdened with the project or the scope of the project was not communicated clearly to students. A dialogue session was conducted with student representatives to determine the reasons for such a situation. Based on that dialogue, it was found that most students misunderstood the scope of the open-ended project and better communication on the scope of the project was required.

The integrated project was formulated to provide opportunities for students to practise the technical knowledge that they had learned and to bring together the various aspects of chemical engineering courses to the overall engineering objectives. Figure 2 shows students' feedback on these elements of the integrated project. More than 85% of students in the first semester and 90% in the second semester agreed that the project successfully integrated the different aspects of chemical engineering courses. Regarding opportunities to apply their chemical engineering knowledge, 86% of students in the first semester and 93% in the second semester agreed that the integrated project allowed them to practise their technical knowledge and reinforced the various chemical engineering subjects to the overall chemical curriculum.



Semester 1

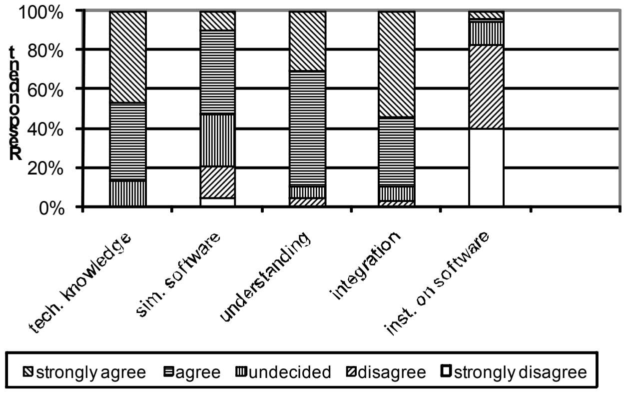


Semester 2

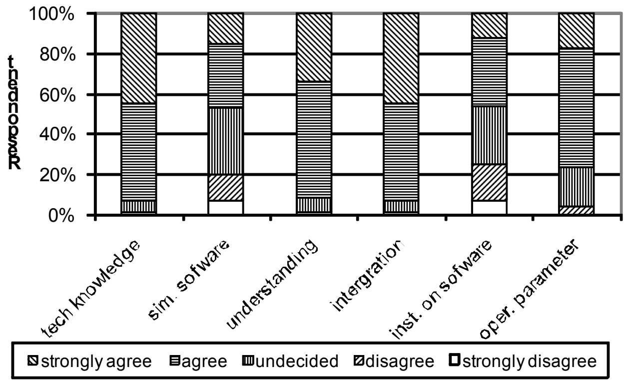
Figure 1: Implementation of the integrated project.

Figure 2 also shows that the introduction and application of professional simulation software helped to show the relevance of the different subjects to the overall engineering objectives. The application of professional software helped students to gain a better understanding of the lecture topics and to appreciate the influence of operating parameters on chemical engineering unit operations. However, most of the students felt that they were not provided with adequate exposure and instruction on the use of the professional software.

The outcomes of the two engineering degree programmes offered in the Department targeted graduates having the soft skills required of practicing engineers. The implementation of the open-ended integrated project provided excellent opportunities for the development of soft skills, such as teamwork, independent learning and communication. Figure 3 shows students' opinions on the targeted soft skills. More than 90% of students agreed that the integrated project required them to carry out independent learning or active learning. More than 90% of students in the first semester and over 96% in the second semester of the 2006/2007 academic year agreed that the integrated project provided an excellent means to develop their teamworking skills. Figure 3 also shows that most students agreed that the integrated project allowed them to practise their communication skills, both oral and written.

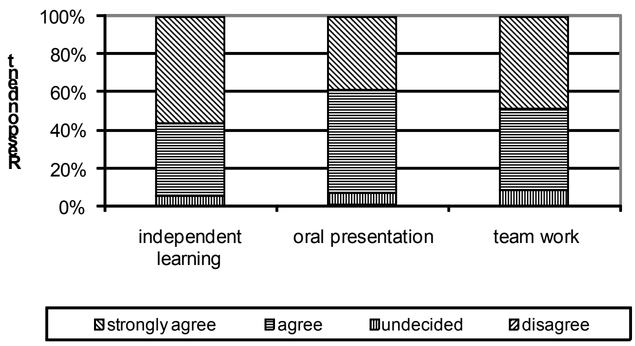


Semester 1

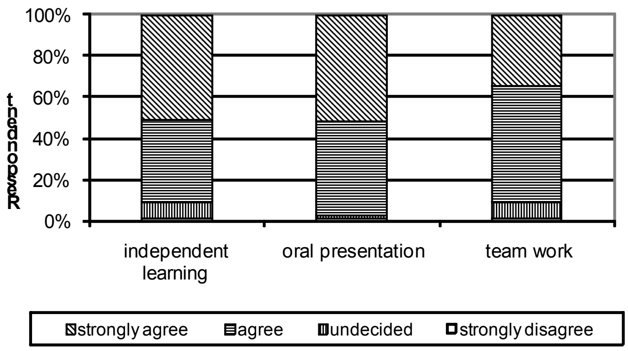


Semester 2

Figure 2: The application of chemical engineering knowledge and the integration of different courses.



Semester 1



Semester 2

Figure 3: The development of students' soft skills.

The UKM engaged two leading chemical engineering scholars from the University of Manchester, UK, and Monash University, Australia, to provide an assessment of its biochemical and chemical engineering degree programmes, respectively. Both had a high regard for the integrated project. Webb stated in his assessment report:

> *The introduction, recently, of an Integrated Project to bring together aspects of several course units is a particularly innovative feature of the degree program. It was introduced in response to graduate and industry feedback and is an excellent example of how useful such feedback is. Student feedback since its introduction has been very positive and students appreciate the opportunity to reinforce what they have learned in several modules, while at the same time recognizing that it also helps with preparation for formal assessment. The marks awarded for the project serve as the coursework element for the relevant course modules* [4].

Rhodes considered this as a novel feature in the programme and stated the following in his report:

> *… some courses in a given semester are linked through integrated projects. Towards the end of the semester students work in teams to tackle projects where the skills developed in individual courses are applied to a single project. For example: in semester 3, a single process becomes the focus of an integrated project where skills developed in Chemical Process Principles, Chemical Engineering Thermodynamics and Physical Chemistry for Engineers are applied. The 2nd year student interviewed by the assessor reported that students found this approach to be very useful in showing the relevance of the different subjects to the overall engineering objectives* [5].

CONCLUSION

The implementation of an integrated project is an innovative delivery technique that successfully relates and reinforces the various chemical engineering subjects to the overall chemical curriculum. The integrated project was formulated in response to graduate and industry feedback, and is an excellent example of how useful such feedback is. It has provided excellent opportunities for the development of soft skills like teamwork, independent learning, communication, etc, among students.

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Supporting collaborative learning interactions: an activity theory-based approach

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ABSTRACT: In this article, the author attempts to integrate existing work on supporting collaborative learning interactions within the activity theory perspective in order to provide insight into the features of the online collaborative process in a more consistent framework. In particular, the author presents the basic elements of this theory, focusing on a classification scheme of the collaboration mediating artefacts and their relevant roles. A series of collaborative interactions modelling approaches and technologies that realise artefacts from the entire above scheme are also presented. The verification of the efficiency of a supporting character mediation, as experimental uses have shown, proves the potentiality of the proposed integration. Moreover, it motivates a further elaboration of the functionality of the above artefacts across their classification scheme at a higher level of abstraction towards a more refined support by capturing the implicit characteristics of the collaborative interactions.

INTRODUCTION

The evolution of technology that supports collaborative learning is highly connected to learning theories that justify such design efforts. Within the sociocultural approach, Activity Theory (AT), as introduced by Leontiev, is proposed here as a framework for the analysis of a Web-based, asynchronous, written collaborative activity [1-4]. More specifically, such an activity can be modelled, according to AT, by an activity system as depicted in Figure 1a [5]. Within this system, collaboration takes place between subjects and a community, all sharing the same interest to perform the activity, according to predefined rules and division of labour, ie to transform an *object* (eg a case study) into an *outcome* (eg, a text that provides the solution to the case study problem(s)). Artefacts, ie tools in a broad sense that include real and mental objects, mediate the activity being subjects to transformations and carriers of the cultural characteristics of the community [6]. This transformation motivates the whole conscious activity [7]. This activity holds a dynamic character of parallel processes that take place at three levels according to the objects they are oriented to [6].

More specifically, the first level of this hierarchical structure, foresees the collaborative *activity* that is oriented to the *motive*, eg the text production. At the lower level, the *actions*, eg collaborative interactions, take place towards conscious *goals*, eg effective collaboration. Finally, the *actions* are realised by the *operations*, eg the mouse clicks that take place at the third level and are defined by the available *conditions* (eg the interface design).

Within a collaboration management system, the design of artefacts that describe the current and desired quality of the collaboration may serve the realisation of the necessary support at the collaborative interactions level towards an effective collaborative activity [8]. Thus, specific artefacts can follow the externalisation of subjects' cognitive processes that are expressed through collaborative interactions at the cognitive level [4]. Other facilitate the internalisation of feedback information they carry concerning the quality of the collaborative interactions at the metacognitive level [4][9]. At the latter level, the artefacts may enrich the subject's awareness of his/her emotional situation during collaboration and enhance his/her ability to apply strategies towards the improvement of collaborative interactions at the cognitive level. These strategies may also be externalised as meta-cognitive interactions and followed by artefacts.

From the above it is evident that cognitive and metacognitive procedures can be distributed to artefacts [10]. Thus, they can differentiate their mediating role and lead to their classification into four levels [11][12]. This is depicted in Table 1.

On the basis of the aforementioned collaboration management cycle, a supporting activity system may be developed in conjunction with the collaboration activity system, as depicted in Figure 1(b). Within the former, the subject and supporting system share the common goal of improving the quality of subjects' collaborative interactions towards a balance, which is expressed by the Balance of the Collaboration Activity (BCA) indicator [13]. The BCA, in turn, defines the division of labour in the collaboration activity system.

Motivated by the above, the present work focuses on presenting examples of supporting artefacts during asynchronous written collaboration towards the BCA (see Figure 1b) as seen from the AT perspective. More specifically, their examination within the above artefacts classification scheme sheds light on the intrinsic characteristics of collaborative interactions as seen from various perspectives.

Table 1: The classification of artefacts within an activity system.

Level	Class	Characteristics
1^{st}	The *what*	It contributes a *means* of achieving the outcome
2^{nd}	The *how to*	It contributes to the *understanding* of how to achieve the outcome
3^{rd}	The *why*	It *motivates* the achievement of the outcome
4^{th}	The *where to*	It provides the estimation of the next state of the activity in order to provoke the *evolution* of all the components of the activity system towards the achievement of the outcome.

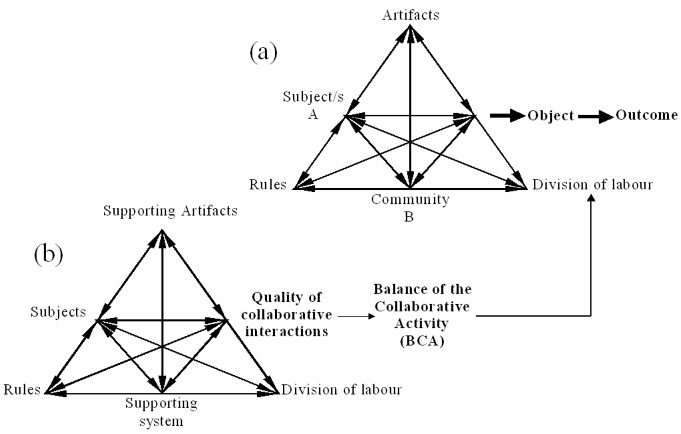

Figure 1: Activity systems for (a) collaboration and (b) the provision of support to collaborative interactions.

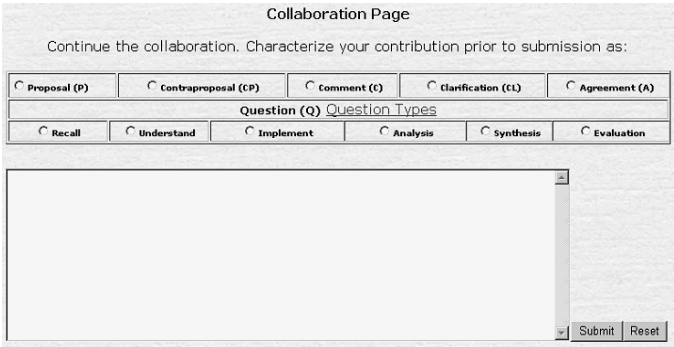

Figure 2: The *Lin2k* semi-structured communication tool showing an excerpt from the individual interface dedicated to collaboration.

EXAMPLES OF ARTEFACT IMPLEMENTATION

The artefacts that are discussed here are embedded in the *Lin2k* tool [13]. This is used for Web-based asynchronous, written collaboration. More specifically, all of these artefacts hold a supporting character, ie they materialise the activity system presented in Figure 1b, which supports two collaborating subjects $n=A,B$ (Figure 1a).

Capturing the Data (the *What* Artefacts)

In general, these artefacts are physical, tangible devices that facilitate the sharing of the common *goal*. In the asynchronous written collaboration environment, examples of such artefacts include the elements detailed below.

One such example is the virtual space(s) where the collaboration takes place, eg interfaces of common sight that facilitate the subjects to follow the threads (history) of the collaboration.

Another example covers tools for communication like semi-structured individual interfaces (eg Figure 2) that materialise an artefact with a two-fold function in both the activity systems presented in Figure 1. In the first case (Figure 1a), it materialises a dialogue management system by allowing specific interactions to take place, whereas in the second case (Figure 1b), it contributes to archiving their characteristics.

Another example incorporates log files or databases for the logging of information concerning collaborative interactions, ie type of collaborative interactions (such as *proposal, contra-proposal, comment, clarification, agreement* and *question* in Figure 2) [13]. This also invovles their sequence and the level of the subject's mental activity they express, ie cognitive or metacognitive [13]. Further elaboration of these raw data leads to the development of artefacts of higher levels.

Establishing a Common Vocabulary (the *How* Artefacts)

These tangible or intangible artefacts contribute to the realisation and use of the *what* artefacts by the subjects. In the collaboration system under consideration (Figure 1b), they refer to artefacts with an informative character that aim at the establishment of a common language between the community, ie the subjects and the system. Examples of such artefacts include information concerning the following:

- An explanation of the BCA as a goal;
- The rules that define the time intervals for the feedback provision by the system that lead to a successive sessions-concept of collaboration, namely *steps of collaboration*;
- A weighting system that differentiates the collaborative interactions on the basis of the cognitive effort that is employed for their preparation (eg a *proposal* is more highly weighted compared to an *agreement*);
- The interpretation of the feedback that is provided by the system in the form of specific indicators or depictions, eg Figure 3;
- The usage of the communication tools provided at the cognitive and metacognitive levels in order to facilitate the proper manipulation of relevant forms and interfaces by subjects during the collaborative procedure [13].

Motivating (the *Why* Artefacts)

The aim of these artefacts is to facilitate the achievement of the *goal*. An example in this direction is the modelling of the $n=A,B$ subjects' interactions in a way that provides information concerning the current quality of their collaborative interactions in the form of an indicator. In particular, a third-class artefact, namely C/M-FIS, was developed on the basis of fuzzy logic [13]. C/M-FIS managed to model the ambiguity of the linguistic description of an expert's evaluating system of the quality of collaborative interactions and provide the C_n^s indicator (see Figure 3a).

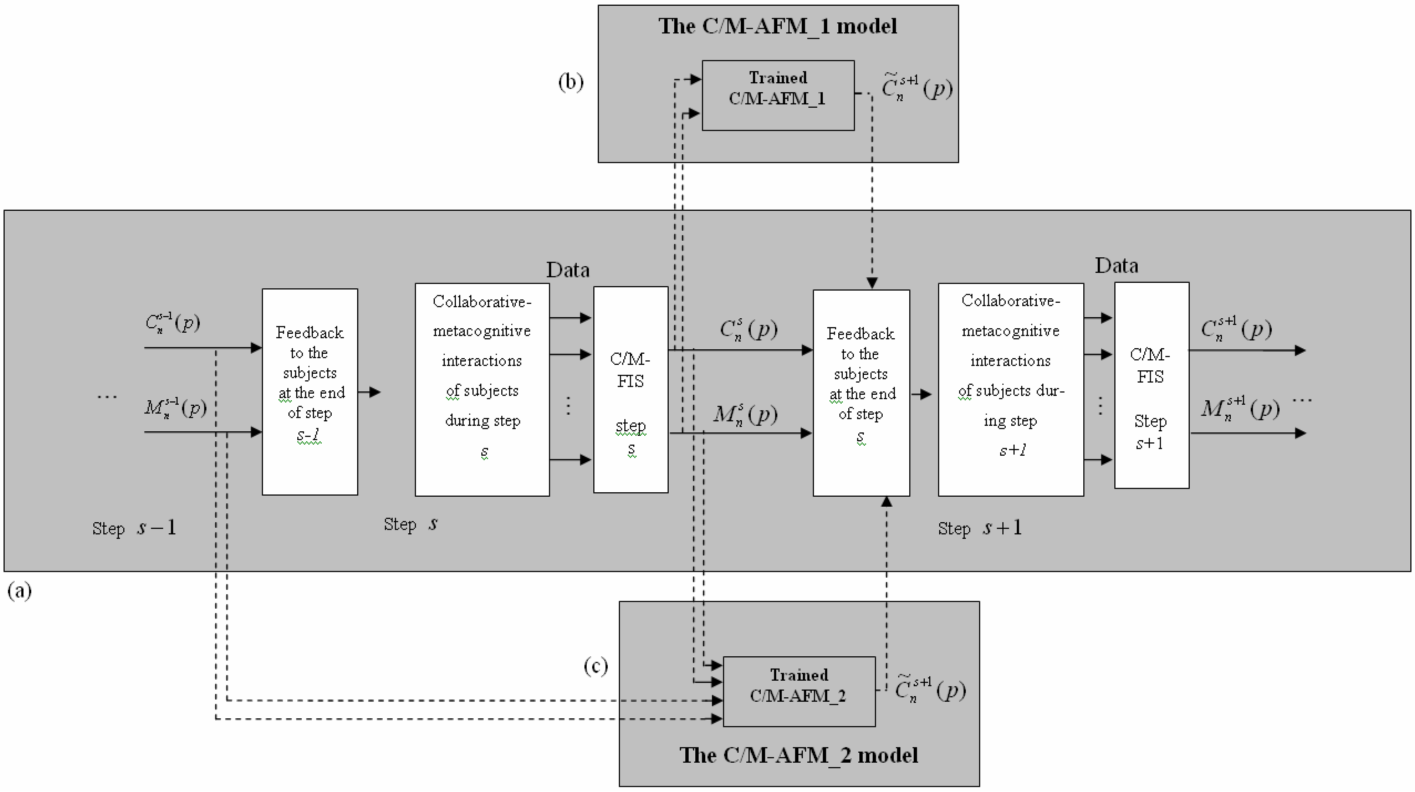

Figure 3: The integration of the *why* and *where to* artefacts within the *Lin2k* supporting activity system.

The C_A^s and C_B^s values were appropriately normalised in order to be aggregated up to 100%, the latter denoting the overall group (n=A,B) collaborative activity. Thus, a low percentage, eg of C_A^s, indicates the low contribution of A to the above activity as opposed to B, whereas a value of between 40% and 60% denotes the accepted zone of the BCA (Figure 4).

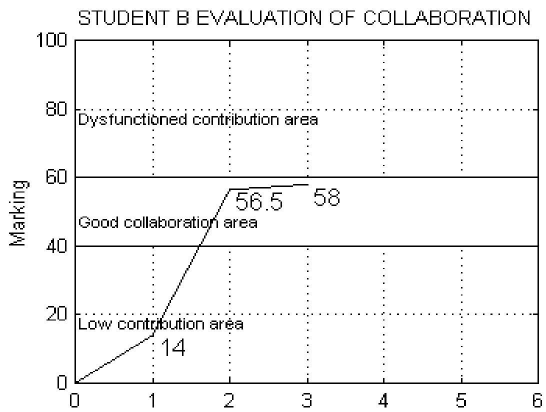

Figure 4: The depiction of the $C_B^{s=1:3}$ indicator values (%) and the BCA zone (marking 40-60%) is included in the feedback content to the subject at the end each step s.

Such information, compared to the BCA, is expected through internalisation to provoke an adjustment of the subject's collaborative strategy in the next step of collaboration [13]. The latter intention is explicitly expressed by the subject by filling in an appropriate metacognition form prior to entering the next step of collaboration. This form includes declarative sentences of *proper* collaboration and, upon selection, the improvement to specific aspects of collaboration is denoted. Raw data from this form are modelled, again through the C/M-FIS artefact, to output the M_n^s indicator (Figure 3a). The M_n^s values were also normalised in the range of 0-100% (corresponding to *no intention* to improve and to *intention for total improvement*, respectively). Within this range, the M_n^s value quantifies the intention of improvement in the forthcoming step according to the provided rules of *proper* collaboration. The divergence of the M_n^s and M_n^{s+1} indicators produces a further refinement of the feedback information (Figure 3a) that aims at the enhancement of the metacognitive strategies.

An alternative, yet with a similar aim to the above, is the development of artefacts that lead to the detection of those out-of-limits values of the C_n^s indicator in order to capture and make explicit the possible dissonance between subjects' collaborative activities and the motivation for its minimisation. In particular, in ref. [14], the use of the Quality Control Analysis (QCA) was employed for the development of an artefact of the same class. Through the upper and lower limits that are automatically defined through samples of the C_n^s and M_n^s values, which are acquired by experimental uses of the C/M-FIS, it specifies the accepted range of the absolute value $dC_{A,B}^s = \left|C_A^s - C_B^s\right|$. The latter serves as a measure of the divergence from the BCA and the QCA further refines the feedback content.

Another example of the third class artefact can be found in ref. [15], which, on the basis of the Lempel-Ziv algorithm, calculates a complexity indicator of the interactions turn-taking, proving an increase of its value when the feedback is provided.

Frustrating the Goal (the *Where to* Artefacts)

The prediction of human behaviour is quite a common situation in real-life contexts. When a *goal* is frustrated, it is then necessary to realise what to do next and set a new goal [6]. Keeping this analogy, when the goal of the collaborative activity under consideration, ie convergent to the BCA, is envisioned to be unsatisfactory, then adjustment procedures may be challenged. Following this direction, predictive models can be employed to provide the *where to* artefacts. An example of artefact of the *where to* level can be found in ref. [16].

In particular, fuzzy neural networks technology was used to train a network, namely C/M-AFM, upon historical data. This is aimed at modelling the relation between C_n^s and M_n^s, with $\widetilde{C}_n^{s+1}$ for all the steps, ie to model the implicit characteristic of the adopted collaborative strategies by the subject per step. Two scenarios were studied: the C/M-AFM_1 and C/M-AFM_2, respectively. These scenarios differed on the depth of the collaboration history used for the training (Figures 3b and 3c). Small differences were detected between the two scenarios through sufficient model validation procedures. A further refinement of the training procedure is expected to verify this finding. When trained, the C/M-AFM artefact can provide a real-time estimation of the forthcoming $\widetilde{C}_n^{s+1}$ value on the basis of the aggregation of the current step's collaborative and metacognitive strategies. Providing this estimation as feedback to the subject prior to step $s + 1$ (Figure 3a) is expected to support further the BCA *goal*.

CONCLUSIONS

An Activity Theory-based (AT) approach of supporting collaborative learning interactions is presented in this article, placing the features of the collaborative process in a more consistent methodological framework. In the light of the above methodological framework, the use of artefact classes is also proposed. Examples of the *what*, *how*, *why* and *where to* classes of artefacts, involving a range of enhanced processing/modelling techniques, are presented in order to prove the potentiality of the materialisation of all the levels of the proposed taxonomy within the AT framework.

Initial results show that the proposed framework can integrate a variety of approaches that are aimed at facilitating peer collaboration. Detailed information and indicative results of the presented techniques can be found in the cited references.

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Using the biographies of outstanding women in electrical and electronics engineering to overcome teachers' misperceptions of engineers and engineering

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ABSTRACT: In this article, the authors describe an activity that they have carried out with 80 high school physics teachers to enable them to overcome their stereotypical perceptions of engineers and engineering. The activity introduced them to outstanding women in electrical and electronics engineering, and raised their awareness of these female engineers' contributions to engineering and society. The results showed that the activity was effective in dispelling the teachers' misperceptions of engineers and engineering. By providing detailed information about the personal lives and work experiences of the female engineers, the biographies might be useful in countering existing cultural stereotypes of female engineers and initiating changes in perceptions needed to narrow the gender gap in engineering. Teachers and professors can use the examples of these outstanding female engineers as role models to inspire their female students who are aspiring to become engineers.

INTRODUCTION

The perception that engineers and scientists are intelligent Caucasian men who are socially inept and absent-minded people seems to be prevalent among students at all levels, from elementary school to college [1][2]. While the media may, by chance or choice, promote this image, it is unfortunately not far from the reality. For example, while women constituted 46.1% of the general workforce in the USA in 2000, they represented only 25.4% of the engineering and science workforce [3]. These stereotypical images of engineers and scientists as Caucasian men have, in part, discouraged many young women from pursuing any interest they may have in an engineering or science career because they do not want to (and cannot) be the people so often portrayed in the media [4].

Fortunately, research has shown that strategies such as the presentation of female role models, distribution of career information, examination of gender-equitable materials, and participation in hands-on science investigations are effective in countering the stereotypical perceptions of engineers and scientists [5-8]. Research has also pointed to the presence of female role models in engineering and science as the most important factor in sustaining girls' interests in engineering and science [9].

In order to reach out to students at an early age when they are still impressionable, many universities have recently organised outreach programmes to inform high school teachers about engineering and, hopefully, to encourage their students to study engineering [10]. Some universities (eg Purdue University) have even set up an engineering education department for this purpose. The feedback from such programmes has been encouraging.

For this work, which was carried out at Nanyang Technological University in Singapore, the authors wanted to inform teachers about engineering applications, to demonstrate the problem-solving approach of engineers, to correct misperceptions of engineers and engineering among teachers, and to provide them with female role models from the various disciplines of engineering. To achieve these goals, the authors recently conducted a number of outreach workshop activities for 80 high school physics teachers. The teachers were then charged with integrating what they had learned from the workshop into their classrooms.

In this article, the authors describe one of the workshop activities that the authors conducted with high school physics teachers to enable them to overcome their stereotypical perceptions of engineers and engineering. The workshop activity introduced them to outstanding women in electrical and electronics engineering, and raised their awareness of these female engineers' contributions to engineering and society. Teachers and professors can use the examples of these outstanding female engineers as role models to inspire their female students who seek to become engineers.

METHOD

The high school physics teachers consisted of 45 males and 35 females. Their age ranged from 25 to 45. The participants were first asked to complete a *draw-an-engineer* test to assess their perceptions of engineers and engineering. The test required them to draw a picture of an engineer at work [2]. The drawings were analysed as follows:

- Drawings of engineers with short hair and broad shoulders were regarded as males while those with long hair and narrow shoulders were seen as females;
- Drawings of engineers working with one or more of the following items were considered as engaged in building or repairing: hard hat, workbench, heavy machinery,

hammer, wrench, car, engine, rocket, airplane, robot, bridge, road, building, train and train track;
- Drawings of engineers working with a computer, blueprint, pen, model, and/or desk were regarded as engaged in planning or designing;
- Drawings of engineers working with test tubes and/or beakers were deemed as doing laboratory work.

The participants were then randomly divided into groups of four members each, and the various groups were each assigned a female engineer from Table 1 to research on. Table 1 contains 20 outstanding women in electrical and electronics engineering, and their major achievements. The participants were given one week to carry out their research and were encouraged to use Internet resources for their research.

Each group was required to undertake a 20-minute oral presentation and submit a written report of the female engineer assigned to the group. The participants were required to design and present various documents to give an overview of the female engineer's life, for example, birth certificate, educational certificates, marriage certificate, and resume for a hypothetical research post that she wished to apply for. Other items to address during the presentation included the following:

- Who inspired the person to become an engineer?
- What was the nature of her work?
- What were her research interests?
- What were her major research findings, and how had they influenced the current knowledge then?
- What were the difficulties she had encountered in her research or work, and how had she overcome them?
- What were some issues in her life which were unusually inspiring for young women studying engineering?

Each oral presentation was followed by a five-minute question-and-answer session. After all the groups had presented, the *Draw-an-engineer* test was administered to determine the effectiveness of the oral presentations in dispelling the participants' misperceptions of engineers and engineering. The significance of differences in drawings before and after the intervention was assessed by McNemar's Test for the Significance of Changes [11]. A post-activity survey consisting of four forced-choice items was also administered, and this required the participants to indicate what they had noted about the biographies of the female engineers in terms of the following:

- Who inspired them to become engineers?
- What appointments did they hold?
- What were the difficulties they had encountered at their workplaces?
- How did they cope with both work and family life?

RESULTS AND DISCUSSION

The authors observed that the female engineers featured during the oral presentations really captured the attention of the participants. The participants seemed to show greater enthusiasm than anticipated, and they participated actively in the question-and-answer sessions.

The participants commented that administering the *Draw-an-engineer* test at the outset without them suspecting anything was a powerful method to make them become aware of their misperceptions of engineers and engineering.

The results showed that before the intervention, the perception of engineers as men seemed to be more prevalent among the male participants as compared to the female participants – all the male participants depicted engineers as men while 91.4% of the female participants did so. The results showed that the activity was effective in dispelling the participants' perceptions of engineers as men. The percentage of male participants who depicted engineers as men decreased from 100% before the intervention to 62.2% after the intervention ($p < 0.01$). Similarly, the percentage of female participants who depicted engineers as men decreased from 91.4% before the intervention to 31.4% after the intervention ($p < 0.01$). After the intervention, the male participants seemed to be more tenacious of their perceptions of engineers as men than the female participants – the percentage of male participants who depicted engineers as men decreased by 37.8% whereas that of female participants decreased by 60.0%.

In the drawings, the participants showed engineers engaged in building or repairing, planning or designing, or laboratory work. The results showed that the activity was effective in countering the participants' perceptions of the nature of engineering jobs. The percentage of male participants who portrayed engineers engaged in building or repairing decreased from 66.7% before the intervention to 4.4% after the intervention while that of female participants decreased from 74.3% to 2.9% ($p < 0.01$). Conversely, the percentage of male participants who depicted engineers engaged in planning or designing increased from 26.7% before the intervention to 91.2% after the intervention while that of female participants increased from 20.0% to 91.4% ($p < 0.01$).

Thus, prior to the intervention, a majority of the participants had the misperception that engineering jobs involved a lot of manual work and were physically demanding. The oral presentations enabled the participants to note that engineers were increasingly required to think, plan, design and communicate, and not do just manual work. In order to encourage more girls to pursue engineering, teachers need to highlight to students that in today's knowledge-based and innovation-driven economy, engineering requires intellectual abilities and the capacity for innovation, and not so much manual work.

The participants noted that the female engineers featured here cited the role of their parents or teachers in encouraging their pursuit of an engineering career. Research has pointed out the importance of parental support in fostering young women's interest in science-related careers [12].

Research has also shown that teachers play a critical role in young women's decision to pursue careers in engineering and science [13]. All these might suggest that organising outreach programmes directed specifically at parents or teachers might help to narrow the gender gap in engineering.

The participants noted that the female engineers featured here held senior positions in academia, government or industry. Many of them were members of the US National Academy of Engineering (NAE). They were different from those the participants had ever encountered and those found in many studies where most female characters were shown as pupils, laboratory assistants or science reporters [14]. The female engineers featured here could, therefore, be used to overcome existing stereotypes of female engineers.

Table 1: Outstanding women in electrical and electronics engineering and their major achievements.

1.	Eleanor Baum Previously appointed President of the Accreditation Board for Engineering and Technology (ABET), and President of the American Society for Engineering Education (ASEE). Appointed Dean of Engineering of the Cooper Union for the Advancement of Science and Art in New York City since 1987 [16].
2.	Edith Clarke Awarded a patent in 1921 for a *graphical calculator* that was used for solving electric power transmission line computations. Authored a two-volume reference book entitled *Circuit Analysis of AC Power Systems*, which became classics in the field [17].
3.	Esther M. Conwell Developed the theory behind the conduction of electricity in semiconductor materials used in transistors. Investigated the transport and optical properties of organic conductors, which were important components of xerographic copiers and printers. Held four patents. Elected a member of the US NAE [18].
4.	Denice Denton Researched micro-electro mechanical systems as an enabling technology, and in the arena of transformational change in higher education. Appointed the Dean of Engineering at the University of Washington in 1996, and the Chancellor of the University of California at Santa Cruz in 2005 [19].
5.	Mildred Spiewak Dresselhaus Established high-field magneto-optic spectroscopy as a tool for the study of the electronic structures of semi-metals. Modified the structures and properties of electronic materials, carbon fibres, fullerenes and bismuth nanowires. Appointed the Director of the Office of Science of the US Department of Energy in 2000. Elected a member of the US NAE [20].
6.	Mitra Dutta Developed unique optical characterisation and diagnostic techniques, which were used for the design of novel hetero-structures for optoelectronic and electronic devices of superior performance. Held 24 patents [21].
7.	Delores M. Etter Contributed to adaptive signal processing, digital filter design and biometric signal processing. Appointed Deputy Under Secretary of US Defense for Science and Technology in 1998, and Assistant Secretary of US Navy for Research, Development and Acquisition in 2005. Elected a member of the US NAE [22].
8.	Elsa M. Garmire Discovered the key features of stimulated light scattering and self-focusing. Demonstrated the key components of integrated optics in semiconductors. Invented a generic class of hybrid-electrical optical bi-stable devices, a technology pivotal in digital optical computing. Held nine patents. Elected a member of the US NAE [23].
9.	Evelyn L. Hu Developed microfabrication and nanofabrication techniques to facilitate the study of superconducting and semiconducting devices and circuits. Examined the processes critical for the fabrication and operation of superconducting, electronic and optical devices. Studied the formation of high-quality, heterogeneous interfaces, such as that between semiconductors and superconductors. Elected a member of the US NAE [24].
10.	Jennie S. Hwang Recognised as a pioneer and longstanding leader in the fast-moving infrastructure development of electronics miniaturisation and environment-friendly manufacturing, including Surface Mount Technology and environment-friendly lead-free electronics. Held nine patents. Appointed the President of the H-Technologies Group Inc and Asahi Technologies America Inc. Elected a member of the US NAE [25].
11.	Shirley Ann Jackson Recognised for her work on the polaronic aspects of electrons in two-dimensional systems. Her research in solid-state physics resulted in rapid improvements in the signal-handling capabilities of semiconductor devices. Spearheaded the formation of the International Nuclear Regulators Association. Appointed the President of Rensselaer Polytechnic Institute in 1999. Elected a member of the US NAE [26].
12.	Leah H. Jamieson Co-founded the Engineering Projects in Community Service programme. Contributed to research on speech analysis and recognition; design and analysis of parallel processing algorithms; and the application of parallel processing to digital speech, image and signal processing. Appointed the Dean of Engineering at Purdue University in 2006, and the President of the Institute of Electrical and Electronics Engineers in 2007. Elected a member of the US NAE [27].
13.	Betsy Ancker-Johnson Described plasma as a fourth state of matter after solids, liquids and gases, and discovered that solid-state plasmas could serve as microwave sources of radiation. Developed a high-frequency signal generator. Appointed Assistant Secretary of US Commerce for Science and Technology in 1973. Elected a member of the US NAE [28].
14.	Kristina M. Johnson Recognised for her contributions to holography, optical and signal processing, liquid crystal electro-optics, and using a novel variety of liquid crystals to create new types of miniature displays and computer monitors. Founded Colorado Advanced Photonics Technology Center, ColorLink, KAJ LLC, Colorado Microdisplay, and Southeast TechInventures. Held 43 patents. Appointed the Dean of Engineering at Duke University in 1999 [29].
15.	Linda P.B. Katehi Recognised for her contributions to three-dimensional integrated circuits and on-wafer packaging. Held 13 patents. Appointed the Dean of Engineering at Purdue University in 2002, and the Provost and Vice Chancellor for Academic Affairs at the University of Illinois in 2006. Elected a member of the US NAE [30].

16.	Cherry Murray Developed the optical fabric for the first all-optical cross connect for telecommunications networks, and 40 Gbit electronics for Lucent Technologies' optical products. Held two patents. Elected a member of the US NAE [31].
17.	Irene Carswell Peden Determined the bulk electromagnetic properties of Antarctic ice 7,000 feet thick using surface data. Developed analytical model for interpreting data from a probe lowered into deep ice, yielding the first direct measurements of VLF dielectric and loss properties. Elected a member of the US NAE [32].
18.	Manijeh Razeghi Initiated the design and implementation of epitaxial growth techniques. Developed a number of semiconductor structures for advanced photonic and electronic devices. Pioneered the growth of (Ga,In) (As,P)-based hetero-structures, thereby overcoming numerous material problems. Held 50 patents [33].
19.	Evangelia Micheli-Tzanakou Contributed to research on neural networks in biology and medicine, visual and auditory systems, and the modelling of neurological disorders. Established the first brain-to-computer interface using her algorithm ALOPEX. ALOPEX has also been used for digital signal processing, image processing and pattern recognition [34].
20.	Doris Kuhlmann-Wilsdorf Studied tribology and the mechanical properties of metals. Developed a theory of crystal defects, crystal plasticity and electric contacts. Invented metal-fibre brushes, which were critical parts of motors and generators. Held six patents. Elected a member of the US NAE [35].

The participants noted that the female engineers featured here acknowledged that they had encountered difficulties at their workplaces, such as the absence of female role models, mentors and colleagues, supervisors' stereotyping of women's abilities, differences in communication style and sexism, but they also mentioned recent progress made towards acceptance and equality. The participants felt that although these difficulties truthfully reflected the experiences of female engineers, such revelations might deter talented young women from pursuing careers in engineering. This is a significant point because research shows that young women are less likely to choose careers in science because of the difficulties associated with doing science [15]. The participants felt that while it was important to raise young women's awareness of the *chilly environment* that might exist in engineering, it was even more important to highlight the improvements made in producing more inclusive workplaces in engineering.

The participants noted that the female engineers featured here were able to cope with both work and family life because of pro-family workplace policies, and having a supportive, and understanding husband and efficient domestic help. This is an important point because concerns about how to balance work and family responsibilities appear to be a recurring issue in research on the factors that keep young women from pursuing engineering and science careers [1]. In order to encourage more young women to pursue engineering, it was thus important to highlight how female engineers successfully combined work and family.

CONCLUSION

In this article, the authors describe an activity that can be used to correct the misperceptions of engineers and engineering among high school teachers. By providing detailed information about the personal lives and work experiences of prominent female engineers, these biographies might be useful in countering existing cultural stereotypes of female engineers and initiating changes in perceptions needed to narrow the gender gap in engineering. The activity could also be used for elementary and middle school teachers – this might enable them to correct misperceptions of engineers and engineering among their students. Furthermore, the activity could be carried out by professors with female undergraduates or graduate students so as to provide them with female role models – this would encourage them to pursue and excel in electrical and electronics engineering as a course of study and as a profession.

It is hoped that more educators will use this type of activity to correct the myth among girls and young women that a career in engineering is not suited for them. Professors and teachers need to take every opportunity to assure girls and young women that females can contribute as equally as males to engineering, as illustrated by the outstanding female engineers featured here. As the world economy becomes increasingly reliant on a technologically literate workforce, the world cannot afford to overlook the talent and potential contributions of half of the population. If it does, societies, nations and our world will suffer.

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A study of enterprises' employment terms and competences for technological and vocational school graduates in Taiwan

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ABSTRACT: This study is aimed at exploring enterprises' employment terms and the required competences of technological and vocational school graduates in Taiwan by using two methods, specifically content analysis and in-depth interviews. The former was used to analyse employment terms in the 104 Job Bank to understand the requirements of applicants in the commercial labour market, while the latter was used to explore the competences of applicants by interviewing personnel managers in four industries, including the food and beverage industry, the national trade industry, the financial industry, and the wholesale and retailing industry. The findings reveal that employers in businesses and the service industry placed great emphasis on the following competences of applicants: basic technique, information application, individual management skills and teamwork. The findings indicate that junior college graduates are the favourites in the labour market for commercial industries. Also, employers take study major, certification and experience into account when hiring employees.

INTRODUCTION

The current occupational structure in Taiwan is undergoing a transformation as technology, the degree of automation and industry grow. In August 1993, the service industry occupied 58.03% of the employment structure. In particular, customer service and sales staff increased by an average of 2.8% annually. It is estimated that the number of workers in the customer service field will equal 2,199,000 people in 2014. The increasing numbers will be maintained at around 120,000 from 2001 to 2011 [1-3]. As a consequence, customer service and sales workers will be the workers most in demand in the labour force in the near future. Figures quoted in a report by the Council of Labor Affairs' Employment and Vocational Training Administration (EVTA) concerning popular occupations indicate that office clerks and workers in the financial and service sectors amount to 27.03%, which roughly amounts to a quarter of all job vacancies provided by the employment service centre. Regarding job vacancies in the business and service sectors, the need for accountants and salespeople is up to 32.36%. The work of professional assistants, office clerks and salespeople in these two sectors occupied the majority of job vacancies for both employers and employees [1-4].

Mid-level experts in Taiwan are mostly cultivated by the technical and vocational school system in response to industrial trends. The development of vocational education should correspond to the demands of enterprises. The employment rate among graduates in business sectors is highest at 25.78% [1]. The Council of Economic Planning and Development has suggested that under the influence of the amended ratio of senior high and vocational high schools, the number of graduates from senior high schools will grow by 1.4%, while the number of graduates from vocational high schools will fall by 3.4%. Therefore, student enrolments at higher vocational education institutions will be affected. In addition, the expansion of higher vocational education and the updating of junior colleges have given rise to increasing numbers of vocational schools as well as subjects. Although the Ministry of Education in Taiwan has set controls on the level of growth, the majority of schools have not reached saturation point. In other words, the sum of students at technical and vocational schools is set to increase yearly in subsequent years.

Over the past few years, the birth rate has fallen and the channels for higher education have become more diversified. With an imbalanced supply and demand, technical vocational schools should enhance the nature of their organisation, create attractive school specialties, understand thoroughly industry demands, and adjust academic systems, subjects and courses to ensure the sustained relevance of educational institutions.

The National Association of Manufacturers (NAM) conducted the third national industry survey over the past decade to explore the cause of the economic recession in the USA. It was found that 80% of manufacturers blamed bad work quality, two-thirds thought the shortage of employment competences was responsible, 60% cited the lack of required skills, and 40% considered that the failure to boost efficiency was the culprit. Jasinowski's survey indicated that over 75% of employers thought that graduates were not well prepared to enter the employment market, so employers appealed to the government to ensure quality education. Only by shortening this gap in technical skills can the estimated 120,000 vacancies in skilled positions projected for 2020 be filled [5][6].

National and international analyses of labour force demands and benefits are classified according to employment, income, employment rate, unemployment rate and the degree of labour contribution in order to understand the balance of supply and demand of human resources [7-12]. Since the late 1970s, non-monetary efficiency factors, such as working hours and the diverse application of professional abilities, have been taken into consideration to estimate the value of human resources and education [13-23]. However, from the viewpoint of employers' demand for labour, Liu pointed out that employers were inclined to consider human capital when emphasising an applicant's capabilities or productivity [24]. When the candidate had relevant and recognised work experience, an educational degree from a junior college or university made little difference. So what are the employment requirements in different industries? What are relevant employment competencies? What are the requirements criteria for different levels of education? In this study, the authors aim to explore these issues by using content analysis and in-depth interviews to understand enterprises' employment competence demands and employment in order to explore their influences on vocational schools and their corresponding strategies, and to serve as a reference for vocational schools to adjust their courses in order to cultivate talent [25-30].

METHODS AND IMPLEMENTATION

In this study, the 104 Job Bank database was used to analyse employment conditions. In addition, human resource departments or persons in charge of personnel departments in businesses and the service industry were selected to be the subjects for in-depth interviews. The findings can serve as a reference for business and administration departments to be used to cultivate talent that meets their needs [31].

Methods

Content analysis and in-depth interviews were applied in this research as follows:

- The 104 Job Bank database was utilised to analyse industries' employment demands with regard to different occupational types, educational degrees, position types or ranks, as well as the required contents of different educational degrees;
- In-depth interviews were used to interview managers in human resource departments to understand their employment demands of new recruits.

Implementation

Employment data collection and analysis in the 104 Job Bank was analysed from 7 August 2006 to 26 August 2006. As Table 1 shows, industry employment sectors were sorted into five categories: financial securities, international trade, management consultancy, general merchandising and retailing, and food and beverage. The collected data totalled 3,059, but the data that was complete and analysed totalled 3,052 [31].

Table 1: Data collection duration.

Industry Type	Duration	Data Amount
Financial securities	8/7, 8/12, 8/17, 8/22	859
International trade	8/8, 8/13, 8/18, 8/23	814
Management consultancy	8/9, 8/14, 8/19, 8/24	420
General merchandising and retailing	8/10, 8/15, 8/20, 8/25	750
Food and beverage service	8/11, 8/16, 8/21, 8/26	209

According to categories of occupations in Taiwan, the collected data were classified into six categories: managerial staff, professionals, assistant professionals, routine staff, customer service and sales staff, and part-time and assistant routine staff. Other basic data were organised based on the employment requirements listed in Table 2.

Table 2: Basic information descriptions.

Basic Information	Category	Amount	Ratio
Type of industry	Finance	859	28.1%
	International trade	814	26.7%
	Management consultant	420	13.8%
	General merchandise and retailing	750	24.6%
	Hotel and restaurant	209	6.8%
Type of role	Management	474	15.5%
	Professional	580	19.0%
	Assistant professional	1,229	40.2%
	Office staff	298	9.8%
	Customer service and sales	356	11.7%
	Part-time staff or assistant	115	3.8%
Education degree	University	709	23.2%
	Junior college	1,108	36.3%
	Senior high school	1,036	34%
	Non-requirement	198	6.5%
Rank in the organisation	Manager	567	18.7%
	Mid-level cadre	892	29.3%
	Basic-level labour	1,586	52%

It can be seen from Table 2 that the highest proportion, regarding the type of role, was for assistant professionals, while the smallest segment covered part-time and assistant office staff. It was also found that 71.85% of employment opportunities were not limited by gender. Females were required in work totalling 23.1% and males 5.0%. As for education degree requirements, university level or higher stood at 23.2%, junior college degree or above was 36.3%, senior high school degree or above took 34%, and no educational degree requirement was 6.5%. Rankings in organisations were dominated by basic-level workers (52%), the mid-level cadre (29.3%) and then managerial staff (18.7%) [1-4][31].

Managers in personnel departments acquiesced to in-depth interviews, which were undertaken in order to understand the content requirement of human resource departments. Prior to the interviews, an outline was developed based on the literature review and content analysis; a manager of a human resource department in an unknown enterprise was selected to be interviewed. The interview outline, content, order and researcher's manner of expression were amended accordingly.

A total of four managers, two from human resource departments and two from personnel departments, accepted the interview, undergoing interviews for two or three hours. The profiles of the subjects were researched and gathered on a Web site in advance. The interview was conducted based on interview outlines and interview plans. The contents of the interviews were recorded after receiving the interviewees' approval. The interviewees, human resource structures and interview codes are classified in Table 3.

DATA ANALYSIS AND DISCUSSION

The data were analysed in the following two ways:

Table 3: Interviewee and labour force structure of the interviewed company.

Industry Type	Title of Interviewee	Labour Force Structure of the Interviewed Company	Interview Time and Code
Restaurant and recreation park	Human resource manager	Staff (including interns): 550 Junior high school degree or below: approximately 50 (~10%) Senior/vocational high school: approximately 300 (~58%) Junior college (including university): approximately 200 (~32%)	18 September 2006 (R950918)
International trade (automobile manufacturing international trade department)	Personnel department manager	Staff: 680 people Junior high (and below): 130 (senior staff) Senior/vocational high school: 300 Junior college: 200 University: 50	29 September 2006 (N950929)
Finance industry	Bank branch deputy director	Staff: 35 Senior/vocational school: 2 Junior college: 26 University: 7	4 September 2006 (M950904)
Wholesale and retail industry	Manager	Staff: 600 (branch approximately 90) Senior/vocational high school: 60-70 Junior college: approximately 12 (10-15%) University: 7	16 September 2006 (C950916)

- The employment data analysis was according to data collected from the 104 Job Bank. The statistical procedures included a number distribution, percentage and the Chi square test, which were used to determine the distribution of different industries, occupational types and ranks, and variations in the workforce requirements regarding educational degree, graduating department, work experience and qualifications;
- The interview data analysis was derived from managers in personnel departments. In order to facilitate the research and confirm the data, the study encoded interviewees according to industry type and interview date. Based on the interview data, a modified analysis was utilised to organise and analyse the data, and encode the content after interviewing the managers. A constant comparative analysis was used to organise the data and analyse the differences and similarities.

Analysis of Employment Requirements in Different Industries

Education Degree Requirements in Different Industries

The 104 Job Bank analyses revealed that 6.5% of employers did not consider a tertiary degree as an employment requirement. Vocational/senior high school degrees were demanded in the retail industries, while junior college degrees were required in other industries. It was also found that 70% of employers did not see academic majors as an employment requirement. Around 20% of employers only required applicants to have a business background.

The interview data shows that employers did not consider a degree merely as an employment requirement; they emphasised that it was an index to evaluate an applicant's capacities. More importance was placed on an applicant's work attitude. This finding is the same as in employment theory. There were differences found regarding selection in that a degree would affect the talents focused on in the internal flow of a company's use of human resources. Relevant contents gathered from interviews are quoted below:

- *My company does not emphasise an educational degree. Salary will not be affected a lot by the degree, but by experience and performance. Employees with higher degrees are more capable for sure, and degrees and working abilities exist in positive, but not absolute, relationship. Advanced degrees do not guarantee capability, but workers with higher degrees will be assigned more important tasks* (Table 3: R950918);
- *Employees graduating from universities are more liable to get promotion if they have sufficient capabilities. We do not design promotion mechanisms on the basis of a degree, but on the capability to take this job* (Table 3: N950929);
- *We certainly expect highly educated people to work in my company. However, once they become members of the company, their involvement and distribution in work are estimated. A degree is less important basically* (Table 3: C959016).

Qualification Requirements in Different Industries

The data from the 104 Job Bank indicated that around 10% of employers required applicants to hold professional qualifications, which are highly valued in the financial industry.

Work Experience Requirements in Different Industries

The data from the 104 Job Bank revealed that about 38% of each industry required applicants to have work experience covering at least three years.

According to the findings gained from the interviews, business administration experience was valued at the managerial level, while practical experience was valued at the basic and middle levels. Based on the human resource capital theory, employers emphasised practical experience for basic-level workers. Notable statements from the interviews are quoted below:

- *Live experience is very important. If a university student takes a job as manager, what he does is live service work plus administration and management. Employees graduating from two-year institutes of technology start their working life as a clerk. Without administration and management, there is no difference between the work of* *university students and high school students. Therefore, this is an experience-oriented industry* (Table 3: R950918);

- *For management level, it is better to have an employee who used to study business administration to do the work, but I do not think it is mandatory to have them do the work of assistants or clerks, but it is suitable to have them do work pertaining to management. Having life experience is preferable* (Table 3: M950904);
- *I always emphasise our service, which presents our public face. This is the difficulty. Some people cannot wear smiles while working, so we have to educate them. As I said, follow me, follow me. Do what the managers are doing. I will not blame you if you do what I did not do or you made mistakes because you never did it before* (Table 3: C950916).

Analysis of Employment Requirements Pertaining to Different Occupational Types

Applicants' employment requirements in different occupational types are elaborated on below.

Education Degree Requirements in Different Occupational Types

The data gathered from the 104 Job Bank revealed that junior college and vocational/senior high education degrees were required in business, service and sales, and assistant and part-time jobs. University and junior college degrees were required at the managerial staff, professional or assistant levels. It was found that 43.2% of enterprises demanded that applicants be equipped with university degrees for work at the managerial level [31][32].

Graduation Requirements in Different Occupational Types

From the data in the 104 Job Bank, more than 70% of enterprises did not consider applicants' graduating majors as an employment requirement. In particular, 95% of service and sales employers and 81% of business and part-time or assistant employers did not consider majors as an employment requirement. Other business job vacancies only required a business background [31][33].

The data from the interviews showed that the graduating majors of applicants were not the main consideration when hiring. Enterprises placed emphasise on applicants who had acquired business administration knowledge. Furthermore, applicants graduating from business administration departments have more job opportunities. Students' basic skills and attitudes were emphasised. A relevant interview quote is as follows:

> *Actually I think talents with business administration knowledge are applicable in many ways because they have a good sense of business and dabble in diverse fields, so many departments, including technical sectors, employ business administration talents as well* (Table 3: N950929).

Professional Qualification Requirements in Different Occupational Types

The data from the 104 Job Bank showed that the qualification requirements for those applying for business jobs was up to 12%; the majority focused on the certification of securities and futures. Qualifications for life insurance and cooking were in the minority [31].

Employment Requirements at Different Levels

Work Experience Requirements

The data from the 104 Job Bank showed that the work experience requirement is higher for managerial staff; in particular a requirement for five years' experience or over was up to 18%. The levels were 7% for mid-level cadres and 1% for basic-level workers. By comparison, the ratio of job vacancies that did not require applicants to have work experience was only 29% for managerial staff, 37% for mid-level cadres and 57% for basic-level workers; the percentage lessened as the level rose [31][32].

Graduating Major Requirements

According to the data, the percentage of job vacancies that did not require applicants to have work experience was 85% for the basic level with 10% requiring a business background; 76% for mid-level cadres with 13% requiring a business background; and 55% for managerial staff where 29% required a business background. Previous findings revealed that graduating majors were required more strictly in response to higher-level positions. In addition to graduating majors, the qualification requirement was highlighted in the securities and futures category, particularly for basic-level workers. The qualification requirement was higher for basic-level staff than for managerial staff [31].

Analysis of Employment Competences at Each Level of the Workforce

According to the data, enterprises had different requirements for workers at each level. In this study, the data were divided into three categories: generic skills, management skills and teamwork skills. This was done in order to explore the degree of importance of employment competence for each different level [27][33][34].

Employment Competences for Basic-Level Workers

According to the data analysis, employment competences for basic-level workers comprised generic skills, management skills and teamwork divided as follows:

- Generic skills included language ability, information application and key-in skills;
- Management skills included active attitude and behaviour, responsibility, working adaptation and learning ability;
- Teamwork skills were divided into teamwork ability and executive ability.

Employment Competences for Mid-Level Cadre

According to the data analysis, employment competences for mid-level cadres comprised generic skills, management skills and teamwork divided as follows:

- Generic skills included language ability, information application and key-in skills;
- Management skills included active attitude and behaviour, responsibility, working adaptation and learning ability;

- Teamwork skills were divided into teamwork ability and executive ability.

Employment Competences for Managerial Staff

According to the data analysis, employment competences for managerial staff comprised generic skills, management skills and teamwork divided as follows:

- Generic skills included language ability, information application and key-in skills;
- Management skills included active attitude and behaviour, responsibility, working adaptation and learning ability;
- Teamwork skills were divided into teamwork ability and executive ability.

Table 4 lists the employment competences and shows the most important abilities for the labour force in technical and vocational schools of commerce.

The findings of the study show that employers emphasised attitudes and generic skills. Basic business subjects were enhanced by professional ability. This finding is the same as in relevant studies. A majority of employers took attitude, communicative ability and previous work experience into consideration besides the education degree and academic performance. Moreover, they also agreed on the significance of generic skills [6]. Notable quotes from the interviews include the following:

- *The education degree is not the key point in practice. You find the service industry is a labour-intensive sector. Even employees with high education degrees have to work on site* (Table 3: R950918);
- *… as just mentioned, the information department, the accounting department, and the business and project departments will all employ talents with business administration knowledge* (Table 3: N950929);
- *We do not absolutely need applicants graduating from business administration departments to engage in financial work. As long as you have some basic knowledge of business, you have the possibility to be hired and accepted into internal training programmes* (Table 3: M950904);
- *Health is the basic ability in the retail industry. Health is, so to speak, normal people. You can understand my words, and you can accomplish an assignment. You will ask if you do not know how to do it. You are literate and you can work. You are diligent* (Table 3: C950916).

CONCLUSIONS

From the above analysis and discussion, it can be concluded that enterprises' employment terms include education degree, qualification, occupational category and work experience. Employment competences classified as generic skills, information application, personal management and teamwork are elaborated on below.

Education Degree

Workers with education degrees from vocational/senior high schools were the main demand of business and the service industry. The finding is the same as the statistics of the Census Bureau, Directorate General of Budget, Accounting and Statistics (DGBAS), Executive Yuan, Taiwan [2-4]. Chou and Shen also pointed out that human resources in retail and social service industries are based on post-secondary school education, followed by junior colleges [35]. This phenomenon is contradictory to Taiwanese industrial trends. This is because when external environments alter, labour demands for junior college degree holders in secondary industries are better than in the first or third industries, showing the impact of economic recession that has resulted in declining demand for junior college education degree holders in businesses and the service industry [36].

Workers with junior college degrees dominated finance and insurance, international trade, management consultancy and the hospitality industry. This is reflected in Chiang's study [37]. In the labour market, the generation of human resource capital of junior college education degree holders is greater than for those with senior high school and university education degrees. From the perspective of human resource capital theory, employers in businesses and the service industry consider workers from junior colleges to be more flexible and better adjusted in labour force applications. Moreover, payroll expenses are less than for university degree holders. Consequently, applicants with junior college degrees have become the main source of labour for employers in businesses and the service industry.

Study Major

Requirements according to study majors are considered less important for enterprises. This is probably because learning content is homogeneous in business subjects and graduates from business departments are likely to be engaged in businesslike jobs. The study of the National Center on the Educational Quality of the Workforce in 1995 pointed out that general skills are built up as fundamentals in business departments [38].

Table 4: Listing of employment competences showing the most important abilities for the labour force in technical and vocational schools of commerce.

<table>
<tr><th>Level</th><th colspan="2">Generic Skill, Attitude and Behaviour</th></tr>
<tr><td>Institute of technology</td><td rowspan="3">1. English competence
2. Word
3. Excel
4. Chinese typing
5. Active attitude
6. Responsibility
7. Communication and coordination
8. Cooperation</td><td>Passion, reaction, optimism, learning motivation and teamwork</td></tr>
<tr><td>Junior college</td><td>Passion, prudence, optimism, pressure resistance, learning motivation and leadership</td></tr>
<tr><td>Vocational high school of commerce</td><td>Interest, prudence, pressure resistance, originality, ambition and teamwork</td></tr>
</table>

Qualifications

The findings indicate that a professional qualification requirement is higher for employees in the securities and futures industry and for basic-level staff. Employers' reasons for demanding a qualification are divided into professional and businesslike demands. The former is more recognised for professional certification, such as futures clerks for the Ministry of Economic Affairs; the latter refers to business qualifications issued by the Bureau of Employment and Vocational Training or key-in certifications issued by the Computer Skills Foundation. The financial industry is involved in the legitimate running of businesses, so qualifications are required for basic-level staff to prove their capabilities. Diplomas and certifications have no direct or close link with the position in the labour market but are still criteria impacting on the selection.

Occupational Category

Assistant professionals comprise the majority in the national occupational categories. In particular, business, service and sales oriented, assistant or part-time jobs are based on junior college and senior high school degrees. Small and medium-sized enterprises, which dominate Taiwan's industrial structure, contribute to this result. Consequently, basic-level workers, such as assistants, technicians and operators in assembly lines, are the main labour sources introduced by employment institutions [35][38][39].

Work Experience

Around 40% of employers require applicants to have work experience. A work experience requirement is lower in the financial industry, firstly because qualification requirements are considered as a selection device and secondly because financial industries provide comprehensive pre-service training programmes in order to complement an insufficiency of work experience. In the same way, Chao and Yen pointed out that enterprises select applicants mostly by their education degrees, past experience, language capabilities and personal (including personality) traits [40][41]. They do not exclusively consider work experience. In selection theory, education degree and language capability requirements become selection devices in the labour market via the education system. In human resource capital theory, work experience, practical experience and salary are in a direct ratio, also as a part of human resource capital. The professional capability requirements for employers in businesses and the service industry are based on graduating majors and work experience.

Employment Competence

Generic skills, information application, personal management and teamwork were found to be the main employment competences for human resources in businesses and the service industry.

The findings in this study are proximate to those of Levy and Murnane, Haste, Berman and Ritchie, and Weinert [42-45]. Berman and Ritchie found significant correlations between student personal characteristics, student background characteristics, and their work-related competences [44]. However, Levy and Murnane listed emotional quotient in generic skills with respect to economic theory [42]. Weinert listed metacognitive ability as an employment competence. This differs from the findings of this study [45]. Regarding the aspects of personal management and teamwork skills, the study's findings are close to those of Canto-Sperber, Dupuy and Murnane [43][46]. Nevertheless, Canto-Sperber and Dupuy, looked from a philosophical viewpoint, thought normative competences and narrative competences affected personal interaction attitudes [43]. Perrenoud, in his book, from the angle of sociology, considered resource management, developing strategies and systematisation to be generic skills in community operation, differing from this study's findings [47].

COMMENTS AND SUGGESTIONS

Key findings are detailed below regarding employment requirements and employment competences in businesses and the service industry, the influence of vocational and technical education upon cultivating talent in businesses and the service industry, and potential strategies.

High homogeneity in workforce requirements for vocational high schools of commerce and senior high schools disadvantages graduates of vocational high schools of commerce entering the labour market. As such, it is necessary for vocational high schools to adjust their subjects and courses.

Employers emphasise the generic skills and attitudes of graduates from vocational/senior high schools in the employment market; by comparison, graduates from vocational high schools entering the labour market cannot display their professionalism in businesses and the service industry due to the high level of homogeneity with graduates from senior high schools. As a result, segmenting heterogeneous demands for the vocational/senior high school labour force needs to be considered when vocational high schools of commerce undergo a transformation. The rising demands for a labour force with a business knowledge background will facilitate the employment of graduates and the transformation of schools. Therefore, the authors list the following three concrete solutions to adjust vocational business subjects and courses:

- *Enhance students' academic and vocational abilities*: in addition to cultivating general academic knowledge, schools should also provide corresponding preparation for students to pursue higher education to further their abilities in response to employers' demands, and advance their career plans;
- *Make academic ability the first priority and career plans second*: students take general subjects in the first grade and take categorised classes or programs in different tracks with the purpose of gaining skills in businesses and the service industry;
- *Set core abilities to be the principal axis*: in response to students' uncertainty in their aptitudes and career plans, schools should design curricula based on a basic curriculum plus a professional core curriculum to meet students' needs for further study and employment.

Employment requirements are beneficial to workers with junior college degrees. People with business backgrounds are the favourite in businesses and the service industry. Junior colleges of commerce have room to develop and reset their roles in businesses and the service industry.

Workers with junior college degrees dominate the finance and insurance, international trade, management counselling, and hospitality industries. These are the same results as Chiang's study [37]. In the labour market, the generation of human resource capital from junior college education degrees is greater than both senior high school and university education degrees. From the perspective of human resource capital theory, employers in businesses and the service industry consider graduates from junior colleges to be more flexible and generative in labour applications, with lower payroll expenses than for workers with university degrees. Consequently, applicants with junior college degrees have become the main labour source to meet employers' demands in businesses and the service industry. National studies have also noted that females with junior college of commerce education degrees obtained higher pay at the same level as vocational education degree holders; graduates from junior colleges and universities were paid higher than senior high school students. In particular, groups from junior colleges of commerce have the most remarkable pay benefits, but the value of the labour participation rate was lower for graduates from agricultural, industrial and junior colleges of commerce than for senior high school graduates [25][48][49].

For the securities and futures category, work experience, study major and qualifications were the main employment requirements for workers with junior college degrees in businesses and the service industry. It was found that employment requirements differed between industries. Experience requirements were usually less than three years. The financial industry demanded the fewest requirements, probably because employers provide comprehensive pre-service training programmes. Employment requirements changed according to the education degree and ranking in the organisation. Part-time assistants had noticeably fewer employment requirements.

Regarding applicants' graduating major requirements in different industries, employers with an institute of technology background were prone to hire graduates from institutes of technology, employers with junior college backgrounds were prone to hire graduates from business departments, and employers with vocational senior high school backgrounds were likely to hire graduates from senior high schools. Graduating majors were enhanced by an institute of technology education degree and were used to estimate professional abilities in accomplishing tasks. By comparison, graduating majors were not emphasised for graduates of junior colleges or vocational high schools, especially for basic-level work. As for qualifications, employers in businesses and the service industry did not consider a qualification as a main employment requirement, but in the futures and securities sector, qualifications were required.

Generic skills, information application, personal management and teamwork were found to be the main employment competences for human resources in businesses and the service industry. Employment competences can be classified as generic skills, individual management and teamwork. Consequently, the above-mentioned abilities should be integrated into present courses so as to enhance students' employment competences. Employment requirements and employment competences for the labour force at each level are as follows:

- For basic-level staff, mid-level cadres and senior managerial staff: the major nine abilities were English language competences, familiarity with software programs like *Word*, *Excel* and Chinese typing, an active attitude, responsibility, communication coordination, and cooperation; the less important abilities were fluency in Taiwanese, familiarity with software programs like *PowerPoint* and *Outlook*, English typing, diligence, and executive ability;
- For basic-level staff: the six major abilities were interest, prudence, ability to cope with pressure, originality, ambition and teamwork; the less important abilities were self-confidence, passion, amiability, optimism, reaction, learning motivation and leadership;
- For mid-level cadres: the major six abilities were passion, prudence, optimism, ability to cope with pressure, learning motivation and leadership; the less important abilities were personality, interest, amiability, originality, reaction, ambition and teamwork;
- For senior managerial staff: the five major abilities were passion, reaction, optimism, learning motivation and teamwork; the less important abilities were interest, prudence, ability to cope with pressure, patience, ambition and leadership.

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The application of the case teaching method to a mechatronics course

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ABSTRACT: The case teaching method utilises actual projects for the design of teaching units, for example, for a mechatronics course. Through case teaching, students can acquire problem-solving skills, and develop analytical and creative faculties. Students can identify ways to achieve acceptable outcomes via questions and discussions between students and the teacher. Based on these experiences, students can overcome the learning difficulties associated with other case projects. In this study, the author describes how a teacher uses the case teaching method in a mechatronics course offered by the Department of Industrial Education and Technology at the National Changhua University of Education (NCUE) in Changhua, Taiwan. The teacher explains the case project to the class and mentions several methods that students can apply to tackle the problem, but does not propose a definite outcome. In groups, students design their own project and present their project to the class. In contrast to conventional teaching methods, the case teaching method helps students learn how to think innovatively and develop critical thinking skills for solving problems.

INTRODUCTION

Learning styles vary among individuals. Some individuals may be very efficient when learning from reading materials only, whereas others require hands-on experience. However, psychological investigations have demonstrated that individuals generally only remember roughly 10% of the read content and 90% when the material is actually experienced. Students typically learn and retain information well when they are engaged with instructional materials. Students generally learn 20% of the material taught via hearing, 40% via seeing and hearing, and 75% via seeing, hearing and doing. Well-designed teaching modules offer the possibility of achieving this 75% goal [1].

It should be mentioned that many engineering educational institutions are progressively introducing Computer-Aided Learning (CAL) packages as an alternative to hands-on practical laboratories. Hands-on practical laboratories, such as case projects, can help students understand and apply theoretical knowledge in practice [2][3].

Case teaching is an instructional approach that presents situations for analysis and information based on which decisions are made, rather than teaching concepts and theories to students. Learning through case studies occurs when analysing data, by making decisions based on appropriate recommendations and actions, by communicating such decisions and discussing their rationales with fellow students and the teacher, and, most importantly, accepting responsibility for decisions.

Langdell of Harvard University formally introduced the case teaching method and applied the method for teaching law in 1870. Langdell determined that law students learned more from analysing cases than from reading textbooks. Although textbooks allowed students to memorise laws, Langdell wanted students to learn how to apply laws to different situations [4].

Although the case method has been utilised for years to teach law, business and medicine, it is uncommon in the sciences. However, case studies hold great promise as a pedagogical approach for teaching the sciences, particularly to undergraduates, because it humanises science and effectively illustrates scientific methodology and values. The case teaching method develops students' skills in group learning, speaking and critical thinking. Furthermore, using cases in the classroom makes science relevant [5].

The mechatronics course is a design course that has no definite answers; its goal is to induce students to brainstorm and analyse. Mechatronics projects typically require teamwork and considerable discussion.

APPLYING THE CASE TEACHING METHOD TO A MECHATRONICS COURSE

The case teaching method is a student-centred education concept and strategy that underscores life experiences. This approach uses real cases as a reference point with the aim of identifying a problem solution. Self-learning is an important component of the case teaching method. Interactive teaching processes of question-answer and discussions between teachers and students, as well as among students, are utilised to assist students in gaining real experiences in attacking a problem, developing problem-solving abilities and creativity.

Van Eynde and Spencer demonstrated that the case method yielded the better retention of learned material by students than the traditional lecture [6]. Parkinson and Ekachai compared student perceptions of learning using a traditional lecture format and the case method; students taught using the case method indicated that they had more opportunities to practice critical thinking and problem solving [7].

Several important factors must be considered when applying the case teaching method in a classroom [8]. Teachers must have the following competences:

- Be familiar with the teaching material;
- Be able to lead an exploration;
- Manage a class;
- Handle negative response and emotions.

Since the particular technical aspects of laboratories are a function of the emphasis given by individual teachers, the guidelines identified in this study focus on general concepts that should be applied to technical content. The case method allows students to practice applying course materials and fulfil project requirements. Students must work in groups of three or four. Case project requirements also include a written proposal, work schedule, written report and presentations.

The first requirement that students must meet is a written proposal. Groups generate their own case project topics. These groups then write a proposal for their case project. The case project requires the construction of a mechanical device, the design and construction of the necessary electronics and sensors, and writing software. The teacher reads each proposal and meets with each group. During these meetings, the teacher can increase or decrease the scope of the projects. The scope of the projects is altered to ensure that all of the projects have the same degree of complexity.

After the case projects have been selected, the groups must submit project schedules. During the mechatronics course, a teacher regularly assesses whether the projects are on schedule. Deviations from the schedule are discussed and schedule changes are noted. Work schedules are an excellent tool for minimising student procrastination.

Along with completed case projects, students must submit a written report. This report is written primarily for a mechatronics audience and helps the teacher assess the level of mechatronics in each case project. These reports are an essential resource for future students.

DESCRIPTION OF THE CASE PROJECTS

The following are examples of case projects for the case teaching method. They are an automatic following cart, a fully automatic canopy controlling module and an automatic light-sensitive curtain.

Automatic Following Cart

The aim of this project is the development of a cart that can move automatically. Transportation is an important part in people's lives. Transportation by handcart is not only time-saving but also avoids wasting labour. However, if using a handcart is convenient, the cart still needs someone to set it in action. People cannot carry things that are too heavy for them to bear.

In order to increase transportation efficiency, infrared ray and direct current motor devices are proposed to control and move the cart. This project stabilises the handcart by strengthening the cart's body. User security is provided by a sensor that prevents collisions. Figure 1 shows an example of the automatic following cart.

Figure 1: An example of the automatic following cart.

Fully Automatic Canopy Controlling Module

The fully automatic canopy controlling module is intended to be an advanced version of the manual canopy and half-automatic canopy by being fully automatic. This project is developed by using a circuit with light and rainwater sensors. This project uses a signal from a sensor-circuit's output. After receiving these signals, it compares the various ones already taken. From these inputs, the single-chip module controls the movements of the automatic canopy.

The automatic canopy is adjusted according to the intensity of illumination by lengthening or shortening it. But if it rains, the circuit of the rainwater-sensor sends a signal to the single-chip, causing all movement to be cancelled with command to stretch the canopy to its longest range. This product can detect and examine the intensity of illumination and rain; moreover, it has the automatic functions of opening and closing. A new canopy need not be bought; only the control module and special-purpose motor need to be added and installed to make it a fully automatic canopy. Figure 2 shows an example of the fully automatic canopy controlling module.

Figure 2: A fully automatic canopy controlling module.

Automatic Sensitive Curtain

This project uses a single-chip IC, combined with a luminosity sensor to control the timer setting for automatically opening and closing a window curtain. The proposed method allows for manual and automatic curtain control, providing the user with a convenient method to open or close a curtain when the sunshine is too bright or the sky becomes too dark. This unit has manual, automatic timer and wireless control settings. Figure 3 shows an example of the automatic light-sensitive curtain.

Figure 3: An example of the automatic light-sensitive curtain.

EVALUATION AFTER APPLYING THE CASE TEACHING METHOD

Assessment is utilised to increase standards at universities in terms of teaching, learning and students' achievements. Assessment quality has a marked impact on students' willingness to work hard and encourages teachers to focus on methods to improve attitudes towards the learning of individual students. Assessment occurs continually as judging oneself and others are common practice [9].

Students can make two presentations. The first presentation is required for grading. This presentation focuses on the technical aspects of projects. The optional second presentation is given to a general audience comprised of other group members and students. This is a showcase presentation that allows students to showcase their achievements. These two presentations teach students that a presentation must be tailored to its audience. This showcase presentation also allows students to take pride in their accomplishments and share what they have learned. The mechatronics course assessment is also concerned with individual and group achievements. The individual assessment component is based on periodic reports and individual homework.

The absence of conventional examinations is due to the nature of the course and the level of material covered. Various group activities are the basis for the group-grading component and have special importance in light of the time allocated.

The mechatronics course was inaugurated in the Department of Industrial Education and Technology at National Changhua University of Education (NCUE), Changhua, Taiwan, in 2006, and had an initial enrolment of 20 students. Table 1 presents the questionnaire and a summary of the student feedback. This table was designed to evaluate the case teaching method adopted in the mechatronics course. Students responded to questionnaire items on a Likert scale, ranging from 1 for *strong disagreement* to 5 for *strong agreement*.

All students successfully completed and demonstrated their case projects. No student failed the course. The final grades obtained by students were above average. It is clear from the responses that most students favoured the case teaching method. Most students also had no difficulty with the overall approach. Students obviously enjoyed the flexibility of working at their convenience.

Respondents agreed with two items related to an evaluation of the case teaching method and teaching the mechatronics course. For time allocation, the average response was 2.7, indicating that respondents felt that the case project was not optimised time-wise. Students were also asked to indicate their level of involvement in the learning process. The average response of 2.8 demonstrates that most thought that the case project was important; however, some components fell short of students' expectations.

CONCLUSIONS

The following conclusions have been drawn from the work presented here:

- The case teaching method received positive feedback from students;
- Students enjoyed working within this framework, as evidenced by the care and time devoted to the case projects;

Table 1: Questionnaire and average response for student evaluation of the mechatronics course.

Question	Questionnaire	Response Rate
1	The case projects were useful for learning mechatronics	4.1
2	The background information was useful for understanding content	3.9
3	I could follow the guidelines given in a case project without much assistance	3.9
4	The time allocated was sufficient for me to understand the case project objectives	2.7
5	The course was challenging	4.0
6	Material resources were supplied	3.8
7	I feel that I am actively involved in the learning process	2.8
8	The assessments, overall, provided useful feedback on my progress	4.1
9	I am happy with my performance in the mechatronics course	4.0
10	The mechatronics course, overall, was useful and motivating	4.1

- Students could apply what they had learned to real cases;
- Students understood how to collect, filter and apply information;
- Students learned how to communicate and cooperate with others, and to select from different options;
- Students learned how to criticise others and accept criticism from others;
- Cases can help teachers equally well, especially when teachers care about how their case projects impact on students;
- The overall student satisfaction with learning activities was high.

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Shaping engineering education in the Middle East – a report on four engineering education conferences held at the University of Sharjah

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ABSTRACT: In this paper, a summary report on four international forums on engineering education (IFEE) held at the University of Sharjah in Sharjah, United Arab Emirates, in 2001, 2002, 2003 and 2006 is presented. The International Forum on Engineering Education (IFEE) series in Sharjah was initiated to bring together engineering educators from around the world, especially from the Middle East, as well as students and other stakeholders from the community, to interact and contribute to the enrichment and advancement of engineering education in the region.

INTRODUCTION

Achieving quality and excellence in engineering education is high on the agenda of Middle East regional universities. Most engineering educators in regional universities completed their graduate studies with many serving as engineering educators abroad. Upon joining regional universities, educators face the challenge of adapting to new educational systems that share some qualities with, but also differ in many ways from, universities in technology-generating countries. Some of the areas of comparison include the following:

- *Pace of change and evolution*: engineering education in the Middle East region generally evolves slowly compared with engineering education in technology-generating countries;
- *Technical and generic engineering education*: engineering education at the undergraduate level in this region tends to focus on feeding technical information and is generally uneasy about the broadness of education and the importance of developing generic qualities in engineering programmes;
- *Partnership with stakeholders*: in the Middle East region, a serious rift exists between engineering colleges and the community in terms of science and applied technology, although engineering disciplines differ in this regard;
- *Integration of faculty activities*: the degree of integration of teaching, research and community service in regional universities is reflective of the technology generation activity in the region.

The above four issues were identified, among other issues, as serious issues that need attention and extended discussion in the region. Accordingly, a group of faculty from the University of Sharjah, based in Sharjah, United Arab Emirates, and colleagues from regional universities initiated in 2001 a series of forums titled *International Forum on Engineering Education* (IFEE) to bring together engineering educators from around the world, especially from the Middle East region, as well as students and other stakeholders from the community, to interact and contribute to the enrichment and advancement of engineering education in the region. The main long-term objectives of establishing this forum series was to establish engineering education as a major focus of the engineering discipline in the region. The first four forums, all held at the University of Sharjah, were devoted to addressing the four issues listed above, under the following themes:

- IFEE 2001: The Changing Role of Engineering Education in the Information Age - Innovation and Tradition;
- IFEE 2002: Generic Attributes in Undergraduate Engineering Education - Issues and Development;
- IFEE 2003: Building Partnerships with Government, Industry and Society;
- IFEE 2006: Integration of Teaching and Research with Community Service.

In this paper, a summary addressing each of the four IFEE themes is presented and discussed with appropriate conclusions drawn. The authors acknowledge the contributions of the engineering educator delegates to the four forums on engineering education [1-4].

IFEE 2001: THE CHANGING ROLE OF ENGINEERING EDUCATION IN THE INFORMATION AGE - INNOVATION AND TRADITION

In the wake of modern challenges that are reshaping engineering education, the focus of engineering colleges and departments must be on quality and excellence in designing and delivering educational programmes and developing strategic collaborative links with industry, the community and other educational institutions. Building and maintaining quality and excellence is a major challenge for new universities competing in the increasingly global environment.

Universities in the Arabic and Islamic worlds in particular must balance tradition and innovation in designing and delivering educational programmes. Achieving the balance between innovation and tradition must be viewed as an opportunity that adds unique values to educational programmes but not an obstacle that hinders development.

The engineering profession has experienced substantial change over the past two decades. In terms of the enrolment of high-achieving students, some traditional engineering specialties and disciplines have experienced decreasing interest while others have gained substantially. In addition, combined and double degree programmes combining the disciplines of engineering together or with other disciplines, such as business and information technology, have become increasingly attractive to students. These combined programmes are also being developed and marketed to attract more and quality students to engineering programmes.

With increasing community awareness and the enactment of more stringent regulations, traditional models of engineering education, which emphasised the ability of engineers to conquer their surroundings, have also been rejected. Instead, the engineering programmes of today and tomorrow are expected to address social concerns and the environmental impacts of development. In order to achieve this goal, universities around the world are actively integrating the principles of sustainable development into their educational programmes, especially engineering education programmes. Sustainable development is aimed at balancing economic and social development, environmental protection and generational equity.

Regional universities and societies are actively involved in absorbing the impacts of the information and globalisation age, characterised by the rapid pace of communication technology advancement, the expansion and intrusion of mega-corporations, as well as availability of information. The Internet is rapidly replacing the library as the source of science and technology information. The Internet educational industry is booming and regional universities are trying to adapt to new technologies while struggling to maintain traditions and preserving culture in the face of information flooding, rapid technological changes and competition for leading international universities that are expanding locally.

Middle East regional universities are not leading in their response to these changes but are merely responding and trying to cope. Exhaustion, stagnation and self-assurance are more relevant descriptions of many local universities than leadership, trend-setting, excellence and radiance.

With the above issues in mind, the participants of IFEE 2001 were invited to discuss issues under many themes. A summary of the themes presented during IFEE 2001 include:

- Creative approaches to teaching and learning;
- Effective teaching and learning: case studies;
- Curriculum design, development and implementation;
- Online delivery, flexible delivery, distant education and open learning;
- Globalisation and engineering education;
- Integration of generic skills into engineering education;
- Environmentally educated engineers;
- Integration of sustainable development into engineering education;
- Use of technology in education;
- Student support systems;
- Student learning and evaluation;
- Gender equity in engineering education;
- Continuing education;
- Projecting and meeting the needs of employers;
- Quality and excellence in delivering programmes and courses: assessment models;
- Student/instructor interactions in the university and beyond;
- Role of alumni;
- Role of advisory committees;
- Administration of teaching and learning programmes;
- Accreditation in a changing environment;
- Broad or specialised undergraduate programmes;
- Graduate studies and the culture of engineering education;
- Peer and student evaluations;
- Interdisciplinary collaboration in engineering education;
- Changing community views of the engineering profession and demands;
- Admission criteria.

Below are some of the key themes that emerged from the forum.

- A perspective on engineering education at the start of the new millennium that is based on considering engineering education as a key element of the wealth of any country and is, therefore, an integral component of national policy and economy. To fulfil that role with excellence, engineering education must offer more than science and engineering knowledge, but also entrepreneurship and technological advancement;
- A paradigm shift in engineering education from *knowledge-based* to *learned competences*, *skills-based* and *outcome-based*;
- The role of accreditation at the local and international levels, such as the US-based ABET accreditation, in assuring the quality of engineering programmes. Accreditation also assures employers and graduates, and allows for mutual recognition arrangements between countries;
- The need to progressively open up engineering education to change perceptions of engineering as being disconnected with social and environmental values, and disengaged from the community. Rather, it is important to emphasise the need for engineers to be leaders in their societies in areas other than technical excellence. In this regard, the need for engineers to act as role models who excel in areas other than engineering was emphasised.

The main issues of IFEE 2001 were pointing in two clear directions, which are as follows:

- The need to reconsider the focus on technical knowledge to supplement programmes with an adequate focus on developing and nurturing the essential generic attributes of engineering education;
- The need for engineers to actively participate in society's interests in the arts, humanities and similar areas that are equally, if not more, important to societies than science and technology.

These issues were developed into the main theme for IFEE 2002 and are discussed below.

IFEE 2002: GENERIC ATTRIBUTES IN UNDERGRADUATE ENGINEERING EDUCATION - ISSUES AND DEVELOPMENT

Professional engineers are required to provide practical solutions to real life problems, communicate their ideas and contributions, work well and cooperatively in various teams, and manage projects, budgets and personnel. Employers of engineers look for responsible and enthusiastic graduates, who are technically competent, but also good communicators and good team workers with good potential for growth and development. In addition, the community expects that professional engineers consider and address the social, environmental and other impacts of their work.

Professionally successful engineers possess more than technical skills and experience. They have extra, non-technical skills that allow them to transform their contributions into recognisable accomplishments. Successful professional engineers have well-developed interpersonal skills, can work with others in an easy and cooperative manner, and are recognised and respected by their peers. They are capable of communicating their ideas and contributions in a clear way. These engineers also have well-developed business and finance skills. They fit within their organisations and are recognised as contributors to the overall success of their organisations. Some of these extra qualities are listed below and classified as generic skills.

Generic qualities and skills desired in engineering programmes include the following:

- The ability to apply knowledge of basic science and engineering fundamentals;
- The ability to effectively communicate with engineers and non-engineers;
- Competence in an engineering discipline;
- Competence in information technology;
- The ability to identify and formulate problems and solutions;
- The ability to work in multidisciplinary and multicultural teams;
- The ability to understand and consider the social, environmental and cultural responsibilities of professional engineering;
- Commitment to the professional and ethical responsibilities of engineering practice;
- Commitment to the principles of sustainable development;
- Commitment to a life-long process of learning.

In the past, engineering education was focused on the technical aspects of engineering. As we enter the 21st Century, the roles of engineers have changed and a paradigm shift in undergraduate engineering education is becoming appropriate. No one doubts that the formation of technical skills must remain at the core of engineering education. However, the concept of the core must be expanded to include the non-technical and professional aspects of engineering practice.

IFEE 2002 thus focused on improving the development of generic capabilities in undergraduate engineering education through systematic approaches that address the development of such capabilities throughout engineering programmes. As such, the Forum's delegates were invited to discuss issues like profiling existing efforts to develop generic attributes in engineering programmes as well as present ideas on balancing technical, *hard* engineering skills and non-technical *soft* engineering attributes.

The main themes of IFEE 2002 were as follows:

- Integration and development of generic skills into engineering education;
- Measuring success in the development of generic attributes;
- Projecting and meeting the needs of employers;
- Curricula design and meeting the new accreditation requirements;
- The community's changing views of the engineering profession.

The discussions concluded with a call for engineering faculty to take serious steps to formalise the development of non-technical and professional attributes alongside the development of technical engineering skills. In addition, certification and documentation were proposed to track and formalise the development of generic and professional skills alongside technical skills. In order to accomplish the above, delegates called upon decision-makers in universities offering engineering programmes to take serious steps to debate these issues and initiate the required process of change. It was noted that this change would require the investment of significant resources and proper staff development programmes.

The delegates recommended that engineering departments in the region start by profiling the existing generic attributes that are emphasised in their programmes. Faculty members could also be encouraged to clearly state the technical, non-technical and professional teaching and learning objectives in their course outlines. It was also recommended to involve engineering employers, professional engineers, non-engineering professionals and the community in partnerships to develop the generic attributes of engineering graduates.

At the end of IFEE 2002, the delegates proposed the theme for the next IFEE gathering in 2003, which was to be focused on the relationship between engineering departments/colleges and the community.

IFEE 2003: BUILDING PARTNERSHIPS WITH GOVERNMENT, INDUSTRY AND SOCIETY

The delegates of IFEE 2002 concluded that in a regions where technologies are mainly imported rather than locally generated, the relationships between engineering colleges on the one side and government, business and industry on the other side are critical and worthy of discussion as the main theme of IFEE 2003. In addition to contributing to developing technologies and new applications, universities are well positioned to be involved with government and industry in a variety of collaborative educational and professional activities, including research and development, consulting, professional training, joint programmes and continuing professional education. Society can greatly benefit from such collaborations that can lead to better and more practical educational programmes, excellent career potentials for graduates, industry satisfaction with a skilful workforce, and targeted opportunities for continuing and professional education, as well as joint projects involving students, faculty and practicing professional engineers. As such, IFEE 2003 delegates sought to identify ways to achieve the benefits of collaboration and partnerships with sensitivity to culture and societal values in the region.

Modern engineering accreditation criteria emphasise the need for engineering graduates to possess strong design and professional skills. In order to instil these skills, engineering programmes must rely on the cooperation of practicing professional engineers to participate in the educational process, and rely on government and industry organisations to sponsor students' projects and provide internships opportunities as part of a healthy and mutually beneficial relationship. As employers of engineering graduates, government and industry have a major stake in the quality of engineering education and must, therefore, actively advise, support and participate in shaping the quality and direction of engineering education programmes.

Universities offer government and industry great opportunities for collaboration and possible synergy, including international experience of faculty and talents of students in addition to advanced research, consulting, training and information facilities. IFEE 2003 aimed to bring together engineering educators and professionals from government, industry and society to discuss avenues towards encouraging active collaboration and building partnerships among the stakeholders of the engineering education process. The forum organisers encouraged participants to share their practical experiences, present case studies, and discuss creative approaches to establishing and nurturing effective partnerships among university-industry-government-society.

The above-discussed issues formed the main discussion themes for IFEE 2003, which were as follows:

- Effective avenues for university, government and industry collaborations;
- Effective training of engineering students;
- Continuing professional engineering development;
- Curricula development and meeting the needs of government and industry;
- Government and industry-sponsored engineering design projects;
- Collaborative and funded research and educational programmes.

Furthermore, the delegates presented diverse views on the collaboration subject and expressed their optimism and concerns. This included the following:

- One of the most important relationships among the parties relates to education and employment. Engineering colleges need to graduate readily employable engineers who are up-to-date in terms of knowledge and possess clear technical and relevant non-technical generic skills. Government, business and industry need to continue to provide proper employment opportunities;
- Engineering societies need to proactively promote the profession;
- Employers must take a more active approach in terms of training engineering students while studying and immediately after graduation;
- Universities need to actively offer appropriate continuing training opportunities for practicing engineers;
- A major limitation relates to the fact that technology is generally not generated locally, meaning that fewer opportunities exist for engineering faculty and industries to engage in high level, research-based consulting projects. Engineering faculty may tend to offer common consulting services as means to supplement their salaries and for community service;
- The need to establish and activate university-industry liaison or consultative bodies that bridge the gap between the parties and reduce the isolation of engineering education from market needs.

After three successful IFEEs that facilitated discussions on various important issues relating to engineering education, the delegates proposed that there be a pause to allow for reflection and integration. As such, the following forum was staged in 2006, IFEE 2006, and was focused on integration.

IFEE 2006: INTEGRATION OF TEACHING AND RESEARCH WITH COMMUNITY SERVICE

Teaching, research and community service are the main duties of faculties and universities. The purpose of teaching is to facilitate the learning of knowledge, and the purpose of research is to increase knowledge and identify its useful applications. The mission of universities is to serve the community through teaching and research. The university mission is mainly accomplished through the efforts of its faculty.

The traditional career model for faculty has been to pursue all three functions: teaching, research and service. The service component includes university development, professional practice and community service. With constantly shrinking resources, faculty find themselves pulled in various directions due to external and internal expectations and pressures. Students expect and deserve quality teaching time, both inside and outside the classroom. The public expects faculty to excel in teaching and to contribute to the development of the community. University administration demands excellence in teaching, research and service. Accreditation and funding agencies and reviewers also require excellence in teaching, research and service. Faculty members expect a fair system that is based on merit, rewards contributions, allocates appropriate workloads and balances resources with expectations.

The purpose of IFEE 2006 was to discuss, from an engineering perspective, all issues relevant to the mission of universities in terms of teaching, research and service, and how best to integrate teaching and research into community service. The main themes discussed during IFEE 2006 were as follows:

- Philosophies, rationale and objectives for integrating teaching and research with community service;
- Strategies for integrating teaching and research with community service;
- Examples and case studies of the successful integration of teaching and research with community service;
- Partnership of stakeholders for successful integration;
- Incentives and rewards for integrating teaching and research with community service;
- Balancing teaching, research and community service;
- Other related topics.

The above are highlights of some of the issues and challenges that relate to the role of universities in the community and the role of academics in universities. In response to these changes, IFEE 2006 delegates confirmed the main themes of the Forum by identifying the paths of the evolution of engineering education in the following directions:

- Integration of teaching, research and community service: this approach saves time and effort by integrating all three functions into multipurpose activities without compromising quality;

- Redefining scholarship in universities: excellence in teaching, university development, professional practice, and community service is being gradually recognised alongside research excellence;
- Some universities have opted to give faculty the choice to focus efforts on one or two of the three university functions (teaching, research and service) and the flexibility to change the focus with time. In this way, not all faculty are required to contribute equally to all functions. Faculty positions that are mainly research, teaching or service in orientation are sometimes created with appropriate incentives offered in each track;
- The distinction between teaching, research and service universities is being re-examined regionally and internationally.

SUMMARY AND CONCLUSIONS

There exists a great will and enthusiasm among engineering faculty in the region to achieve excellence in engineering education. Unfortunately, such a positive energy may not always be matched with the necessary opportunities to flourish and grow at a normal pace. The issues are complex and have to do with the nature of engineering education and the status of development of the region in terms of science discoveries and technology generation.

Engineering faculty are willing to increasingly focus on excellence in engineering education provided that universities recognise such efforts as essential, and reflect such recognition in staff development and promotion. Participants at the four IFEE events suggested that regional universities better focus on excellence on engineering education and strategic and collaborative academic research rather than focus aimlessly at individual and self-motivated exploration research.

Participants at the four IFEE events discussed a comprehensive list of important issues that are of general concern. Perhaps it is convenient at this stage of IFEE development to focus on specific issues in engineering education. At the present, preparations for IFEE 2008 are underway with the Forum most probably focusing on accreditation.

Finally and with increasing attention being paid to engineering education in the region, positive collaboration among regional parties is a must. At IFEE 2002, a proposal was put forward to establish a regional association on engineering education. It may be time to start such an association to unify efforts and follow up on related activities in the region. Figure 1 shows the growth of participation in the IFEEs.

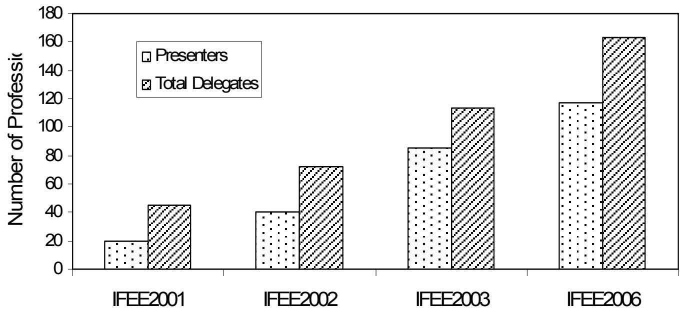

Figure 1: Growth of participation in the IFEEs.

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Identifying an educational void and new teaching approach for input modelling

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ABSTRACT: One of the most critical elements to a simulation study is input modelling where data are collected, prepared and analysed so as to accurately capture the activity of entities and processes for the system of interest. The ability to represent the data through probability distributions aids the computational efficiency of the simulated model. However, before utilising well-known distributions, the analyst must first ensure that the data are independent. Very few textbooks provide information on this crucial step; if they do, they either lack examples or only provide graphical means for examining patterns in the data – patterns that may suggest independence. These graphical examinations rely on the *judgement skills* of the analyst for their interpretation – a skill not usually found in students taking their first simulation course. In this article, the authors examine a set of non-parametric runs tests that relieve students from having to use their own judgement when determining independence. This study fills the educational void on testing for independence, and examines the advantages and disadvantages of employing the runs tests based on characteristics of the underlying data. The goal here is to provide guidance on teaching input modelling for an introductory simulation course.

INTRODUCTION

In general, today's simulation modelling languages handle the execution of discrete-event logic with ease, allowing a first course in simulation to focus on having the students learn discrete-event logic and simulation modelling through the use of a particular simulation language. Here, students are usually given nicely-worded problems that contain a complete description of the system in terms of its inputs and functions (processes) where the goal is to develop a simulation model of the system so as to answer a specific question (or sets of questions) on system performance. In practice, however, *nicely-worded* system descriptions are rarely, if ever, available and the practicing engineer/simulationist must conduct a simulation study from *crib-to-death* (a completely open-ended problem, ie there are no textbook descriptions in industry!).

A simulation study involves the execution of approximately eight high-level reiterative steps (as shown in Figure 1) while the conventional course objective for an introductory undergraduate course in simulation is to have students be able to take a complete description of the system of study and encode the description into the simulation language of choice (almost always chosen by the instructor). Introductory course textbooks for teaching simulation languages provide examples and problem sets where the arrival processes and service mechanisms are entirely described; the student is left with only the abstraction tasks (Step 4) and the process of verifying that his/her code accurately reflects the behaviour of the described system (Steps 5 and 6). Additionally, the student is often asked to perform some type of system analysis (Step 7), such as obtaining a confidence interval on a parameter of interest or performing a *what-if* analysis on various system levels (eg the number of resources available or their scheduling schemas). Hence, the student tends to become well versed in Steps 4 through 7 of a simulation study (see Figure 1), while the first three steps are often overlooked or perhaps provided to the student by the instructor or course textbook. Step 8 is usually not encountered until the student is able to utilise simulation in practice or is allowed to implement the results of his/her simulation study through an internship, project or capstone course. However, Step 3 of Figure 1, input modelling, can be covered in an introductory simulation course – and it should be as it is one of the most critical elements to a simulation study, since as with all computer programs, garbage-in-garbage-out!

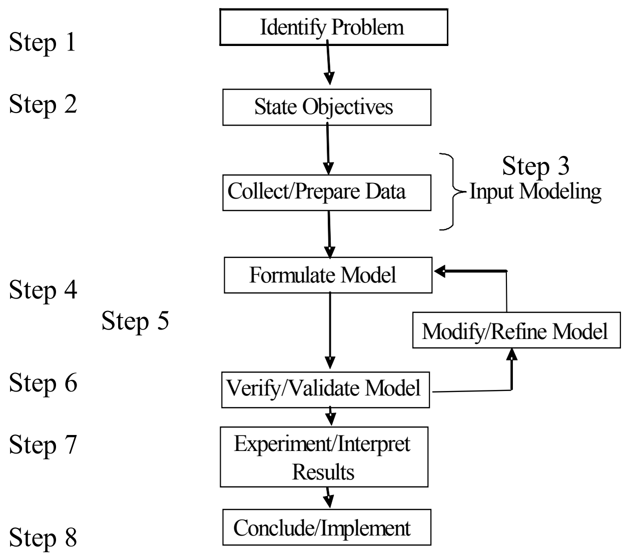

Figure 1: Eight reiterative steps of a typical simulation study.

Imperative to the ability of implementing a well-known distribution as one of the input processes is that the analyst/student ensures the data collected on that known activity are independent. Until recently, very few textbooks provided information on this crucial step, testing the data for independence [1]. Additionally, textbooks used to introduce simulation modelling languages do not contain chapters or even sections on input modelling. If they do, then they either omit the issue of independence or only provide graphical means for visualising the data [1][2]. These graphical means rely on the *judgement skills* of the analyst/student for his/her interpretation (qualitative tests). So students taking their first introductory simulation course may not have the necessary experience to make sound decisions, or they may not trust their own judgement skills. There are very few non-parametric statistical (quantitative) tools available to assist the student/ simulationist in determining whether the process shows statistical evidence that the data are independent.

A set of non-parametric independence tests are presented in this article that are used to calculate a test statistic for determining whether a set of data pass a test of independence. The calculable test statistics relieve the student/analyst from having to use his/her own judgement. The work presented fills the educational void found in textbooks that may be used to teach an introductory course in simulation modelling – particularly when the course is model or language focused and not data or analysis focused.

BACKGROUND

There are essentially four *activities* (Activity 0 - Activity III) to follow when fitting data to a well-known probability distribution. The initialisation activity assumes that the data are independent, but it has very little documentation available to test that critical assumption. Court first documented and named an *Activity 0* in 1994 for the IE5573 course, *Statistical Analysis of Simulation*, at the University of Oklahoma [3]. Activity 0 initially only involved using graphical means to see if trends or patterns existed in data via scatter plots or perhaps correlation plots. But Court also borrowed the methodologies that were being used on testing the independence of pseudo-random number generators and applied them to Activity 0 [3]. She presented those examples on her IE5573 course Web site (as taken from Banks and Carson [4]).

In 1994, the remaining activities (Activity I-III) were named and well documented in Law and Kelton [5]. However, Activity 0 is where the authors' research contributions lie – a thorough search of the literature on non-parametric tests, identifying those that may be suitable for Activity 0 and determining the best for an introductory simulation course. So only Activities I-III are briefly described in order to provide a complete definition of the activities involved in input modelling and note that Activities I-III can only be performed on data that are independent.

Activity I entails hypothesising the family using shape, where the independent data are first categorised as discrete or continuous. Activity II involves the estimation of parameters for the hypothesised distributions identified from Activity I. Typically, Maximum Likelihood Estimators (MLEs) are used to obtain estimators for the unknown distribution parameters. A list of MLEs and their calculations or associated algorithms for many well-known probability distributions are available in ref. [1]. Activity III is the goodness-of-fit tests. Here, various tests are performed with the hypothesised distribution and with the data fitted *against* the hypothesised distribution to determine a measure of the fit. The statistical tests may include the Komolgorov-Smirnov (KS) test, the Anderson-Darling (AD) test and the Chi-square test. All tests provide a p-value and hence give the analyst information on the power of the fit.

So, Activity 0 is in need of a non-parametric test that produces a test statistic that could assist the analyst/student when determining whether the data set is independent, thus providing the student with the justification to continue on to Activities I-III. Unfortunately, while there are several tests for data independence in literature, most are parametric or require knowledge about the hypothesised distribution, so they are more suitable for Activity III of input modelling and not Activity 0.

After a thorough review of literature, five potential candidates were found for supporting Activity 0: poker and gap tests [6], Pearson's Chi-square test of independence [7], Spearman's rank order correlation test [8], Sobolev test [9] and runs tests [6]. Upon further evaluation, several issues were detected with all but one of the tests: run tests. The Person's Chi-square test of independence is one of the most well-known independence tests; however, it is a parametric test – in particular, this test assumes that the data are normally distributed. The Spearman's rank order correlation test, while it is a non-parametric test, measures the correlation between observed *data pairs*. Thus, the application of this test will require the student to manipulate the data into *pseudo-pairs*. The Sobolev test, also non-parametric, determines the *geographica*l independence of data points. Again, manipulation (the implementation of a *pseudo x-y plane*) of the data is required for supporting Activity 0. While the poker and gap tests are non-parametric and leave the data in its original form, they are typically used for testing pseudo-random number generators and are usually constrained to those that generate three-digit data points. Here, the sequences of digits *within* a data point are examined for randomness, ie they do not test for independence *between* data points. The runs tests are a set of statistical tests also used to test the independence of data generated by pseudo-random number algorithms, but they allow the data to stay in its original form and they do test for independence *between* data points.

One of the authors' main observations about students in introductory simulation courses is that they tend to be confused as to the suitability and application of statistical tests when the tests require the data to be manipulated (eg the batch means method – an output analysis technique). So the goal is to eliminate tests that require data manipulation for Activity 0. Additionally, if the tests require a strong mathematical or statistical background on the part of the user and/or the test statistics is not readily calculable (eg cannot be calculated in an electronic spreadsheet), again, students tend to lack the skills set to implement the test. Thus, the runs tests are the only potential candidates most suitable for Activity 0.

Banks et al define four runs tests that are used to test the independence and uniformity of data generated by pseudo-random number algorithms: runs up and down (R_UD), runs above and below the mean (R_ABM), runs length up and down (RL_UD), and runs length above and below the mean (RL_ABM) [6].

R_UD looks at trends within the data – whether the data exhibit positive trends/behaviour and/or negative trends/ behaviour. The analyst compares the N collected data points and assigns + signs and - signs to the data indicating a positive or negative relationship between data pairs, respectively. A series of like signs constitutes a *run*, with a *run up* being made up of all + and a *run down* being made up of all -. The R_UD hypothesis test is defined as follows:

Let H_0: X_i's ~ independently, H_1: X_i's not ~ independently with α = P(reject H_0 | H_0 true):

Test statistic: $Z_0 = a-[(2N-1)/3]/[(16N-29)/90]^{1/2}$ (1)

Failure to Reject H_0: $-z_{\alpha/2} \le Z_0 \le z_{\alpha/2}$

where a is the observed total number of runs both up and down.

R_ABM examines the relationship of the data points to their mean. Here, the analyst uses the sample mean to compare each data point, and all of the + and - signs are reassigned according to the distance from the sample mean. The number of *runs up* and *runs down* is also adjusted accordingly. While the acceptance region for H_0 is the same as R_UD, the R_ABM test statistic for $n_1$or n_2>20 is defined as:

$$\text{Test statistic:} \quad Z_0 = \frac{b - (2n_1n_2/N) - ½}{[2n_1n_2(2n_1n_2 - N)/N^2(N-1)]^{1/2}} \quad (2)$$

where b is the observed total number of runs, n_1 is the number of individual observations above the mean (+) and n_2 is the number of individual observations below the mean (-).

RL_UD examines the number of data points with increasing (positive) and decreasing (negative) trends, and looks at the length of these run types. So here, the number of + and - signs in a *series-of-like-signs* is kept track of (the length within a run) for this test. Rather than an approximately normal test statistic, this test statistic follows the Chi-square distribution. So, RL_UD for N>20 data points has the following test statistic and acceptance criteria:

$$\text{Test statistic:} \quad \chi^2_0 = \sum_{i=1}^{L} \frac{[O_i - E(Y_i)]^2}{E(Y_i)} \quad (3)$$

$$\text{Failure to Reject } H_0\text{:} \quad \chi^2_0 \le \chi^2_{\alpha,L-1} \quad (4)$$

where O_i are the observed runs of length I; *E(Y)* are the expected runs of length i; L=N-1; and:

$$E(Y_i) = [2/(i+3)!][N(i^2+3i+1) - (i^3+3i^2-i-4)] \quad \text{for } i \le N-2 \quad (5)$$

and
$$E(Y_i) = 2/N! \quad \text{for } i = N-1 \quad (6)$$

Note that the mean total number of runs, μ_a, for all run lengths i is denoted below as:

$$\mu_a = (2N-1)/3 \text{ for all i} \quad (7)$$

The same acceptance region and test statistic is used for the fourth test, RL_ABM, except that L=N for this test. Here, the sample mean is calculated and the + and - signs are determined according to the data's relationship with the mean. Next, the lengths of the runs are observed, hence the *length of runs above and below the mean*. But new calculations are required for the expected values and, as before, only hold when N>20:

$$E(Y_i) = Nw_i/E(I) \quad (8)$$

w_i, the approximate probability that a run has length i, is:

$$w_i = (n_1/N)^i(n_2/N) + (n_1/N)(n_2/N)^i, \quad (9)$$

and E(I), the approximate expected length of a run, is:

$$E(I) = n_1/n_2 + n_2/n_1 \quad \text{for N›20} \quad (10)$$

and E(A) is the approximate expected total number of runs of all lengths:

$$E(A) = N/E(I) \quad (11)$$

Of the four runs tests, the last two tests require the most number of calculations and rely on the student to have an understanding of the Chi-square test. So, if the student has had an experimental design course or a statistical analysis course prior to the introductory simulation course, the student should have enough prerequisite knowledge to understand the mechanics of all four tests – as is the case with the introductory simulation course mentioned above. Thus, all four runs tests are carried into the methodology section below.

METHODOLOGY AND RESULTS

The methodology described here has been built to test the robustness of the runs tests for their ability of testing data sets for independence. The following sets of distributions are proposed as the test bed:

- *Data sets known to be dependent*: dependent data sets are chosen to see if the runs tests can identify data sets that are dependent, ie reject $H_0|H_0$ is false. Here, the waiting time in queue (W_q) of an M/M/1 queue with 90% utilisation (an arrival rate of one customer per minute and a service completion rate of one customer every 0.9 minutes) was chosen. Obviously, waiting times in queues are dependent and the higher the utilisation, the higher the dependency;
- *Data sets known to be independent and symmetric*: since runs tests serve as a means for testing the robustness of pseudo-random number generators, they are most likely robust for the uniform distribution of U[0,1]. However, another well-known symmetric distribution was selected: the normal distribution with parameter set N(5,2.5);
- *Data sets known to be independent but skewed*: for the fourth data set, a distribution was chosen that is quite frequently encountered in simulation studies, ie the exponential distribution – a highly skewed distribution. This data set was chosen in order to determine the ability of the runs tests to avoid Type I errors (ie reject $H_0|H_0$ is true). The intention was to see if the RL_UD and RL_ABM tests have a tendency to reject data that come from highly skewed distributions. The reader should recall that these two tests are actually Chi-square tests; it is believed that these tests will have a tendency to reject skewed distributions merely due to the data's underlying shape. An Exp(5) is used for this.

A *rule-of-thumb* in simulation analysis is to have at least 200 data points before one fits data to a distribution, so all of the data sets for each run test contain the minimum number of points, ie 200. If the runs tests are robust with the minimum number of points, then it should be robust for larger data sets.

Each of the four runs tests are applied to 40 sets of the 200 data points generated from each test bed, ie where α = P(reject $H_0|H_0$ is true) or the p-value is set at 0.05 (5%). Thus, for α to be at its stated level of significance, no more than two of the 40 tests for a particular run test will reject H_0 when testing a set of data known to be independent (ie H_0 is true).

To generate the random variates for the data sets, the inverse transformation method was used and executed in Microsoft® *Excel* for most of the data generation. For example, -1/λ*ln(rand()) is used to generate the exponential data sets with λ =5. The Arena Input Analyzer was used to generate the normal data and then it was imported into in *Excel* for post processing [2]. The W_q data were obtained by performing the discrete-event logic in an *Excel* spreadsheet, which is a conventional homework assignment in an operations research course (typically held for second semester undergraduate industrial engineering students prior to their first simulation course). All runs tests were performed in *Excel*. So the data analysis tools chosen represent a common set of tools that an undergraduate student would possess when taking an introductory course in simulation.

The results of the calculated Type I error (α') for each of the independent data sets are shown in Table 1. The values represent the fraction of tests (out of 40) that rejected H_0. The authors suspect that the Chi-square tests, particularly RL_ABM, would be more likely to reject skewed data sets, eg Exp(5), since runs tests were designed to favour symmetric distributions. Surprisingly, the symmetric data sets (normal and uniform) also failed the RL_UD and RL_ABM tests.

Table 1: Resulting Type I errors for the 40 sets of 200 data points on each independent test bed.

α' = [number of tests rejecting H_0 | H_0 true)]/40				
Test Bed Distribution	R_UD	R_ABM	RL_UD	RL_ABM
U[0,1]	0.05	0.00	0.30	0.50
Exp(5)	0.05	0.05	0.35	0.85
N(5,2.5)	0.00	0.00	0.30	0.45

The RL_UD and RL_ABM tests also had difficulty in rejecting the dependent data sets (W_q), ie H_0 was accepted 7% and 10%, respectively, when H_0 was false, while the R_UD and R_ABM tests rejected H_0 100% of the time for the dependent data.

A PROPOSED TEACHING APPROACH

Only one set of non-parametric tests – runs tests – was found in the literature to suit the objective to have the data remain in its original form for the analysis to be calculated. Of the four runs tests, those involving the run length (RL_UD and RL_ABM) failed to uphold the stated level of significance. Additionally, those tests had a tendency to accept H_0 when H_0 was false. So the evidence suggests that both RL_ABM and RL_UD should not be used in input modelling when testing data for independence. However, R_UD and R_ABM did meet or exceed their stated level of significance for all test beds. Additionally, these tests were easier to calculate and less computationally tedious than the RL_UD and RL_ABM tests.

R_ABM and R_UD are the two recommended non-parametric runs tests to teach in an introductory simulation course for the subject, *testing data for independence when fitting data to well-known probability distributions – Activity 0*. It is recommended that students be taught these tests in the following manner:

- Students are given independent sets of data points that are known to be independent and from well-known probability distributions (eg exponential or normal). Each student has his/her own independent data set (ie while the data set is from a particular distribution, random number generators are used to provide different sets of the random variates to each student);
- Each student is *walked through the analysis* for the two runs tests, R_UD and R_ABM, eg the assignment of + and - to the data; they are then asked to calculate the corresponding test statistic;
- The results of the tests are openly discussed in the classroom. A good approach is to have the class tally the number of data sets with *failure to reject H_0* and the number of data sets with *reject H_0*. Hopefully, the percentage of *reject H_0* will match the stated level of significance. Then a discussion of the p-value will bring to light the need for students to understand how important the concept is to statistical analysis;
- Students are then given independent sets of dependent data, and steps 2 and 3 are repeated. However, a discussion of Type I and Type II errors can now take place, eg false positives and false negatives in hypothesis testing;
- To solidify the topic, students should be required to collect data from a *real-life* system (eg the time of car arrivals at an intersection) and apply the two runs tests to the collected data. This last task will give students some experience in utilising the runs tests in practice.

CONCLUSIONS AND FUTURE RESEARCH

This work represents the first study conducted on the quantitative testing of data for independence in simulation input modelling and provides the first documented approach for teaching this topic. Future research could be aimed at providing a larger test bed of the data sets – more replications of the distributions to calculate a confidence ban on the power of the tests. Additionally, the test bed could be expanded to include other distributions, eg beta and gamma distributions. The size of the data sets could also be expanded past 200 data points to see the impact of N on the power of the runs tests.

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Developing a Safety Performance Scale (SPS) in departments of electrical and electronic engineering at universities: an exploratory factor analysis

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ABSTRACT: In this article, the authors focus on developing a Safety Performance Scale (SPS) with high validity and reliability for assessing group-level safety performance. In all, 164 teachers from departments of electrical and electronic engineering at various Taiwanese universities completed self-administered questionnaires in November 2006. This represented a response rate of 54.67%. The investigators used SPSS to perform an exploratory factor analysis and to make an internal consistency analysis. Three factors had eigenvalues greater than 4.3, namely: safety motivation, accident investigation and safety inspection. These three factors produced an accumulated explained variance of 77.75%. These three factors all also had Cronbach's αs greater than 0.92. The results show that the SPS developed in this study is both valid and reliable.

INTRODUCTION

While there are many management levels in any organisation, there are two general levels on which to assess safety performance, specifically: macro-measures and micro-measures. The former are used for larger units, or whole organisations, such as incident rates in a company; while the latter are used for lower and smaller units of an organisation, such as the number of supervisor inspections, communications or observations in a department.

It should be determined which level of the organisation is intended to be measured. As a rule, there are two kinds of assessment tools available in this context, namely: activity measures and results measures. Activity measures concern what steps are taken in order to ensure occupational safety, while results measures refer to whether those safety objectives have been accomplished [1]. Thereupon, the safety performance measures at the departmental level at a university measure the safety activities implemented by head teachers.

At the organisational level, many authors have proposed safety performance dimensions, such as safety organisation and management, hazard control and monitoring, safety training and education, accident investigation and statistics, safety motivation and communication, and so on [2-5]. However, at the management level, Petersen suggested safety performance measures of the supervisor, which may include the following activities:

- Inspection;
- Accident investigation;
- Training;
- Motivation, etc [1].

According to the current Taiwanese Labor Safety and Health Act and Regulations, safety training is a function of the Labor Safety Department (organisational level) but a duty of the first line unit. Therefore, the authors divided the safety performance area at the departmental level at universities into safety inspection, accident investigation and safety motivation.

The purpose of this study is to explore the safety performance dimensions at the departmental level at universities. Another objective is to develop a Safety Performance Scale (SPS) and, through empirical study, ensure it has good validity and reliability as the tool to assess safety performance in electrical and electronic engineering departments at universities.

METHOD

Sample

When the study was carried out (in September 2006), there were 147 universities in Taiwan, 70 of which established electrical and electronic engineering departments [6]. In total, there were 2,913 teachers in these departments (including lecturers, assistant professors, associate professors and professors). The subjects were selected by way of purposive sampling based on their location and ownership, with two universities in the northern location, two in the central location, and two in southern location being chosen for the study. Thus, there were six universities (three public universities and three private universities) to be tested. In all, 50 subjects were selected from each university; thus, there were 300 subjects participating in the study. In mid-October 2006, the investigators posted each subject a questionnaire, souvenir and return postage, plus a cover letter was attached explaining the investigation's purpose. The investigators mailed two reminders to prompt the subjects to send back their questionnaires after completing the questions. The researchers received 174 questionnaires up till late November 2006, and after removing 10 invalid questionnaires, there 164 valid questionnaires, yielding a response rate of 54.67%.

Instrument

The Safety Performance Scale (SPS) in this study included the three following dimensions:

- Safety inspection;
- Accident investigation;
- Safety motivation.

All of the above dimensions included six items, so there were 18 items in total. The items in the safety inspection dimension were generated from the Labor Safety and Health Act and Regulations (regarding the supervisory function) and the supervisory measurement of safety performance (the area of inspections) proposed by Petersen [1]. The items of the accident investigation dimension were revised from the safety audit assessment (the area of accident investigation) as proposed by Schneid and the supervisory measurement of safety performance by Petersen [1][2]. The items of the safety motivation dimension were modified from Petersen's supervisory measurement of safety performance (the area of motivation) and Swartz's safety audit elements (the area of safety motivation) [1][3].

Data Analysis

The investigators used the *Statistical Package for the Social Science* (SPSS 12.0) as the tool for statistical analysis to perform an item analysis, validity analysis and reliability analysis of the SPS. The item analysis adopted a correlation analysis, the validity analysis employed an exploratory factor analysis, while the reliability analysis applied Cronbach's α coefficient.

RESULTS

Item Analysis

As shown in Table 1, each of the 18 items of the SPS showed a significant ($p < 0.01$) positive correlation with the total safety performance score (0.644 to 0.837). This means that each item in the SPS differentiates significantly in the same direction as the total scale, which indicates the appropriate discriminative power of each item [7].

Validity Analysis

In order to examine the construct validity of the SPS, the investigators employed an Exploratory Factor Analysis (EFA). This analysis shows that in distribution Kaiser-Meyer-Olkin (KMO) measure of sampling adequacy was 0.928, indicating that the data were appropriate for this analysis [8].

Bartlett's test of sphericity was significant for the test ($\chi^2 = 2890.190$, $p < 0.001$) (Table 2), indicating that correlations existed among some of the safety performance scales.

The principal component analysis was used for the factor extraction of the SPS and a Varimax rotation was employed for better interpretability of the factor loadings. Moreover, in order to enhance interpretability, only those factor loadings greater than 0.50 were selected [9].

The EFA of the 18-item SPS produced three factors with eigenvalues greater than 1 (Kaiser criterion), which accounted for 77.75% of the total variance (See Table 3). The table also shows that each of the communalities of the 18 items was greater than 0.61. A scree plot of the size of the eigenvalues against the number of factors in their order of extraction is shown in Figure 1.

Table 1: Correlation coefficients of each item with the SPS.

Item Number	Item Total Score Correlation
1	0.823**
2	0.837**
3	0.792**
4	0.780**
5	0.825**
6	0.764**
7	0.671**
8	0.770**
9	0.762**
10	0.733**
11	0.657**
12	0.644**
13	0.746**
14	0.790**
15	0.762**
16	0.739**
17	0.748**
18	0.799**

Note: $^{**}p < 0.01$

Table 2: KMO and Bartlett's test of sphericity.

Kaiser-Meyer-Olkin measure of sampling adequacy	0.928	
Bartlett's test of sphericity	The approximate chi-squared distribution	2,890.190
	Degrees of freedom	153
	Significance	0.000

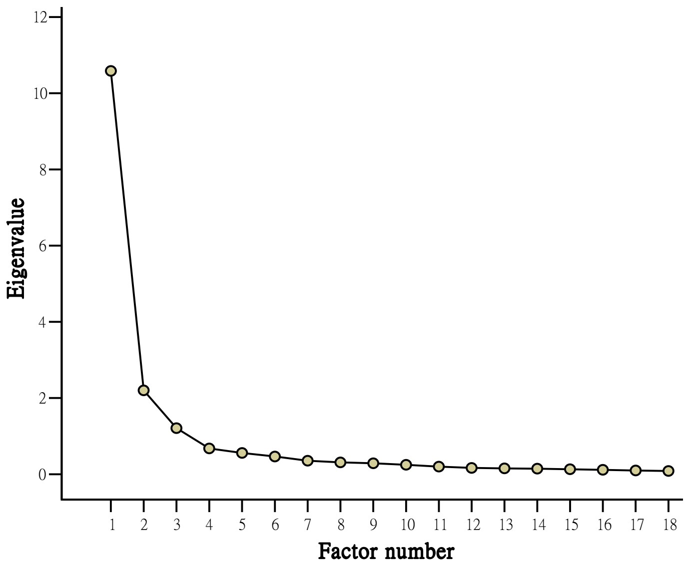

Figure 1: Scree plot of the factors.

Reliability Analysis

Internal consistency reliability was measured for each subscale of the SPS using Cronbach's α [10]. As shown in Table 4, the reliability coefficients ranged from 0.926 to 0.953, all of which are acceptable.

Table 3: The eigenvalues, communalities, factor loadings and explained variances of t safety performance scale by the EFA.

Factors	Eigenvalues	Item Number	Communalities	Factor Loadings	Explained Variances	Accumulated Explained Variances
Safety motivation	5.027	16	0.813	0.849	27.93%	27.93%
		17	0.780	0.822		
		15	0.757	0.792		
		14	0.764	0.770		
		18	0.756	0.761		
		13	0.728	0.752		
Accident investigation	4.588	11	0.785	0.846	25.49%	53.42%
		10	0.807	0.843		
		12	0.728	0.809		
		9	0.768	0.786		
		8	0.764	0.772		
		7	0.614	0.707		
Safety inspection	4.380	3	0.850	0.817	24.34%	77.75%
		4	0.835	0.794		
		6	0.788	0.792		
		5	0.849	0.773		
		1	0.793	0.706		
		2	0.816	0.699		

Table 4: Internal consistency of each subscale of the SPS.

Subscale	Cronbach's α
Safety motivation	0.939
Accident investigation	0.926
Safety inspection	0.953

DISCUSSION

Kaiser argued that a more explained variance will result if only those components with eigenvalues greater than one are retained [11][12]. The eigenvalues of these three factors in the SPS were all greater than 4.30, indicating that the SPS had good explanatory power to a certain degree. Cattell advised to keep all eigenvalues before the break point of the scree plot [13]. So, as Figure 1 shows, the authors retained the eigenvalues of the three factors in this study. Cattell and Jaspers, Browne and Linn suggested that while the number of variables is less than 40, if the criterion is to retain those with eigenvalue greater than one, the communalities should be greater than 0.40 [14-16]. In this study, the communalities of the 18 variables were greater than 0.61, so the accuracy of the SPS is supported.

According to Gay, what constitutes an acceptable level of reliability is determined by the type of test. Of course, a coefficient greater than 0.90 would be acceptable for any test. For achievement and attitude tests, the coefficient should not be less than 0.90 and for personality measures, it is acceptable if the coefficient is more than 0.70 [17]. Nunnally and DeVellis also supported that the minimum level of acceptability for the coefficient of a scale is 0.70 [18][19]. This contention was also supported by Cooper, who proposed that a different safety practice could be distinguished only if the coefficient is greater than 0.70 [20]. However, with a stricter criterion, DeVellis suggested that a scale would not make much academic contribution unless the coefficient is greater than 0.95 [19].

In this study, the values of the coefficient of these three subscales were all greater than 0.92. Accordingly, the SPS shows good reliability and academic level.

ACKNOWLEDGEMENT

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A study of the teacher quality index of professional teachers at vocational industrial high schools in Taiwan

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ABSTRACT: The purpose of this research was to investigate and consider the quality index of professional teachers at vocational industrial high schools, and provide directions to advance the cultivation of teachers. In order to achieve this research purpose, the authors first reviewed and analysed the relevant literature. A quality index of professional teachers at vocational industrial high schools in Taiwan was then developed after conducting interviews with seven kinds of internal/external customers of professional teachers at Taiwanese vocational industrial high schools. Based on the literature review and the interview results, the quality index hierarchy structure of professional teachers at vocational industrial high schools was confirmed via a focus group discussion. Finally, based on the survey results, the weights of the quality index were proposed by the authors.

INTRODUCTION

In Taiwan, the knowledge economy, the impact of globalisation, the structural transformation of industry, industry demands of the workforce, the decreasing national birth rate, education reforms, etc, have indirectly or directly influenced the future development of vocational education [1]. The success of vocational education is intimately dependent on teacher quality. Therefore, identifying how to promote teacher quality is certainly a central issue for Taiwan, as well as many other countries. Teacher quality is an indicator of a student's achievements. In other words, enlightened teachers are likely to cultivate accomplished students. Consequently, the continuous improvement of an index of teacher quality is necessary in order to produce good teachers.

Based on the importance of laying the foundations for quality teachers, this study was designed to explore the quality of professional teachers. The result provides a valuable reference point for the cultivation and future development of professional teachers. The aim of this research was to illustrate the importance of the quality index of professional teachers at Taiwanese vocational industrial high schools.

LITERATURE REVIEW

Many researchers have given definitions of teacher quality. For example, Reichardt proposed that the most basic definition of teacher quality is a teacher's ability to help students reach high standards [2]. According to the National Research Council, teacher quality refers to the knowledge, skills, abilities and dispositions of teachers that enable them to engage students in rigorous, meaningful activities that foster academic learning for all students [3]. Hart and Teeter also reported on the definition of teacher quality in their paper on *Americans Speak on Teacher Quality* [4].

The quality teacher is one who has demonstrated various abilities, including the following:

- Skills to design learning experiences that inspire/interest students;
- A lot of enthusiasm for the job;
- A caring attitude towards students;
- A thorough understanding of their subject;
- A great deal of involvement with students' parents;
- Several years' experience as a classroom teacher;
- An advanced degree from a good school of education.

In this research, the authors have also proposed a definition of teacher quality as follows:

> *A teacher should have a competent ability for his/her educational work, have enthusiasm and teaching knowledge, and can help students to achieve the high standard abilities.*

In addition, a teacher should undertake good teaching activities to stimulate effectively the student's studies and promote the student to achieve high standards.

Although scholars had different opinions regarding teacher quality, research work from various sources were generalised, including six outlines and 27 quality items [5-16]. The six outlines are as follows:

- Education knowledge: learning theory, counselling knowledge, classroom leadership theory, education and teaching expertise, general and subject matter pedagogy, and situational knowledge;
- Professional knowledge: professional subject matter knowledge and occupational practical knowledge;

- Teaching skills: the selection and compilation of teaching materials, effective teaching, instructional assessment, instructional improvement, technology manipulation and interdisciplinary integration;
- Professional skills: the acquisition of professional licenses, plus practical skills and factory management skills;
- Generic competences: problem-solving, interpersonal communication and coordination, and cooperation;
- Values and attitudes: high expectation, professional ethics, love of education, life-long learning, enthusiasm, leading by personal example, as well as fairness and justice.

RESEARCH DESIGN

In order to obtain a clear analysis, the researchers undertook interviews, a focus group discussion and a survey as the research methods. This first entailed reviewing the relevant literature. This was followed by a *semi-structured* interview with seven kinds of internal/external customers of professional teachers at vocational industrial high schools with a total of 21 participants who comprised educational administrators, school administrative personnel, professional teachers, students, patriarchs, experts and scholars, and an industry CEO. From this, the researchers constructed the initial quality index hierarchy structure of professional teachers at vocational industrial high schools. After this was completed, 18 persons, who were connected to teacher quality and who also came from seven different kinds of internal/external customers of professional teachers at vocational industrial high schools, were invited to participate in a focus group discussion. The topic of this focus group discussion was to identify the quality index of professional teachers. The confirmed quality index hierarchy structure of professional teachers at vocational industrial high school was proposed after this discussion.

Finally, according the results of the focus group discussion, the *hierarchy weights analysis questionnaire of the quality index of professional teachers at vocational industrial high schools* was established. A total of 20 experts, comprising experts and scholars, educational administrators, school administrative personnel and professional teachers, was then selected to fill out the questionnaire. After the survey, the Analytic Hierarchy Process (AHP) technique was used to confirm the weights of the quality index of professional teachers at vocational industrial high schools.

RESULTS AND DISCUSSION

Interview

From an analysis of the interview results, the authors determined six quality index dimensions of professional teachers of vocational industrial high school. These dimensions consisted of 27 items; specifically, the dimension of *education knowledge* included counselling knowledge, classroom leadership theory, as well as education and teaching expertise; *professional knowledge* included professional subject matter knowledge, occupational practical knowledge and new knowledge related to industries, *teaching skills* included teaching materials selection and compilation, effective teaching, instructional assessment, instructional improvement, and technology manipulation; *professional skills* included practical skills and the acquisition of professional licenses; *generic competences* included problem solving, interpersonal communication and coordination, cooperation, creativity and innovation, emotional management, and international perspective; *values and attitudes* included humanistic qualities, professional ethics, love of education, life-long learning, enthusiasm, leading by personal example, as well as fairness and justice.

Focus Group Discussion

After the focus group discussion, the establishment of the *hierarchy structure of the quality index of professional teacher at vocational industrial high schools* was composed of six dimensions and 35 items, as shown in Figure 1.

Hierarchy Questionnaire Survey

The study calculated the overall hierarchy weights listed in Figure 1. These were sorted by the level of importance in the quality index of professional teachers, as shown in Table 1. Among all the dimensions, *professional knowledge* was found to be the most important.

Table 1: Levels of importance for the dimensions of the professional teacher quality index.

Order	Quality	Eigenvector
1	Professional knowledge	0.245
2	Values and attitudes	0.242
3	Professional skills	0.185
4	Teaching skills	0.138
5	Education knowledge	0.120
6	Generic competences	0.069

The *education knowledge* dimension included the items of education and teaching expertise (eigenvector 0.293), classroom management theory (eigenvector 0.187), general and subject matter teaching principles (eigenvector 0.168), counselling knowledge (eigenvector 0.149), learning theory (eigenvector 0.131) and situational knowledge (eigenvector 0.073). In summary, the *education knowledge* of professional teachers was focused on *education and teaching expertise*.

The *professional knowledge* dimension included the items of correct concept of employment (eigenvector 0.295), professional subject matter knowledge (eigenvector 0.263), professional skills-related knowledge (eigenvector 0.260) and new knowledge related to industries (eigenvector 0.182). The *professional knowledge* of professional teachers was dominated by the *correct concept of employment* item.

The *teaching skill* dimension included the items of pedagogy application (eigenvector 0.388), teaching materials selection and compilation (eigenvector 0.160), technology manipulation (eigenvector 0.121), instructional improvement (eigenvector 0.120), instructional assessment (eigenvector 0.116), and interdisciplinary integration (eigenvector 0.095). The *teaching skills* aspect of professional teachers was focused on *pedagogy application*.

The *professional skills* dimension included the items of practical operation (eigenvector 0.409), factory management (eigenvector 0.181), the acquisition of professional technology licenses (eigenvector 0.148), assisting students in project work (eigenvector 0.139) and assisting students in obtaining professional technology licenses (eigenvector 0.123). The *professional skills* dimension of professional teachers was mainly focused on *practical operation*.

The *generic competence* dimension included the items of interpersonal communication and coordination (eigenvector 0.239), problem solving (eigenvector 0.232), emotional management (eigenvector 0.177), cooperation (eigenvector 0.126), research and innovation (eigenvector 0.118), language proficiency (eigenvector 0.067), and international connections (eigenvector 0.041). The *generic competences* dimension of professional teachers was emphatically focused on *interpersonal communication and coordination*.

The *values and attitudes* dimension included the items of professionalism (eigenvector 0.336), working attitude (eigenvector 0.229), professional ethics (eigenvector 0.143), leading by personal example (eigenvector 0.088), life-long learning (eigenvector 0.074), fairness and justice (eigenvector 0.072), and humanistic qualities (eigenvector 0.057). The *values and attitudes* aspect of professional teachers was mainly skewed towards *professionalism*.

The ranking of all 35 quality index items are listed in Table 2, with practical operation being the most important item.

CONCLUSION

The viewpoint of internal/external customers of professional teachers and the quality index should be considered when developing the curriculum of professional teachers at vocational industrial high schools. In the research presented in this article, the authors created a quality index hierarchy structure of professional teachers at vocational industrial high schools with six quality index dimensions and 35 items that may contribute to the advancement of the quality curriculum development of professional teachers.

Of note is that *professional knowledge*, as well as *values and attitudes*, were found to be particularly important with regard to cultivating the curriculum of professional teachers at vocational industrial high schools. Also, the quality index hierarchy and its weights could be reference materials for teacher evaluations of professional teachers at vocational industrial high schools, especially with regard to evaluation items and measurement.

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Table 2: The ranked importance of the various quality index items.

Ranking	Quality Index Item
1	Practical operation
2	Pedagogy application
3	Professionalism
4	Correct concept of career
5	Education and teaching expertise
6	Professional subject matter knowledge
7	Professional skills-related knowledge
8	Interpersonal communication and coordination
9	Problem-solving
10	Working attitude
11	Classroom management theory
12	New knowledge related to industries
13	Factory management
14	Emotional management
15	General and subject matter teaching principle
16	Teaching materials selection and compilation
17	Counselling knowledge
18	Professional technology licenses obtainment
19	Professional ethics
20	Assisting students in the project work
21	Learning theory
22	Cooperation
23	Assisting students in obtaining professional technology licenses
24	Technology manipulation
25	Instructional improvement
26	Research and innovation
27	Instructional assessment
28	Interdisciplinary integration
29	Leading by personal example
30	Life-long learning
31	Situational knowledge
32	Fairness and justice
33	Language proficiency
34	Humanistic qualities
35	International connections

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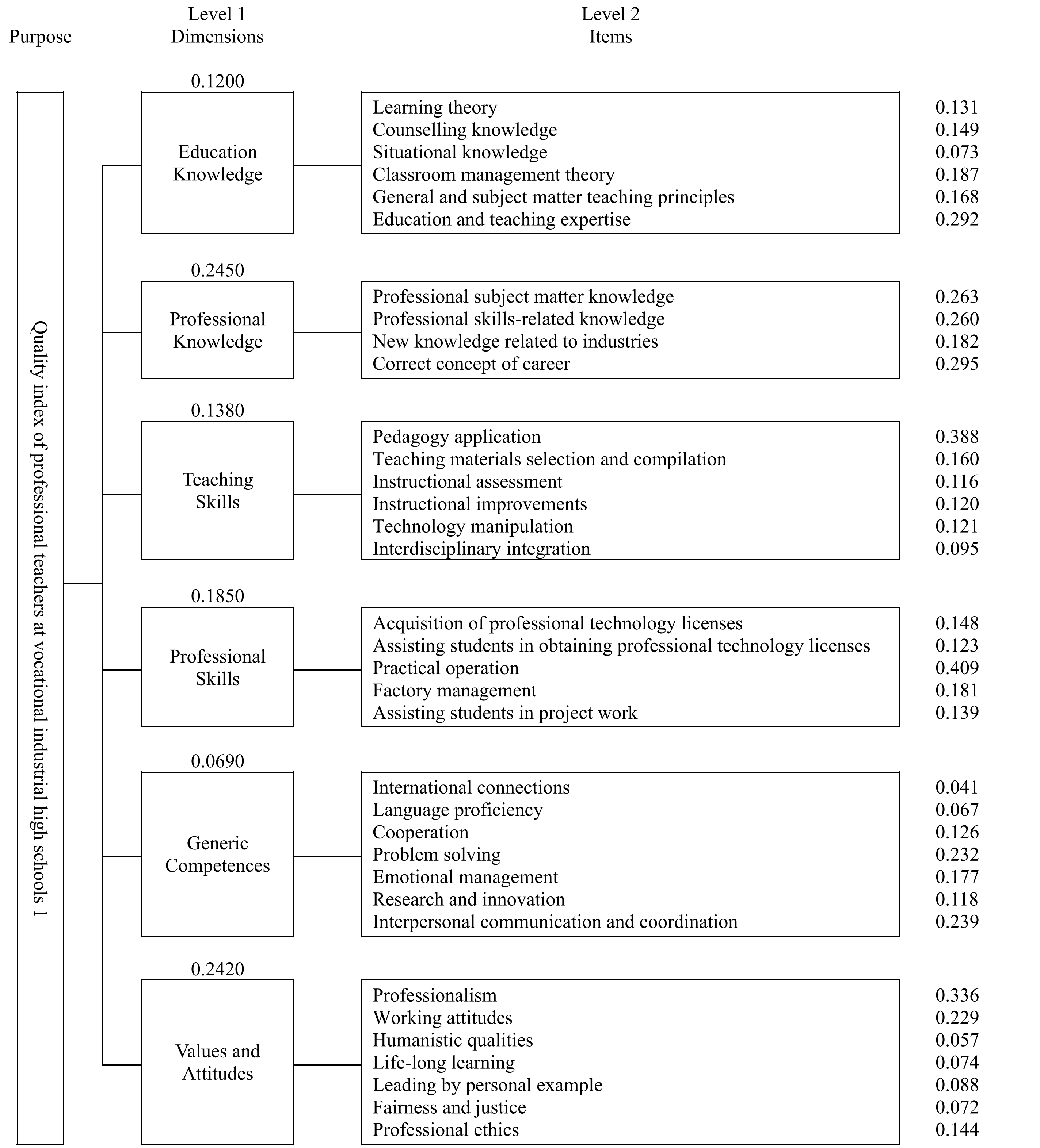

Figure 1: The hierarchy structure and the weights of the quality index of professional teachers at vocational industrial high schools.

Critical issues and their solutions in the international accreditation of engineering and technology programmes in Taiwan

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ABSTRACT: With the coming trend of ensuring graduates' competences, the issue of accreditation became increasingly popular from 1998 to 2002 as articles published in the *Journal of Engineering Education* demonstrate. The purpose of this study was to explore the critical issues and their solutions in the international accreditation of engineering and technology programmes in Taiwan based upon the Washington Accord. A literature review, in-depth interview, panel discussion and survey questionnaire were employed in this study to achieve the research purpose. There were 149 questionnaires distributed and 94 valid questionnaires were obtained, which led to a return rate of 63.1%. According to the results of analysis, the following two conclusions can be made: 33 critical issues have been identified and appropriate solutions to these issues developed; and compared to unaccredited engineering and technology programmes, accredited engineering and technology programmes have fewer difficulties in critical issues and generate a more positive attitude in solutions.

INTRODUCTION

In the mega-trend of global economic and international competition, more and more countries in recent years have expressed their needs for human resources to accommodate social change. These human resources have to be qualified with competences in problem solving, computer applications, data analysis and teamwork in dealing with future complicated problems [1]. Actually, these competences are related to engineering and technology education as demonstrated by the numerous position papers expressing the importance of engineering and technology education all over the world.

With the increasing trend to ensuring graduates' competences, the issue of accreditation became popular from 1998 to 2002 as demonstrated by papers published in the *Journal of Engineering Education* [2]. The ideal accreditation model comes from the Washington Accord; its focus is on recognising the substantial equivalency of accreditation systems of organisations holding signatory status and the engineering education programmes accredited by them [3]. Over the last decade, more and more countries want to become a signatory and ensure that their engineering and technology (ET) programmes foster graduates' competences using the Accreditation Board for Engineering and Technology (ABET). Taiwan follows this trend of accreditation.

Growing Demand for Accreditation in Taiwan

Taiwan is famous for electronic products and is known as the *Green Silicon Island*, so there is a great need for graduates of ET programmes in industry. However, graduates' performance in ET programmes does not always meet employers' needs. Therefore, the Institute of Engineering Education Taiwan (IEET) is driving the accreditation of ET programmes in Taiwan and trying to become a provisional signatory to the Washington Accord. In order to become a provisional signatory, the IEET translated and revised the ABET standards, renaming it as the Accreditation Council 2004 (AC 2004) [4]. There have already been 88 ET programmes accredited with limitations and many ET programmes are still waiting for accreditation [5].

Identification of Critical Issues and Their Solutions are Vital to ET Programmes' Accreditation

Because more and more Taiwanese universities are interested to have their ET programmes gain AC 2004 accreditation, critical issues and their solutions need to be identified for continuous improvement. Therefore, the purpose of this study is to explore the critical issues and their solutions according to accredited and non-accredited ET programmes' experiences. It is believed that ET programmes in Taiwan or all over the world could take the results of this study as a reference point in applying for accreditation.

METHODOLOGY

Research Methods

A literature review was first conducted to develop a draft of critical issues and solutions in the international accreditation of ET programmes. Data were collected from the ABET Web site and the social science citation index by utilising the keywords of issues, solutions, engineering and technology, and accreditation. Finally, according to the literature review results, a draft of the critical issues and their solutions was made.

Because the draft of critical issues and their solutions developed in the literature review focused on international experiences, there might be some differences in applying for accreditation. Thus, in-depth interviews were employed to explore the real critical issues and their solutions in Taiwan. One dean and one programme head who had applied for

AC 2004 accreditation were invited to the in-depth interview and made many suggestions to the draft. Finally, the critical issues and solutions to those issues in Taiwan were developed after the in-depth interview.

A panel discussion was utilised to make the critical issues and their solutions in Taiwan more complete. Five programme heads were invited to the panel discussion on 5 May 2006, and they all had experience in preparing for accreditation. A questionnaire entitled *Critical Issues and Their Solutions in the International Accreditation of Engineering and Technology Programmes in Taiwan* was developed from the suggestions made by the panellists.

The questionnaire was employed to collect opinions from two cohorts of ET programme heads. Cohort 1 had experience in applying for accreditation conducted by the IEET. Cohort 2 had no experience in applying for accreditation. When a university/college had Cohort 1, its ET programmes having no experiences of applying for accreditation were counted for Cohort 2. There were 149 questionnaires distributed on 22 May 2006, and 63 valid questionnaires were obtained. A follow-up questionnaire was then distributed on 13 June 2006 with 94 valid questionnaires collected in total, leading to a rate of 63.1%. Among the 94 questionnaires, 36 questionnaires were collected from Cohort 1 giving a rate of 76.6%, and 58 questionnaires were collected from Cohort 2, yielding a rate of 56.9%. Finally, critical issues and their solutions were identified according to an analysis of the 94 questionnaires.

Research Tool

The major research tool was the questionnaire, *Critical Issues and Their Solutions in the International Accreditation of Engineering and Technology Programmes in Taiwan*. The validity of questionnaire was verified according to content validity. The Cronbach α value of reliability for the whole questionnaire was 0.95, while the Cronbach α value of the dimension of *critical issues* and *solutions to issues* were 0.94 and 0.93, respectively. That is, the whole questionnaire and its two dimensions were deemed to be reliable.

RESULTS

Among the 94 programme heads, 61 of them were affiliated to general universities/colleges and 33 of them were affiliated to universities/colleges of technology. Further, 49 of them were affiliated to public institutions and 45 of them to private ones. The average number of years of their working experiences and preparation length for accreditation were 2.2 (*SD*=1.7) years and 1.4 (*SD*=0.6) years, and the average degree in being familiar with accreditation was 7.0 on a nine-point scale.

According to the results listed in Table 1, the critical issues and their solutions in the international accreditation of engineering and technology programmes in Taiwan can be divided into the three stages: preparation, pushing and future stages.

Preparation Stage

There were four important issues in the preparation stage (listed in Table 1) with the most important issue being *the tasks of preparation are complicated* (*M*=4.35, *SD*=0.99). That is, if Taiwanese universities want to apply for the accreditation of their ET programmes, they may face the issue of the task of preparation being complicated. The solutions for each issue are also shown in Table 1, with the appropriateness of each solution being acceptable. In other words, the solutions to issues could be taken as an important strategy to resolving issues during the preparation stage.

Pushing Stage

Five issues were identified in the pushing stage (see Table 1). In the *standards* aspect, only one issue was identified: *the meanings of AC 2004 standards need to be explained more clearly*. AC 2004 standards have been developed according to ABET standards, which are utilised to accredit ET programmes in Taiwan. This finding corresponds to Prados, Peterson and Lattuca's viewpoint, who believed that the ABET standards were complicated and user-unfriendly [6]. The solution developed for this issue is appropriate to be taken as an important strategy.

In the *institution* aspect, two issues were identified with the most important issue being *not enough resources*. That is, if the institutions wanted to pursue ET programmes for accreditation, they had to strive for enough resources. As for the solutions to these two issues, the solution to the second issue was found to be not so appropriate (*M*=3.29, *SD*=1.17). Therefore, it is necessary to develop the educational goals of the university/college in a step-by-step manner.

In the *programme* aspect, 12 issues were identified and the most important issue was *the tasks of accreditation are hard to be prepared in one time*. ABET published a follow-up report and the results showed that the process of accreditation should be focused on continuous improvement [7]. The solutions aimed at each issue are listed Table 1, with the appropriateness of each solution considered as acceptable. So these solutions can be taken as an important strategy to solving issues.

In the *teacher* aspect, five issues were identified; the most important was *teachers are overloaded with work*. According to this issue, the most appropriate solution is to allocate an assistant to help teachers prepare accreditation data. All solutions to the five issues were found to be acceptable and could be taken as an important strategy.

In the *other* aspect, only one issue was identified: *the status of graduates is hard to follow up*, and the two solutions to this issue and their appropriateness were great. These were to build up the follow-up system to the graduates system, and to make the alumni organisation and system more appropriate. Because graduates' performance is more and more important in recent years, it is also necessary to adopt these two solutions for monitoring a programme's performance.

Future Stage

There were two aspects of issues identified in the future stage, as shown in Table 1. In the IEET aspect, the most important issue being *the programmes do not leave enough time to prepare data for accreditation*. Therefore, the IEET should advance the operation time and then universities will have enough time to complete their work with their programmes in a timely manner. As for the solutions to issues, the appropriateness of each solution to issues was also found to be acceptable.

Regarding the AC 2004 aspect, the most important issue is *the Department of Education has no definite policy for*

Table 1: Analysis of the critical issues and solutions to these issues.

Critical Issues	*M*	*SD*	Rank	Solutions to Issues	*M*	*SD*
Preparation Period						
1. Building a common view is not easy	3.68	1.18	3	1. Hold conferences and invite experts to introduce accreditation	3.77	1.07
2. Research-oriented and senior teachers have a low willingness to join	3.32	1.21	4	2. Persuade teachers patiently	3.62	1.03
3. The tasks of preparation are complicated	4.35	0.99	1	3. Make up working teams effectively	4.11	1.11
4. The funding is not enough	3.89	1.20	2	4. Budget for the accreditation fee in advance	4.33	0.99
Pushing Period						
Standards Aspect						
The meanings of the AC 2004 standards need to be explained more clearly	3.57	1.06	1	Ask members of the IEET for advice	3.77	1.03
Institution Aspect						
1. Not enough resources	3.50	1.20	1	1. Ask the institution for help	4.02	1.12
2. The educational goals of the college/school are hard to develop in a short time	3.14	1.25	2	2. Utilise the school motto and develop educational goals through a formal process	3.29	1.17
Programme Aspect						
1. Inviting industry experts to join is hard	3.13	1.31	8	1. Invite outstanding education fellows to join	4.01	1.07
2. Clarifying accreditation details is hard	3.43	1.04	4	2. Invite experts to clarify questions	4.03	0.92
3. Developing programme standards according to AC 2004 is hard	3.26	1.11	6	3. Develop appropriate standards according to a programme's state of play and characteristics	4.14	0.87
4. Curriculum details are hard to be recognised	3.18	1.02	7	4. Design an appropriate form to present data	3.88	0.93
5. The tasks of accreditation are hard to prepare in one time	4.02	1.04	1	5. Improve continually	4.28	0.95
6. Cooperation between industry and the university/college is not balanced	3.11	1.20	9	6. Set up a permanent consultation committee	3.82	1.21
7. Insufficient room for the storage of evidence for accreditation	3.39	1.31	5	7. Convert accreditation data into an electronic form	3.97	1.01
8. The effects of the curriculum are hard to prove	3.61	1.06	3	8.1 Improve continually	4.21	.89
				8.2 Develop powerful tools to acquire persuasive data	4.00	.89
9. Students do not understand the benefits of accreditation	3.74	1.12	2	9.1 Make a handbook to clarify reasons	3.65	1.04
				9.2 Combine professional license and accreditation	3.66	1.18
10. Choosing one accreditation standard for a programme with two different fields is hard	3.02	1.38	10	10. Select the main accreditation standard and prepare for accreditation according to that standard	3.78	1.05
11. Variation of the programme's name after accreditation	2.47	1.41	12	11. Report to the IEET	3.41	1.28
12. Misconceptions of accreditation is equal to paperwork	2.85	1.35	11	12. The programme head should emphasise that accreditation is an approach to ensuring quality and continuous improvement	4.08	1.14
Teacher Aspect						
1. Teachers have a wait-and-see attitude about reform	3.56	1.07	3	1.1 Communicate continually	4.09	1.07
				1.2 Hold conferences to solve questions	3.81	1.14
				1.3 Invite senior experts to persuade teachers	3.84	1.14
2. Teachers have a low willingness to join	3.55	1.21	4	2. Invite persuasive experts to explain	3.67	1.19
3. The effects of teaching are hard to prove	3.64	1.12	2	3. Cooperate with educational assessment experts in developing evaluation tools and methods	3.80	1.02
4. Teachers are overloaded with work	3.94	1.17	1	4.1 Set up lower working loads	3.63	1.08
				4.2 Allocate assistants to help teachers prepare accreditation data	4.06	1.03
5. Setting up and transforming teaching goals are hard	3.51	1.00	5	5. Set up a permanent consultation committee to assist in the presentation of teaching results	3.96	1.05
Other Aspect						
The status of graduates is hard to follow up	3.85	1.35	1	1. Building the follow-up system of graduates	4.27	1.01
				2. Make education fellows' organisation and system more effective and efficient	4.20	1.02

Table 1 (continued).

Critical Issues	*M*	*SD*	Rank	Solutions to Issues	*M*	*SD*
Future Period						
IEET Aspect						
1. The programmes do not leave enough time to prepare data for accreditation	3.11	1.64	1	1. Advance the operation time	3.69	1.60
2. Accreditation committee members change the required documents without advance notice	2.87	1.42	2	2. Accreditation committee members have to make sure to identify all the required data in advance	3.93	1.19
3. Accreditation committee members are recruited inappropriately	2.67	1.60	4	3.1 Hire accreditation committee members carefully	3.85	1.29
				3.2 Clarify accreditation committee members' misunderstandings between accreditation and assessment	3.80	1.31
4. Some programmes have no related standards to be accredited	2.85	1.54	3	4. Refer the question to the Washington Accord	3.49	1.33
AC 2004 Aspect						
1. Not a signatory to the Washington Accord	3.43	1.66	4	1. Become a signatory to the Washington Accord as soon as possible	3.99	1.44
2. Promoting accreditation is not easy	3.46	1.39	3	2.1 Support accreditation by offering a reward or excusing assessment	4.09	1.21
				2.2 Combine with teacher evaluation	3.89	1.35
				2.3 Combine accreditation with professional technicians' examination	3.68	1.38
3. The relationship between accreditation and assessment is hard to clarify	3.56	1.42	2	3. Continually clarify accreditation and assessment through advertisements	4.07	1.08
4. The Department of Education has no definite policy for accreditation	3.63	1.54	1	4. Suggest that the Department of Education supports accreditation	4.21	1.17

accreditation. That is, universities hoped that the educational authority could assist in the accreditation process for their programmes and offer some benefits to them. The other solutions were also appropriate for each issue. In sum, 33 issues were identified and solutions to each issue were also developed in this study. Universities applying for accreditation of their ET programmes can use the results of this study as a reference to choose the most appropriate strategy.

Differences in Critical Issues and Solutions between Accredited ET Programmes and Unaccredited ET Programmes

According to the results shown in Table 2, differences in the critical issues between accredited ET programmes and unaccredited ET programmes include *developing standards of programmes according to AC 2004 is hard* (t=-2.40, p=0.02) and *the status of graduates is hard to follow up* (t=-2.23, p=0.03). Therefore, accredited ET programmes had fewer difficulties developing programme standards and following up graduates' status. So unaccredited ET programmes can ask accredited ET programmes for help in these two issues.

According to the results listed in Table 3, differences in issue solutions between accredited ET programmes and unaccredited ET programmes include *to improve continually* (t=2.04, p=0.04), *to set up a permanent consultation committee* (t=2.23, p=0.03), *to communicate continually* (t=2.00, p=0.04), *to set up a permanent consultation committee to assist in the presentation of teaching results* (t=2.18, p=0.03), *to support accreditation by offering a bounty or excusing assessment* (t=2.53, p=0.01), and *to combine with teacher evaluation* (t=3.72, p=0.00). Therefore, accredited ET programmes were perceived more positively regarding six solutions to the key issues. So the developers of accredited ET programmes had more experience in utilising the six solutions to the issues mentioned above.

CONCLUSIONS

With the increasing trend of ensuring graduates' competences, the critical issues of accreditation has become more popular. The purpose of this study was to explore the critical issues and solutions to issues according to accredited and unaccredited ET programmes' experiences.

Through the process of the literature review, in-depth interviews, panel discussion and survey questionnaire, 33 critical issues were identified for the three stages of preparation, pushing and future. More than one solution was developed in order to face each critical issue. Therefore, if universities seek international accreditation for their ET programmes, the critical issues and their solutions identified and developed in this study could be taken as a reference.

According to the results of analysis, accredited ET programmes exhibit fewer difficulties in critical issues and more positive attitudes towards solutions. Therefore, if the developers of unaccredited ET programmes want to apply for international accreditation, they can invite the heads of accredited ET programmes as experts. ET programme heads had more experience in facing critical issues of international accreditation and resolving them.

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Table 2: Differences in the critical issues between accredited and unaccredited ET programmes.

Critical Issues	Accredited ET Programmes		Unaccredited ET Programmes		*t*
	M	*SD*	*M*	*SD*	
Preparation Period					
1. Building a common view is not easy	3.67	1.20	3.69	1.19	-0.09
2. Research-oriented and senior teachers have a low willingness to join	3.28	1.00	3.34	1.33	-0.26
3. The tasks of preparation are complicated	4.47	0.81	4.28	1.09	0.93
4. The funding is not enough	3.83	1.11	3.93	1.25	-0.38
Pushing Period					
Standards Aspect					
The meanings of the AC 2004 standards need to be explained more clearly	3.78	0.83	3.45	1.17	1.59
Institution Aspect					
1. Not enough resources	3.47	1.08	3.52	1.27	-0.18
2. The educational goals of the college/school are hard to develop in a short time	3.14	1.20	3.14	1.29	0.00
Programme Aspect					
1. Inviting industry experts to join is hard	3.14	1.25	3.12	1.36	0.07
2. Clarifying accreditation details is hard	3.28	0.94	3.52	1.10	-1.08
3. Developing programme standards according to AC 2004 is hard	2.92	1.05	3.47	1.10	-2.40*
4. Curriculum details are hard to be recognised	3.00	0.99	3.29	1.03	-1.37
5. The tasks of accreditation are hard to prepare in one time	3.94	0.98	4.07	1.07	-0.56
6. Cooperation between industry and the university/college is not balanced	3.08	1.18	3.12	1.23	-0.15
7. Insufficient room for the storage of evidence for accreditation	3.39	1.29	3.40	1.32	-0.03
8. The effects of the curriculum are hard to prove	3.56	0.94	3.64	1.13	-0.37
9. Students do not understand the benefits of accreditation	3.61	1.13	3.83	1.11	-0.91
10. Choosing one accreditation standard for a programme with two different fields is hard	3.14	1.38	2.95	1.38	0.65
11. Variation of the programme's name after accreditation	2.56	1.36	2.41	1.45	0.47
12. Misconceptions of accreditation is equal to paperwork	2.72	1.32	2.93	1.37	-0.73
Teacher Aspect					
1. Teachers have a wait-and-see attitude about reform	3.44	0.97	3.64	1.13	-0.85
2. Teachers have a low willingness to join	3.36	1.07	3.67	1.28	-1.22
3. The effects of teaching are hard to prove	3.47	1.16	3.74	1.09	-1.14
4. Teachers are overloaded with work	3.78	1.17	4.03	1.17	-1.03
5. Setting up and transforming teaching goals are hard	3.58	0.97	3.47	1.03	0.55
Other aspect					
The status of graduates is hard to follow up	3.44	1.50	4.10	1.19	-2.23*
Future Period					
IEET Aspect					
1. The programmes do not leave enough time to prepare data for accreditation	3.39	1.29	2.93	1.81	1.43
2. Accreditation committee members change the required documents without advance notice	2.97	1.25	2.81	1.52	0.54
3. Accreditation committee members are recruited inappropriately	2.83	1.42	2.57	1.70	0.78
4. Some programmes have no related standards to be accredited	2.61	1.36	3.00	1.63	-1.20
AC 2004Aaspect					
1. Not a signatory to the Washington Accord	3.75	1.54	3.22	1.71	1.51
2. Promoting accreditation is not easy	3.75	1.05	3.28	1.54	1.77
3. The relationship between accreditation and assessment is hard to clarify	3.81	1.09	3.41	1.58	1.42
4. The department of education has no definite policy for accreditation	3.86	1.22	3.48	1.71	1.25

Table 3: Differences in the solutions between accredited and unaccredited ET programmes.

Solutions to Issues	Accredited ET Programmes		Unaccredited ET Programmes		*t*
	M	*SD*	*M*	*SD*	
Preparation Period					
1. Hold conferences and invite experts to introduce accreditation	3.78	1.02	3.76	1.11	0.08
2. Persuade teachers patiently	3.54	0.95	3.67	1.07	-0.56
3. Make up working teams effectively	4.33	0.79	3.97	1.26	1.57
4. Budget for the accreditation fee in advance	4.36	0.87	4.31	1.06	0.24
Pushing Period					
Standards Aspect					
Ask members of the IEET for advice	3.58	1.08	3.89	0.99	-1.42
Institution Aspect					
1. Ask the institution for help	4.06	1.01	4.00	1.18	0.23
2. Utilise the school motto and develop educational goals through a formal process	3.21	1.12	3.33	1.20	-0.50
Programme Aspect					
1. Invite outstanding education fellows to join	4.25	0.87	3.86	1.16	1.72
2. Invite experts to clarify questions	3.92	0.91	4.10	0.93	-0.96
3. Develop appropriate standards according to a programme's state of play and characteristics	4.25	0.77	4.07	0.92	0.97
4. Design an appropriate form to present data	3.97	0.77	3.83	1.01	0.73
5. Improve continually	4.53	0.70	4.12	1.06	2.04*
6. Set up a permanent consultation committee	4.14	0.96	3.61	1.31	2.23*
7. Convert accreditation data into an electronic form	4.06	0.86	3.91	1.10	0.66
8.1 Improve continually	4.31	0.82	4.16	0.93	0.79
8.2 Develop powerful tools to acquire persuasive data	4.03	0.81	3.98	0.95	0.24
9.1 Make a handbook to clarify reasons	3.75	0.84	3.59	1.16	0.74
9.2 Combine professional license and accreditation	3.74	0.98	3.61	1.29	0.53
10. Select the main accreditation standard and prepare for accreditation according to that standard	3.94	0.81	3.68	1.16	1.16
11. Report to the IEET	3.58	1.18	3.30	1.34	0.96
12. The programme head should emphasise that accreditation is an approach to ensuring quality and continuous improvement	4.26	1.01	3.96	1.21	1.20
Teacher Aspect					
1.1 Communicate continually	4.36	0.80	3.91	1.18	2.00*
1.2 Hold conferences to solve questions	3.92	1.00	3.74	1.23	0.74
1.3 Invite senior experts to persuade teachers	3.78	1.07	3.88	1.18	-0.41
2. Invite persuasive experts to explain	3.72	1.21	3.63	1.19	0.36
3. Cooperate with educational assessment experts in developing evaluation tools and methods	3.81	0.86	3.79	1.12	0.06
4.1 Set up lower working loads	3.74	0.95	3.55	1.16	0.81
4.2 Allocate assistants to help teachers prepare accreditation data	4.11	0.95	4.04	1.09	0.35
5. Set up a permanent consultation committee to assist in the presentation of teaching results	4.25	0.77	3.78	1.16	2.18*
Other aspect					
1. Building the follow-up system of graduates	4.44	0.81	4.16	1.11	1.36
2. Make education fellows' organisation and system more effective and efficient	4.44	0.81	4.05	1.11	1.83
Future Period					
IEET Aspect					
1. Advance the operation time	4.00	1.47	3.48	1.66	1.52
2. Accreditation committee members have to make sure to identify all the required data in advance	3.88	1.34	3.96	1.09	-0.30
3.1 Hire accreditation committee members carefully	4.09	1.10	3.68	1.40	1.40
3.2 Clarify accreditation committee members' misunderstandings between accreditation and assessment	4.00	1.15	3.65	1.41	1.19
4. Refer the question to the Washington Accord	3.69	1.23	3.37	1.39	1.05
AC 2004 Aspect					
1. Become a signatory to the Washington Accord as soon as possible	4.23	1.48	3.81	1.39	1.31
2.1 Support accreditation by offering a reward or excusing assessment	4.47	0.84	3.84	1.34	2.53*
2.2 Combine with teacher evaluation	4.44	0.84	3.53	1.50	3.72*
2.3 Combine accreditation with professional technicians' examination	3.94	1.15	3.50	1.50	1.51
3. Continually clarify accreditation and assessment through advertising	4.31	0.79	3.91	1.21	1.74
4. Suggest that the Department of Education supports accreditation	4.47	0.91	4.02	1.30	1.80

Using collaborative learning projects to blend teamwork and technical competences in an aviation technology curriculum

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ABSTRACT: There is a need for learners in aviation technology and engineering curricula to better develop and apply teamwork, communication and problem-solving competences in addition to technical degree skill sets as they prepare to enter industry. However, these competences are often underdeveloped due to a heavier focus upon the technical aspects of a learner's targeted degree area. Faculty at Purdue University in West Lafayette, USA, are exploring a collaborative learning approach within its aeronautical technology curriculum in which students practice interdisciplinary teamwork, communication and problem-solving competences within a simulated aviation production maintenance environment, utilising the University's large transport aircraft maintenance management and advanced materials manufacturing laboratories.

INTRODUCTION

Organisations in technology industries rely upon employees who can effectively wield both interpersonal and technical skill sets not only within their own work groups, but also across the organisation. The aviation industry in particular continues to call for maintenance and engineering graduates capable of adapting to rapid change both in technological and business model components of their work.

Effectively blending such competences with core technical skill sets is an expectation of new hires by many companies and a requirement of the aviation industry where services or products incorporate hazardous technologies, stringent regulations and time-driven work goals. Today's graduates must be able to *hit the ground running*, as fluent in teamwork, problem solving and communication skills as they are in their degree area skill sets. This poses significant challenges to educators preparing graduates in technical and engineering curricula, where such competences are often overshadowed by the pursuit of the learner's core technical degree skills and, in the case of certification or licensure, constrained by time and regulatory requirements as well [1].

THE NEED FOR INTEGRATED SKILL SETS

It is well known that strong communication skills (among other key competences) are critical to professional success within any organisation [2]. This is underscored by employers increasingly demanding a more comprehensive understanding of the engineering technology discipline and improved levels of communication skills from graduates of such programmes [3][4].

Workers in technology industries are challenged every day not only by hardware or product issues, such as aircraft or equipment, but equally by the human element in operations. It has been evident for years that even within the most highly regulated work environment, the human element still has a profound affect on the operation not only in productivity, but in achieving other critical benchmarks of quality and safety, and can become as big a roadblock to effective job accomplishment as any technical issue [5].

In the 1990s, researchers identified 12 of the most commonly observed factors affecting human decision-making and overall safety in hazardous industrial operations, which included communication, teamwork and assertiveness in the list [6]. This remains true for today's graduates entering any technical workforce, especially in aviation. Achieving success in industry requires collaborative problem solving, communication and teamwork capacities, which must be employed effectively across different departments of an organisation as well as among its local teams.

Learners in technology and engineering education run the risk of missing key technical teamwork and problem-solving abilities when a skill-specific degree remains the only educational goal. An educational and experiential gap exists for many graduates of technical programmes in which they often enter job roles based almost exclusively upon a technical degree qualification, only to encounter great difficulty overcoming commonly encountered people issues or barriers to process flow, finding it extremely difficult to adapt with the speed and resiliency necessary for problem solving required of the modern technical workforce [7].

Far from merely packaging and shipping out a bad part to be *fixed*, technical maintenance crews must interact with a variety of skilled support personnel to communicate, clarify and develop viable, airworthy repair paths or manufacture quality parts, all while ensuring timely delivery and cost control. Given the difficulty of communication involving technical information and rapid turnaround times, it is not enough to merely follow written instructions, or copy and paste a solution from an aircraft engineering diagram. Such scenarios challenge those in industry everyday and require a collaborative and proactive effort from both sides.

A specific example where such collaboration is required is the maintenance engineering department or machine shop supporting an aircraft maintenance line of work in advanced repair methods for mechanical or structural discrepancies. This example is the basis of a learning laboratory collaboration of a similar scenario currently being explored within an aviation maintenance technology curriculum at Purdue University in West Lafayette, USA.

CREATING THE CROSS-FUNCTIONAL SETTING

The scope of modern aviation maintenance operations is complex. A single aviation maintenance and repair operation can require an individual to working with several different aircraft fleet types, different customers with varying and sometimes conflicting requirements and, given the global nature of aviation and growing international markets, a multinational technical workforce. Business models have changed, requiring even frontline workers to take on the roles of leadership and teamwork once relegated to upper management. Hallmarks once used to determine effective leadership and *team building* capabilities of an upper manager are now everyday expectations of the frontline technical team. Communication, teamwork and problem solving are no longer just good ideas. They are essential, entry-level skills for effective cross-functional teams.

With this in mind, it was believed the skills gap identified in this paper – the same skills called for by industry – could be more explicitly addressed before the graduate enters the workforce through the purposeful, hands-on integration of collaborative learning projects among courses within the degree curriculum. It is well known that hands-on projects are motivating and help sustain students' interest in technology and the curriculum. As well, this concept has been used in university settings to prevent students from switching to other majors [8].

Purdue University faculty in the Aeronautical Technology curriculum have recently developed and begun practicing hands-on interaction between two aviation technology courses, in a similar fashion to interactions experienced in industry among production maintenance and related technical support groups.

Faculty determined that an ideal learning platform existed to address the need for communication and problem-solving experiences at a cross-disciplinary peer level through the incorporation of appropriate collaborative technical projects between two different technology courses. Among the requirements for such a link between courses were realistic and relevant projects that remained connected to technology and engineering principles with tangible deliverables, but that also promoted student-to-student communication, teamwork and problem solving. These courses are described below.

AT 402 - Aircraft Airworthiness Assurance

The first is a capstone aviation maintenance management course: AT 402 - Aircraft Airworthiness Assurance, which simulates a maintenance operation utilising the University's large transport Boeing 737 and 727 aircraft. Senior maintenance technology students function as operations managers and are tasked with researching, planning and implementing a simulated large aircraft maintenance operation in which they manage lower level student technical crews in accomplishing segments of a specified maintenance check.

Initially beginning with the construction of a simplified maintenance process and general job task card development, the course has grown to incorporate more robust concepts of safety management systems, the use of process mapping in problem solving and process streamlining, technical writing, the creation of engineering job card change requests, training development and delivery, as well as the incorporation of key leadership competences in communication, team building and process management into laboratory maintenance activities.

AT 408 - Advanced Aircraft Manufacturing Processes

The second course is AT 408 - Advanced Aircraft Manufacturing Processes. This course was selected in that projects and outcomes for the course fit with the AT 402 philosophy, targeting both technical and team work/leadership competence outcomes. Students in AT 408 have developed basic aircraft materials skills from previous coursework as regulated by US Federal Aviation Regulations (FARs) [1]. Students have learned to integrate larger problem-solving skills and next-step processes including structural joint design, in-depth manufacturing processes, the use of CNC equipment and working within quality control frameworks like QC 9000.

AT 408 is a final senior level course performing advanced materials manufacturing, and is almost entirely project-based allowing students to perform research and design products to better understand engineering fundamentals and technology applications in industry. It also requires communication and planning skills as students acquire the new language of manufacturing and take projects from planning to hands-on delivery, which includes following all stages of the design process, as well as the development of project costs, establishing timelines and producing process sheet and work instructions.

MAKING IT WORK

Actual aircraft discrepancies identified as possible project candidates during the maintenance process in the AT 402 laboratory are first evaluated for repair options by the AT 402 maintenance team and instructor approval is obtained to initiate a project request for manufacturing support. A non-routine job card write up is generated and, just as in industry, placed on the local maintenance job board with the part's status and routing documentation.

Once an item has been identified and prepared for routing to the AT 408 manufacturing laboratory, specifications are further researched and documented on an Initial Project Request form prior to routing. This form is then provided to the advanced manufacturing laboratory team, where a brief project support meeting between the two student teams is then held to further discuss and evaluate details of manufacture, cost and delivery estimates.

A Team Performance Feedback Form was created and is being utilised as one initial testing method to evaluate overall student team performance in both courses. The form is designed to measure performance in planning, problem solution setting, communication and product final delivery quality in terms of customer satisfaction at the team level.

A six-question survey asks each team to assess the other team's aggregate performance for each project initiated throughout the semester. Questions one through four assess team performance utilising a five-point Lichert scale, and the last two questions are Yes-No. The assessment areas are:

1. Planning, preparation and documentation;
2. Verbal communication during team meetings;
3. Participation in setting process direction and deadlines;
4. Incorporation of safety considerations;
5. Were agreed upon project deadlines met?
6. Did the final product meet design requirements?

CONCLUSIONS

While the design and manufacture of a useable, airworthy part with a timely turnaround is the ideal target in industry, such expectations are projected to be, at times, unrealistic given the real life constraints of laboratory timeframes, limited resources and lack of technical field experience among both student groups. However, it is believed the educational value of student teams applying skills in communication and problem resolution in a hands-on technical work environment scenario is significant, closely resembling a common on-the-job scenario in industry, and is indeed the more important metric in this particular setting.

Although still in the early phases, initial observation of team performance in both classes is very promising, bringing an added dimension of realism to both laboratories while widening the student's breadth of experience collaborating outside of their routine work environments.

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11th Baltic Region Seminar on Engineering Education: **Seminar Proceedings**

edited by Zenon J. Pudlowski

The yearly *11th Baltic Region Seminar on Engineering Education* was organised by the UNESCO International Centre for Engineering Education (UICEE) and held Tallinn, Estonia, between 18 and 20 June 2007. The Seminar attracted participants from 10 countries worldwide. Almost 40 papers have been published in this Volume of Proceedings, which grossly document and present academic contributions to the Seminar. All of these published papers present a diverse scope of important issues that currently affect on engineering and technology education locally, regionally and internationally.

The principal objective of this Seminar was to bring together educators from the Baltic Region to continue dialogue about common problems in engineering and technology education under the umbrella of the UICEE. To consider and debate the impact of globalisation on engineering and technology education within the context of the recent economic changes in the Baltic Region, as well as in relation to the strong revival of the sea economy. Moreover, the other important objectives were to discuss the need for innovation and entrepreneurship in engineering and technology education, and to establish new links and foster existing contacts, collaboration and friendships already established in the region through the leadership of the UICEE.

The papers incorporated in these Proceedings reflect on the international debate regarding the processes and structure of current engineering education. They are grouped under the following broad topics:

- Opening address
- Education and training for engineering entrepreneurship
- Innovation and alternatives in engineering education
- New developments and technologies in engineering education
- Quality issues and improvements in engineering education
- New trends and approaches to engineering education
- Simulation, multimedia and the Internet in engineering education

It should be noted that all of the papers published in this volume have undergone an international formal peer review process, as is the case with all UICEE publications. As such, it is envisaged that these Proceedings will contribute to the international debate in engineering education and become a valuable source of information and reference on research and development in engineering education.

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A CDIO curriculum development in a civil engineering programme

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ABSTRACT: A design-directed curriculum based on the CDIO (Conceive - Design - Implement - Operate) principles was proposed for the civil engineering programme in the College of Engineering at Shantou University in Shantou, China (for the class of 2006 and later). The proposed curriculum utilises design projects as vehicles to integrate all the courses. The main differences of the new curriculum from the original one are reported in the article. A fishbone diagram was developed to present the features of the new curriculum better with an emphasis on the design projects. The design projects specifications are introduced as well. It is indicated that the designed-directed CDIO curriculum puts students in a broad and active design environment where they learn and use engineering science, technology and non-engineering knowledge, and exercise their communication, project management, leadership and other skills. All projects are designs that are based on group projects in order to cultivate team spirit.

INTRODUCTION

The CDIO (Conceive - Design - Implement - Operate) education curriculum has been widely used in mechanical, aeronautical and electrical engineering programmes [1]. In order to realise the CDIO initiative better, a design-directed curriculum had been proposed and used in the College of Engineering at Shantou University in Shantou, China [2][3]. The design-directed curriculum puts students in a design environment where they learn engineering science, technology and non-engineering knowledge, and when they need to use them. They are also required to work as a design team and exercise their communication, project management, leadership and other skills.

However, little material on using the CDIO Initiative is available for civil engineering programmes. The challenge for a civil engineering programme is to develop a design-directed curriculum based on the CDIO Syllabus and Standards [1][4]. For example, CDIO Standard 5 requires that a curriculum includes two or more design-build experiences, including one at a basic level and another at an advanced level. However, civil engineering products, like buildings, bridges, etc, require long periods, large spaces, huge amounts of money and special working skills to build them. Hence, it is difficult to plan operating products to fulfil the design-build requirements (ie close to impossible to assume the same way as the other programmes do in designing their CDIO curricula and design-build projects).

Referring to the rationale of the Standard, obtaining and iterating the design-build experiences has the following purposes:

- *Promote early success in engineering practice*;
- *Reinforce students' understanding of the product and system development process*;
- *Provide a solid foundation upon which to build deeper conceptual understanding of disciplinary skills*;
- [Give] *students opportunities to make connections between the technical content they are learning and their professional and career interests* [4].

Great effort has then been paid by the authors to fulfil these objectives by overcoming the above difficulties for the civil engineering programme since 2005.

THE MAIN FEATURES OF THE DESIGN-DIRECTED CURRICULUM

Realising the importance of real-world experiences and the difficulties in implementing students' designs, an integrated approach, termed as design-directed curriculum for civil engineering programme (for the class of 2006 and later), was designed by the authors in order to achieve the overall objectives of the CDIO initiative. The main differences of the new curriculum from the original one are as follows:

- The new curriculum is *design-directed*, whereas the original one was *course-directed*;
- The number of major design projects has increased from three for the original curriculum to six for the new one (as shown in Table 1, the projects *Introduction to Civil Engineering Design*, *Engineering System Design* and *Integrated Design-Build Project* were not included in the original curriculum);
- Factors considered in the projects of the new curriculum are more than those of the original one. The environment, natural resources and professional ethics are included in the projects of the new curriculum.

In accordance with the requirement set out by CDIO Standard 5, in addition to the fundamental courses, a new course,

Table 1: The main projects in the new curriculum of the civil engineering programme.

Project	Stage	Project specifications
Introduction to Civil Engineering Design	Year 2, Semester 1	Students make civil plans for a new town. They pick one item in the plan, such as a building or bridge, and give more specifications on the description/design
Architectural Design	Year 2, Semester 2	Students refer back to their conceptual designs in the first cornerstone project and modify original preliminary designs (such as buildings or bridges) with the new knowledge learnt in this cluster of courses
Structural and Geotechnic Engineering Design	Year 3, Semester 2	Students refer back to their conceptual designs in the cornerstone project and their architectural design, and modify their designs according to the new knowledge learnt in the cluster of courses with special attention paid to structural safety
Engineering System Design	Year 3, Semester 2	Students refer back to their conceptual designs in the cornerstone project, their architectural design, and structural and geotechnic engineering design. Students evaluate and modify their designs according to the new knowledge learnt in the cluster of courses concerning the specifications and considerations of lifecycle design
Integrated Design-Build Project	Year 4, Semester 1	Students form multidisciplinary groups with students from other departments to search for possibilities of innovation, either in the civil engineering field or other professional fields
Advanced Civil Engineering Design	Year 4, Semesters 1 & 2	Students work on a major construction development project, such as the Shantou Metro system

Introduction to Engineering Design (riding on a project), was designed for the common first year for engineering students. This course provides the framework for engineering practice in product and system building, and introduces essential personal and interpersonal skills.

The build-in design project of this course stimulates the fresh interest and creativity of students, exposes students to the process of knowledge creation and development, and gives students a sense of responsibility in social and historical contexts. This introductory course and its build-in project finished in semester 1 of year 1 are thought to provide a good starting point for students to perform their following design projects.

For year two to year four studies, the new civil engineering curriculum can be illustrated by the fishbone diagram shown in Figure 1. It can be seen that the proposed curriculum utilises design projects as vehicles to integrate all courses. The trunk of the fishbone consists of a cornerstone project and a capstone project, both termed level 1 projects. The branches of the fishbone include four level 2 projects with each leading a cluster of core courses. Individual courses may also contain mini design-based projects, termed level 3 projects. Hence, all projects are design-based group projects. The approach is termed as design-directed. The specifications of all level 1 and 2 projects are indicated in Table 1.

MAIN TASK OF THE FIRST PROJECT IN LEVEL 1

As presented in Figure 1 and Table 1, the cornerstone project (*Introduction to Civil Engineering Design*) is to be carried out in the autumn term of year two. Students are given a stretch of land to plan a new town. With little knowledge of civil engineering, students need to make civil plans for the new town. They have to plan the residential, commercial, political, social, educational and recreational districts, and plan traffic facilities like roads and bridges. The purpose is to force students to conceive civil problems within social, environmental and historical contexts.

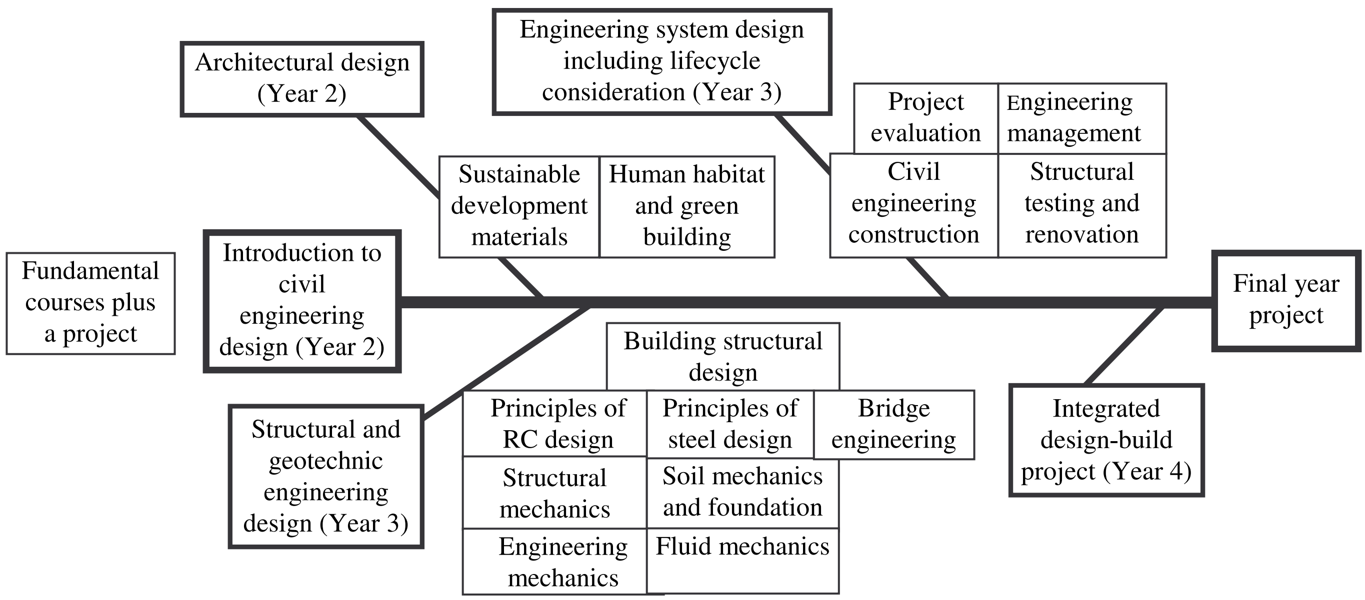

Figure 1: The main framework of the design-directed curriculum for the civil engineering programme.

The key requirement for students is *reasonability*. In order to prove the reasonability of their designs, students have to turn to various resources, which work as a good introduction course and stimulate students' interests. As the plans need only to be *reasonable* instead of being *correct or perfect*, it has the effect to encourage creativity. In this project, each group also needs to pick up one item in the plan, such as a building or bridge, to give more specifications on description/design. Students need to indicate the functions, format, styles, dimensions and materials to be used for the selected design.

AIMS OF THE FOUR PROJECTS IN LEVEL 2

As shown in Table 1 and Figure 1, four level 2 projects were arranged and each integrates a number of core courses. The project *Architectural Design* comprises human habitat and green buildings, as well as sustainable civil engineering materials. The project *Structural and Geotechnic Engineering Design* incorporates courses in mechanics, structures and geotechincs. The project *Engineering System Design* integrates courses in construction, structural assessment and maintenance, as well as renovation, engineering management and project evaluations.

In the first level 2 project, *Architectural Design*, students need to refer back to their conceptual designs in the cornerstone project and modify their preliminary designs (such as buildings or bridges) according to new knowledge learnt in this cluster of courses with an emphases on environment protection and resource saving. This project is different from the original one in the old curriculum, which does not consider resource and environment. The modified designs should be correct and good.

In the project of *Structural and Geotechnic Engineering Design*, students also need to refer back to their conceptual designs in the cornerstone project and their work in the *Architectural Design* project. They need to modify their designs according to the new knowledge learnt in the cluster of courses with a special attention on structural safety. Students are also required to make a balance between safety, aesthetics, feasibility, environmental impact and energy consumption in their design. This balance was not included in the original project of the old curriculum. It is highly encouraged that each group of students modifies the designs finished by another group of students in a cornerstone project and architectural project. Discussions, debates, understanding and compromises are expected in the communication process.

In the totally new project called *Engineering System Design*, students need to refer back to their conceptual designs in the cornerstone project, as well as their work in the *Architectural Design* and *Structural and Geotechnic Engineering Design* projects, and also evaluate and modify their designs according to the new knowledge learnt in the cluster of courses concerning the specifications and considerations of lifecycle design and the macro-costing (including initial investment and anticipated maintenance fees) of engineering projects. Because this project provides students with the opportunity to relate their design activities and decisions to social and professional responsibilities, this approach is quite different from the original one, which introduces students to all the engineering science and technology materials, but where most students have little or no engineering appreciation.

The last level 2 project, entitled *Integrated Design-Build Project*, requires students to form multidisciplinary groups with students from other departments to search for possible innovations either in the civil engineering field or other professional fields. It is expected that this project will lead to an intensive communication practice in students of the whole university.

After these projects, students should have gained good experiences with *conceiving*, *designing* and partially *operating*. The *implementing* part will be made up by onsite internships. While on construction sites, students participate in the implementation process of real-world designs. However, whatever differences exist between the student's design and the design of the real world construction, there must, nevertheless, be some similar components/parts. Students are then required to pay special attention to those parts of implementation and hand in special reports on them.

AIMS OF THE SECOND PROJECT IN LEVEL 1

The second level 1 project called *Advanced Civil Engineering Design* (final year project) works as the capstone to integrate what students have learnt in their four years of study. These projects are large and complex, such as the Shantou Metro system.

The aim of this project is to reach the standards of CDIO in an engineering and society system. The key requirement for each student of a group is, as one member of a team, to provide a correct and feasible individual detailed design using technical and non-technical skills, as well as global insights such as social, environmental and historical contexts.

CONTENT OF THE LEVEL 3 PROJECTS

Design-build projects, termed level 3 projects, are placed in individual courses. Although the major purposes of these projects are to enhance the learning of the core courses, they also compensate the *implementing* deficits of the level 1 and level 2 projects. Examples of level 3 projects include the *Construction Material Design Competition* and *Structural Competition*.

The former is actually an R&D project that may yield practical solutions. Students need to learn the fundamentals of construction materials. They work in groups to make mix designs of Portland cement concrete for specific purposes, such as pavement or marine concrete. They then make the specimens according to the mix and test the specimens to validate the design.

After that, they have to present their work to the class, and discuss and defend their ideas. The properties, environmental impacts and energy consumption of the material's design and production by students are all the evaluation indexes of the competition.

The *Structural Competition* links the theoretical analyses learnt from the course of *Structural Mechanics* to the physical world. Students from the 2003 and 2004 classes have shown great enthusiasm for these projects.

SUMMARY

A design-directed curriculum based on the CDIO Initiative was proposed for the civil engineering programme in the College of Engineering at Shantou University in Shantou, China. The design-directed CDIO curriculum puts students in a broad and active design environment where they learn and use technical and non-technical skills, exercise and design. It is believed that this new curriculum complies with the CDIO Initiative and Standards. Evaluations and modifications will be continuously performed based on the practice of the new curriculum for students of the 2006 class and beyond.

ACKNOWLEDGEMENT

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Modelling computer-mediated collaborative talk and action: a case study on ICT-based music composition in primary schools

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ABSTRACT: In this paper, the author describes an ICT-based collaborative learning model, namely *ComPLuS* (Computer-mediated Praxis and Logos under Synergy), through which peers' collaborative talk and action can be modelled. In this model, peers' dialogues are categorised into five types, ie disputational, cumulative, exploratory, operational and reflective, with each one corresponding to different types of spoken contributions. Moreover, actions are categorised as individual or joint and are used to evaluate the effect of computers on the collaborative activity within a pair. *ComPLuS* was used to analyse transcripts from videotaped observations of nine dyads (11 years) from three Greek primary schools. Their ongoing peer-to-peer communication and actions formed the research data. A mixed (qualitative and quantitative) analysis revealed that peers usually adopted cumulative and exploratory talk. The results suggest that the *ComPLuS* model captures the characteristics of peers' collaborative interactions during their shared discussions and actions, and can lead to a better understanding of the nature of computer-supported collaborative creativity.

INTRODUCTION

There is a positive notion that interaction around computers can afford a particularly productive method of learning [1-3]. Indeed, one of the clearest benefits of computer-based lessons postulated in the literature is the fact that Information and Communication Technologies (ICT) support new modes of learning, such as the collaborative type [4-6]. Stahl has pointed out: *sociocultural theories have been imported from cognate fields to suggest that cognition and learning take place at the level of dyads and/or groups as well as individuals* [7].

Various positions on this issue have been proposed and a number of theoretical perspectives have been recommended. In particular, the concept of communication, which can effectively facilitate learning conversations between learners in proximity, has been developed by examining how meanings and understandings can be shared by peers who construct knowledge by using language. In this manner, language is used in new and functional ways. Following this perspective, it is worthwhile investigating, from a sociocultural approach, learning as a language-based interactive process that can be subsequently and effectively affected by the use of computers.

Thus far, researchers have provided evidence of the potential value of computer-based talk among learners who work together towards a common task, thereby becoming able to develop an understanding through their collaborative conversation [8-11].

Emphasis has been placed on which types of talk are deployed during peers' computer-based collaborative activities that appear to be important and beneficial for the learning process [12-14]. As a result, there is significant consensus about examining the potential of collaborative talk in different subjects, such as literacy, mathematics, geography, chemistry and so on.

However, despite this emphasis, very little empirical research has been carried out on how technology can reinforce collaborative strategies, particularly in the context of music education with reference to the computer-based collaborative composition.

As a response to this deficiency, the current effort presented in this article introduces the *ComPLuS* (Computer-mediated Praxis and Logos under Synergy) model (*praxis*, *logos* and *synergy* are the Greek words for *action*, *talk* (word) and *collaboration*, respectively). The latter is based on a conception of *talk* and *action* (the term action was approached taking into account children's interaction with a music software (*Finale 2007* by MakeMusic, Inc.) when they composed together) as a tool for *thinking together*, with computer software being treated as a resource for organising and focusing children's involvements in compositional collaborative activities.

In this article, learning through computer mediation is considered not only as an individual construction developed when interacting with the computer, but also as a social construction developed within the whole learning activity. Thus far, models have been too simple to describe the complexity of collaborative learning that is based on the communication between learners through talk and action. Therefore, a framework has been created to describe:

- The level of spoken contributions and the talk types they lead to;
- The software-based actions as well as pupils' actions combined with the kind of decisions accompanied by peers' activities.

Additionally, the introduced framework illustrates a systematic approach that has the potential to explore and interpret pupils' computer-mediated collaboration without coaching before and during the collaborative session.

THE PROPOSED MODEL

The framework of grounded theory was adopted as a means to discover the potentially important variables of the *ComPLuS* model from systematically obtained and analysed data [15]. However, this perspective has advantages and disadvantages. On the one hand, a very detailed analysis gives full insight into the different aspects of pupils' talk involving many types of spoken contributions. On the other hand, it gradually increases the complexity of the model but reducing its manageability.

Two important aspects were taken into consideration to find a trade-off between these two opposing trends. These were the similarity and frequency of the spoken contributions. Initially, all different spoken contributions formed a separate category, labelled in MS *Word* documents of transcripts. Next, a grouping procedure took place based on the similarity of these categories, resulting in a re-labelling procedure when required. In addition, categories of spoken contributions that could not be placed within a group were examined for their occurrence across transcripts. In cases when they exhibited low frequency across pairs (eg they appeared only a couple of times in only one pair), they were eliminated from the list of potential categories of spoken contributions; otherwise, they formed a separate, new one. By the end, 28 spoken contributions were identified as the most essential and representative types (see Table 1).

The mapping of the identified categories of spoken contributions to talk types was based on their collaborative character. Wegerif and Mercer defined three types of talk, ie *disputational*, *cumulative* and *exploratory* [14]. Motivated by this categorisation, a grouping analysis took place to evaluate the collaborative characteristics of each spoken contribution type and, hence, classify it into the three categories. However, during the mapping procedure, it was found that two more talk types should be employed to account for all the identified spoken contribution types. To this end, *operational* and *reflective* talk types were introduced as an extension to the approach of Wegerif and Mercer [14]. Table 1 illustrates the types of collaborative talk based on *ComPLuS*.

Peers' activities were approached in a twofold manner. Initially, software-related actions were modelled as:

- AC-FEED: Action related to audio feedback provided from *Finale 2007*;
- AC-T/E: Action related to peers' engagement with a trial-and-error procedure with *Finale 2007*.

Next, peers' collaborative activities combined with the kind of decisions that accompanied peers' actions during the compositional process were examined. As a result, the actions were modelled as follows:

- AC-1: *Individual action* (individual action of one peer without contribution from his/her partner, either in the dialogue and/or the action level);
- AC-2: *Imposed action* (imposed action of one peer to the other, ie the opinion of one peer is ignored);
- AC-3: *Tacit joint action* (tacit action based on a joint decision between peers without providing any oral agreement);
- AC-4: *Explicit joint action* (explicit action based on a joint decision between peers accompanied by a spoken contribution).

A CASE STUDY ON MUSIC COMPOSITION

The *ComPLuS* model was tested on a music composition case study. Pupils aged 11 years of mixed gender were chosen from three Greek state primary schools. All had some basic computer skills and most were familiar with the simple use of word-processing software, ie MS *Word 2003*.

The subject of the collaborative task was a computer-based joint music composition; all pupils had some knowledge of musical notation and rhythm, and a basic experience of listening, performing, composing and appraising music within the classroom, but they had never previously written a composition using the specific music software involved in the study.

Table 1: Types of collaborative talk used in the *ComPLuS* model.

Talk Type	Definition	Indicative Collaborative Spoken Contributions
Disputational (DISP)	There is no evidence of consensus thinking	Short exchanges consisting of proposals as an offer with counter-proposals; disagreements; proposals as an imperative; proposals followed by an individual action
Cumulative (CUM)	There is some effort to build consensus	Proposals as an offer; proposals as a question; counter-proposals; joint proposals as an offer; agreements; comments; repetitions; confirmations; questions seeking assistance; questions seeking agreement; questions seeking confirmation
Exploratory (EXP)	There is evidence that peers debate and explore together to find the best solutions	Proposals as an offer are defined in this type of talk only if they were followed by an explanation, a clarification or an elaboration; proposals followed by an agreed action; disagreements followed by explanation; critique; clarifications; explanations; elaborations/elaborations (S) (involving elaboration with singing (for case studies in music)); questions seeking explanation; questions seeking clarification; questions seeking elaboration
Reflective (REF)	Peers engage critically and constructively expressing self-reflective thinking	Self questions; self elaborations
Operational (OPER)	Peers' utterances relating to operational transactions with regard to talk and software, respectively	Utterances about the task; utterances about the software

Observations of case studies were carried out, and video and audio materials were used to capture the complexity of the collaborative process. Pupils were asked to set up a melody to one of three particular lyrics that were composed by the first author formed in simple language and with a descriptive character working in pairs (see Figure 1).

Figure 1: Pupils working in pairs around the computer to compose a music melody.

In order to analyse the data, mixed methods were chosen that adopted both qualitative and quantitative approaches. After the data collection, a transcription process took place where all the videos were transcribed. During the next step, a textual analysis was adopted that offered an interpretation of what pupils had discussed during their conversation and developed through their actions. The next step involved a numerical coding of the parameters derived by the introduced model, followed by a quantitative analysis, which attempted to measure the frequency of spoken contributions and actions according to the categorisation of the *ComPLuS* model.

RESULTS AND DISCUSSION

Experimental results have shown that pupils were actively engaged in a dialogue during their common task, exhibiting a high number of spoken contributions per pair. Pairs' joint work was active enough, including a sufficient number of actions per pair (108 on average) and the AC-3 action type (actions based on a tacit joint decision between peers) was used most frequently during peers' mutual work (see Figure 2).

Additionally, it was found that pupils acted individually even when they deployed collaborative talk types. From a hierarchical perspective, talk types can be ranked (in a descending order of their frequency in pairs' dialogue) as CUM (cumulative), EXP (exploratory), OPER (operational), DISP (disputational) and REF (reflective). However, it was found that although the cumulative talk type dominated pupils' conversations, exploratory and reflective talk accompanied the activity of peers during their joint work, since a strong correlation (>0.7) of {EXP, REF} talk type group with actions was found (see Figure 3).

Lastly, it was noticed that the lead on collaborative talk did not mean the lead on joint action and that there was no guarantee that collaborative talk equated to joint action because it only correlated with actions AC-1 and AC-2, showing that the two talk types of EXP and REF affected only a peer's individual activity. However, a strong correlation between AC-T/E and AC-3 (see Figure 4), and between AC-T/E and {EXP, REF} talk type group (see Table 2) was found, indicating that the manipulation of software facilitated children's joint action and collaborative talk.

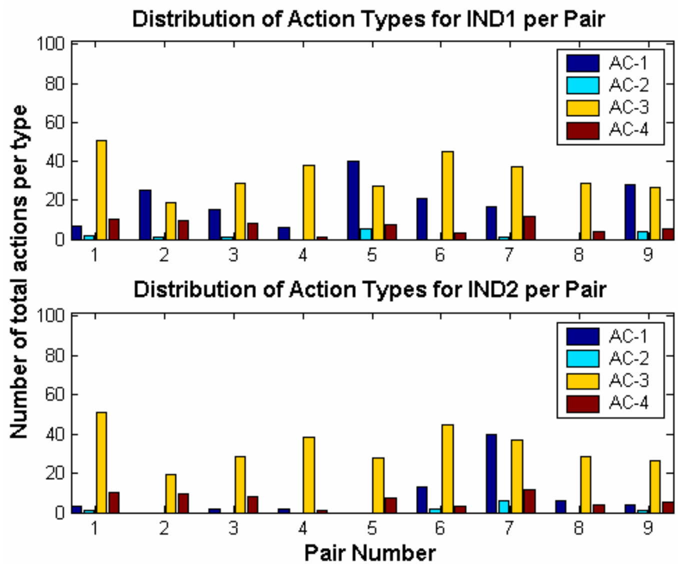

Figure 2: The distribution of the total number of action types for Pupil A (IND1) (top) and Pupil B (IND2) (bottom) for each pair. Action types: AC-1: individual action by one peer; AC-2: imposed action of one peer to the other; AC-3: action based on a tacit joint decision; and AC-4: action based on an explicit joint decision.

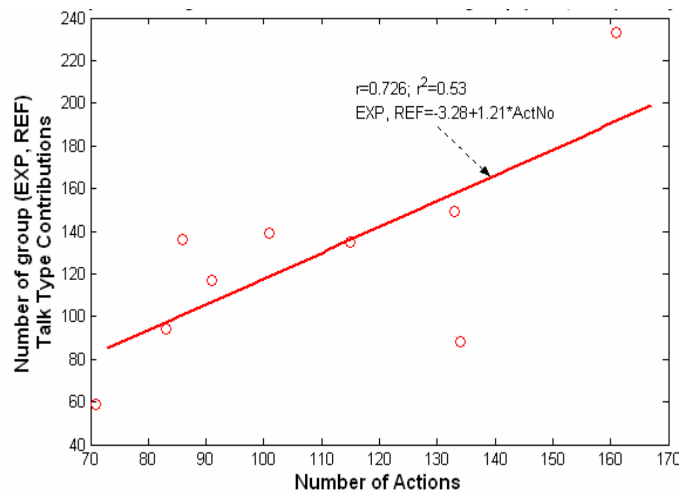

Figure 3: A scatter plot and regression analysis between the total number of actions (ActNo) associated with the group {EXP, REF} of talk type. r and r^2 denote the Pearson's correlation coefficient and the coefficient of determination, respectively.

CONCLUDING REMARKS AND FUTURE WORK

In this article, the author introduces the *ComPLuS* model and explores its modelling efficiency when applied to a music composition case study. Using the *ComPLuS* model, a means for classifying talk and action, which both give insight into the extent of collaboration, is provided. The *ComPLuS* model investigates the learning processes when children are actively involved in pairs in a computer-based compositional task by identifying a variety of spoken contributions that lead to different types of collaborative talk and analyses their actions while they manipulate score writing software and the decisions accompanying those actions during the compositional process.

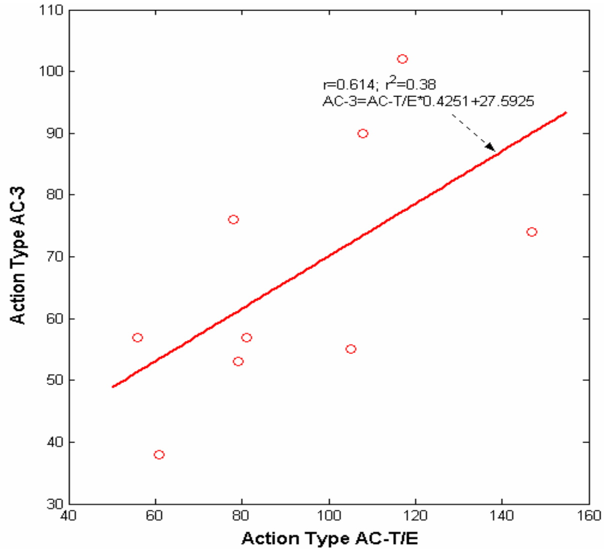

Figure 4: A scatter plot and regression analysis between AC-T/E (action related to trial-and-error procedure with the software) and AC-3 (joint action). r and r^2 denote the Pearson's correlation coefficient and the coefficient of determination, respectively.

Table 2: The correlation analysis results between the software-related action types and the associated talk type groups.

Group of Talk Types	Software-Related Action Types	
	AC-FEED	AC-T/E
{DISP, OPER}	r = -0.247 p = 0.522	r = 0.416 p = 0.265
{EXP, REF}	r = -0.071 p = 0.855	r = 0.750* p = 0.02 < 0.05
CUM	r = -0.251 p = 0.514	r = 0.448 p = 0.226

DISP: Disputational; CUM: Cumulative; EXP: Exploratory; REF: Reflective; OPER: Operational. AC-FEED: Action related to the audio feedback from *Finale 2007*; AC-T/E: Action related to peers' trial-and-error procedure with *Finale 2007*. *: Correlation is significant at the 0.05 level

The findings justify the adoption of the sociocultural approach, since monitoring peers' dialogue and actions contributes to a better understanding of the underlying mechanisms. To this end, by zooming in the collaborative interactions, as the sociocultural approach suggests, the complex processes that reciprocally affect peers during computer-mediated collaborative learning in primary schools are revealed and understood.

To probe further, an analysis of the monitored interactions could be performed in a real-time context, allowing for the provision of appropriate feedback at a collaborative level. For instance, the balance between peers could be estimated based on the level of collaborative talk and the joint actions they exhibit, and when there is a significant divergence or increase in domination, warning messages could be displayed accordingly to facilitate convergence to mutual contribution to the joint task. Ongoing work is currently directed towards this.

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Control systems demonstrations using spreadsheets

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ABSTRACT: In this article, the author illustrates the use of *Excel* spreadsheets as a tool for constructing computer demonstrations in control systems simulation. To show some of these functionalities, two examples are included. The first one shows a simulation of a continuous-time system, whereas the second demonstrates the simulation of a digital control system. Both simulations are wrapped within simple interfaces to provide interactivity and make them valuable for teaching. The examples are not comprehensive since they do not fully exploit all of the features of *Excel*. They were chosen only because they are straightforward and self-contained illustrations of how an *Excel* spreadsheet can be used to create simple interactive simulations.

INTRODUCTION

In the last few years, spreadsheets have become a popular computational tool and a powerful platform for performing engineering calculations. The simplicity of spreadsheet programming, in addition to their rich library of built-in functions, plotting capabilities and other provided utilities, have made them attractive tools in many areas of engineering and science. Moreover, spreadsheets come with a macro language that allows the inclusion of standard computer code.

In the case of *Excel*, the introduction of the Visual BASIC for Application (VBA) language enables developers to greatly extend the capabilities of *Excel* spreadsheets by designing specific add-ins. In fact, VBA has the flexibility of a general programming language and, therefore, it is possible to program any of the standard numerical algorithms for solving systems of equations, ordinary differential equations and so on. The references [1-3] constitute a good core library for anyone who considers the use of spreadsheets for engineering computations.

Spreadsheets are also used as a teaching tool for constructing computer demonstrations and laboratory simulations in a number of engineering areas [4-7]. The immediacy of the spreadsheets and the convenience of their graphical representations make them a powerful didactic tool.

In the areas of control engineering, the use of spreadsheets has not received sufficient attention and the control engineering community uses preferentially professional software such as *MATLAB*/*Simulink* and *LabVIEW*. However, there are some interesting works in the context of this article, where spreadsheets are used as an alternative tool for simulating linear and nonlinear systems [8-11]. Thus, many people might be surprised to discover that *Excel* spreadsheets can be used for simulating control systems. In fact, simple and more complex simulations of common types of systems (discrete, continuous and hybrid) can be performed easily.

The purpose of this article is to present two illustrative examples of how control systems are handled within the *Excel* environment. The first example shows a simulation of a continuous-time system, whereas the second one demonstrates a simulation of computer-controlled system. Both simulations are wrapped within simple interfaces to provide them interactivity and make them valuable for teaching. The two examples are not comprehensive since they do not fully exploit all the features of *Excel*. They were chosen because they are straightforward and self-contained illustrations of how *Excel* spreadsheets can be used to create simple interactive simulations.

THE SIMULATION OF CONTINUOUS SYSTEMS

In this first example, it is intended to design a simple interactive tool that covers the fundamental ideas with respect to linear continuous-time systems. The system considered in this example is characterised by a general second-order transfer function given by:

$$G(s) = \frac{b_1 s + b_2}{s^2 + a_1 s + a_2}. \tag{1}$$

This model has four parameters. It has two poles that may be real or complex, one zero, and the right half-plane zero can be used as an approximation of a time delay. It grasps the dynamics of many systems that can be met in practice: pure integrator, double integrator, first order system, second-order system, oscillatory systems and even systems with a non-minimum phase.

Many analysis methods of linear systems are based on how dynamical systems react to typical inputs, such as impulse, step, ramp or sinusoidal signals.

A simulation of a continuous-time system on a digital computer is an estimation of the solution using a numerical integration algorithm (solver). Many solvers are available and the fourth-order Runge-Kutta algorithm (RK-4) is one of the most commonly-used algorithms in engineering calculations. The RK-4 solver can be implemented using standard spreadsheets. However, programming the solver using VBA is a more versatile approach and gives greater freedom to programmers. A number of traditional sources provide ready-made C/C++ code for standard engineering calculations. *Numerical Recipes in C* is an excellent source and conversion of RK-4 program from C into VBA takes only a few minutes [12].

Additionally, systems given in the state-space formulation are easier to simulate. So the system (1) is rewritten to its equivalent state-space description:

$$\begin{cases} \dot{x}_1 = -a_2 x_2 + b_2 u \\ \dot{x}_2 = x_1 - a_1 x_2 - b_1 x_1 \\ y = x_2 \end{cases} \tag{2}$$

where $x(t)$ is the system state, u is the control input, and y is the output of the process. This set of differential equations can be easily dumped into the RK-4 solver.

User Interface

After the fundamental simulation model has been built, the core functionality is essentially done. The next step is to wrap the simulation with a user interface. The most important feature of spreadsheets is that a worksheet itself can be used as an interface for the simulation, so one does not need to design an input form, although it can be created within *Excel*.

The simulation layout is shown in Figure 1 and its design is extremely straight forward.

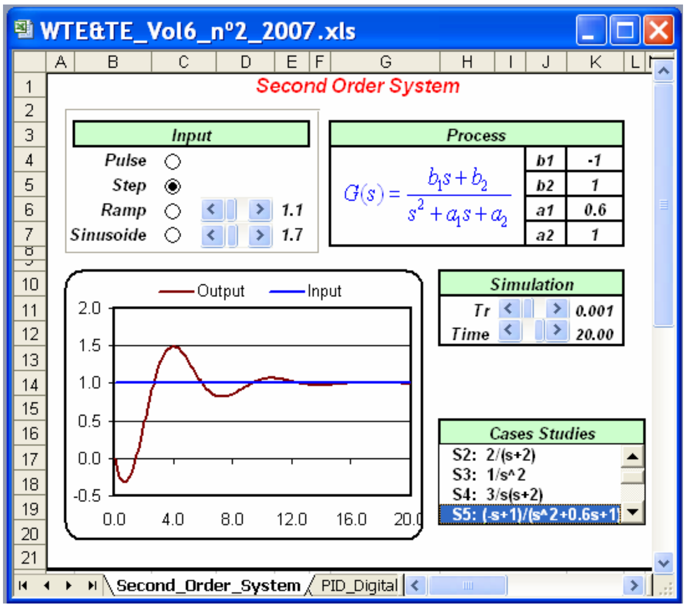

Figure 1: A simulation of continuous systems.

First, a table containing the parameters used by the simulation (the process parameters, the step time and the time simulation) is set up. All these data can be read from a VBA subroutine. Second, radio buttons are used to select the input references and scrollbars are set up to provide simple means for the user to vary the values (the rate of the ramp and the frequency of the sinusoid) in the input reference. In order to speed up and ensure accuracy when users are entering data into a spreadsheet, a number of predefined transfer functions (common model met in practice) are organised as *choose* options from a list box. A table is also reserved that will be filled in automatically and holds the solution (t, u, y) as it is computed. Finally, a chart is added to show the resulting curve that will automatically be updated when an input reference is selected.

This interactive tool is ready to use and does not need any configuration. The user defines a model by entering the parameters and immediately sees its time response plotted in a chart by clicking one button in the input group.

THE SIMULATION OF DIGITAL CONTROL SYSTEMS

Most control systems developed today are implemented using some sort of computers (embedded computer, PLC, etc). Knowledge of digital implementation of controllers is therefore essential. A schematic diagram of a digital control system is shown in Figure 2, where the plant to be controlled $G(s)$ is a continuous-time system, $D(z)$ is the digital controller and *ZOH* is the zero-order hold device.

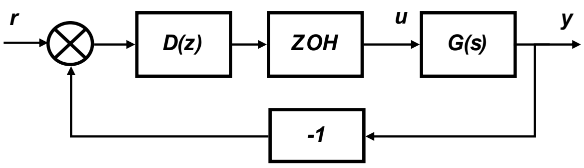

Figure 2: Digital control system diagram.

Simulating hybrid systems, combination of continuous and discrete systems, is also fairly straightforward. In this case, two time intervals (sample time) are used. The continuous system $G(s)$ is integrated using, for example, the RK-4 solver at each sample period Tr, whereas the control input is updated at each time kT. It is clear that $Tr << T$ and Tr should be selected as an integral divisor of T. To simulate a digital control on a computer, one can use the scheme shown in Figure 3.

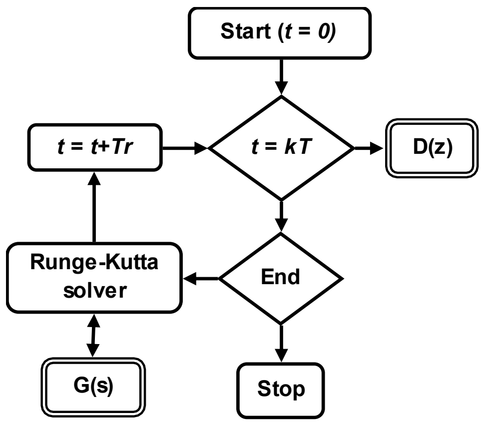

Figure 3: Digital control simulation scheme.

The subtlety of hybrid systems is that the updating routines are called at all sample times, but within these routines, a test is performed to determine if updates are necessary or not.

Digital PID Controller

Tuning a PID controller is one of the most frequent controller design problems. Therefore, it is an unavoidable chapter in basic control education. Thus, in this second example, it is intended to design an interactive tool that covers the fundamental ideas with respect to a digital PID controller. It is not intended to create a complete and sophisticated PID trainer, but only to show how a customised simulation can be designed using the *Excel*-VBA environment.

As an example, it is assumed that the process to be controlled is the model given in (1). Let the controller be a standard continuous PID with the transfer function given by:

$$K(s) = K\left(1 + \frac{1}{T_i s} + \frac{T_d s}{1 + T d s / N}\right) \tag{3}$$

where K is the proportional gain, T_i is the integration time constant and T_d is the derivative time constant. N is used to place the pole of the filtered derivative. The discrete transfer function of the PID controller can be obtained using Euler or Tustin approximations [13].

Now suppose that the control signal is u, the error signal is e, and the parallel implementation using Tustin's approximation yields the following difference equations:

$$\begin{cases} u_i[n] = u_i[n-1] + A\big(e[n] + e[n-1]\big) \\ u_d[n] = \alpha u_d[n-1] + B\big(e[n] - e[n-1]\big) \\ u[n] = K\big(e[n] + u_i[n] + u_d[n]\big) \end{cases} \tag{4}$$

with the constants:

$$A = \frac{T}{2T_i}, \quad B = \frac{2T_d N}{2T_d + NT} \quad \text{and} \quad \alpha = \frac{2T_d - NT}{2T_d + NT}$$

In this example, both the process and controller contain parameters that represent the relevant aspects of the controlled system, and it is convenient to see how they affect the system behaviour.

The interactive simulation layout is shown in Figure 4, where the process parameters can be changed by entering data manually, whereas the controller parameters values can be varied by using slider (scrollbars).

The tool is highly interactive in the sense that any click in the sliders or radio buttons performs an immediate recalculation and presentation of the process output and the control signal (or controller output). Thus, this mechanism makes it possible to observe the effect of varying the controller parameters without typing any command, and makes it easy to explore and understand how a given parameter affects the overall behaviour of the controlled system.

Graphical Plots

If one wants to obtain higher computational accuracy, a shorter simulation sample period will have to be used, but this implies increasing the total number of steps, and hence the number of rows in the spreadsheet. On the other hand, there is a practical limit on the length of a column that can be used (65,536 in *Excel 2003*), not only because spreadsheets have a finite number of rows, but also, more importantly, because calculations on long columns slow down the simulation and the data in long columns sometimes cannot even be plotted.

In order to overcome this problem, the numerical method with a compaction technique is adopted. It consists of compressing many steps into a single cell by storing one result for every n calculation steps [14]. For example, with n = 10 compaction, the simulation performs the computation n times before writing its result to the cell. This achieves the same computational result as it would have been obtained by using a 10-times longer column. Thus, with 200 points, it is sufficient to capture all the interesting parts of a transition response.

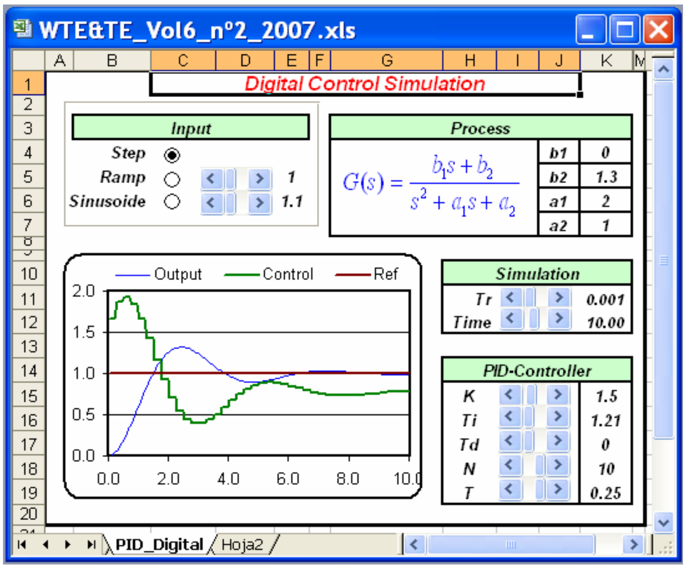

Figure 4: An interactive digital PID control.

PEDAGOGICAL ISSUES

This kind of tool is suitable for both students and teachers who are interested in the first control engineering course, since they offer ease of use and a shorter learning curve than professional software systems. They are intended to complement rather than replace existing approaches to learning, such as lectures and practical laboratory assignments.

The instructor can use them with some sort of projection facilities in lecture presentations for quick simulations and enhance the classroom environment. Because of its high interactivity, students can readily become familiar with the simulation panel quickly and so that their knowledge can be tested. Students can use them as a self-studying framework to help them to grasp quickly many abstract concepts. Furthermore, the high level of interactivity can give students enhanced intuition and a better understanding that can be difficult to achieve from developing exercises using a traditional approach.

These kind of tools are not only effective in presenting control process concepts in the classroom, but are also beneficial in extending students to perform assignments designing complex simulations using spreadsheets. Students often find that incorporating interactivity in their assignments presents them with appealing opportunities for designing attractive outputs, and as a teacher, the author found that this approach made them active and involved in their own learning process. Thus, this initiative can be most useful since it arouses students' curiosity to discover and improve their engagement.

CONCLUSION

In this article, the author shows how interactive tools for control systems education can be created using the *Excel*-VBA environment. The immediacy of spreadsheets and the convenience of its graphical representations can be combined with the wide availability in the literature of sophisticated higher-level programs to design powerful didactic tools.

Two simple interactive tools, a second-order linear system and a digital control systems simulation, are given as illustrations. All the parameters involved in both simulations can be entered manually or varied using sliders, and all the graphics are updated in a coherent manner, instantly reflecting the changes. In order to maximise clarity and maintain simplicity, each interactive simulation is focused on addressing a single core concept. This approach allows students to concentrate on a specific topic and to understand their characteristics better.

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An assessment of an intramural preliminary course of study as a viable alternative matriculation pathway to traditional examinations into the Bachelor of Engineering programme at the University of Technology, Jamaica

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ABSTRACT: The progress of 38 students entering the Bachelor of Engineering programmes at the University of Technology, Jamaica (UTech) in Kingston, Jamaica, including the first batch of Prerequisite Course of Study (PCS) programme matriculants, was monitored for the entire duration of the degree programme, ie from 1999 to 2004 inclusive. The group consisted of students with a mixture of qualifications from the Caribbean Examination Council (CXC), Caribbean Advanced Proficiency Examination (CAPE), the UK-based General Certificate of Education Advanced Level GCE A' Level and the University's own Preliminary Course of Study (PCS). The grades of the students' performance in the matriculation examinations and in every course of the BEng degree were recorded for analysis. The results of the analysis indicate that although the CAPE/A' Level students' performance was consistently above the PCS students, there seemed to be no significant difference between the levels of performances throughout the engineering programme.

INTRODUCTION

The number of students leaving secondary school programmes possessing and possess the necessary qualifications for applying to enter directly into the Bachelor of Engineering programmes at the University of Technology, Jamaica (UTech) in Kingston, Jamaica, is not sufficient to run a cost effective programme, and meet the needs of Jamaica and the Caribbean for sustainable economic development [1]. The reality is that all the tertiary institutions within Jamaica and regionally (Caribbean and North America) are competing for the same pool of students to pursue careers not only in engineering but other science disciplines as well.

Students entering engineering programmes must have a good background in the sciences. This is not the case at the UTech in that only a *few* students have the prerequisite grades and subjects that qualify them to articulate into the BEng programmes. Furthermore, these *few* students are being considered for other professions such as medicine, law, etc.

Mathematics and physics at the Caribbean Advanced Proficiency Examination (CAPE) or A' Level are required to matriculate into the engineering programmes. However, according to a *Jamaica Observer* newspaper report from 22 August 2005, the number of entrants in these subjects is very low [2]. Of the six most popular subjects as shown in Table 1, *Pure Mathematics Unit 1* is the only subject that has any relevance to engineering and science matriculation.

From the information obtained, it is of note that the number of students who have sat those subjects that are required to articulate into engineering programmes (even without considering passing grades) is inadequate (note: Grades A and B for A' Levels, and I and II for CAPE) [1].

Table 1: The six most popular subjects in 2005 (as per the *Jamaica Observer*, 22 August 2005) [2].

Subject	Number of Candidates	
	Region	Jamaica
Communication Studies	5,055	2,810
Caribbean Studies	4,481	2,262
Management of Business Unit 1	2,614	1,130
Pure Mathematics Unit 1	2,325	1,930
Sociology Unit 1	2,065	1,075
Management of Business Unit 2	1,240	643

The Prerequisite Course of Study (PCS) programme was developed in the Faculty of Engineering and Computing at the UTech [3-6]. It was intended to be used as a diagnostic tool to determine the suitability of students without traditional entry qualifications (A' Levels and CAPE) for the engineering programmes. It consists of a one-year (two-semester) programme where mathematics, physics, chemistry and biology are taught to a level that is equivalent to CAPE and A' Levels, together with communications, workshop technology and technical drawing, but with a difference in that the syllabi contents are geared towards the engineering programmes. In addition to being a diagnostic tool, the PCS was introduced as a remedy for the shortfall in the number of qualified students available for engineering programmes with the following expected benefits:

- Increase the number of students eligible to pursue a course in engineering;
- Give students with ability who may be victims of the poor quality within the secondary schooling system a reprieve and the opportunity to pursue their careers at the tertiary level, and engineering in particular;
- Improve the institution's ability to produce engineers in adequate numbers and of the right quality to meet Jamaica's and the region's economic objectives;

- All the students in the PCS programme are being prepared to pursue engineering type degrees;
- Students are allowed to choose the engineering discipline of their choice after one year;
- Students at an early age are able to mingle with the more mature engineering students at an early stage of study that helps them to adjust to the university environment and engineering studies in particular.

The first cohort completed the BEng programme in 2004. The study presented in this article is intended to evaluate the performance of these students and to compare them with students who matriculated in the traditional manner over the four-year period. Figure 1 shows the matriculation paths for students at the UTech and the University of the West Indies (UWI).

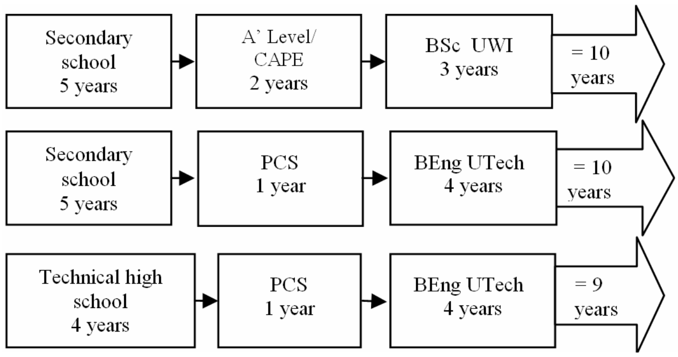

Figure 1: Matriculation paths A' Level and PCS for the UWI and UTech.

Purpose of Study

The study presented here is designed to ascertain if the PCS is a suitable alternative to CAPE and A' Levels for matriculation into the BEng programmes within the UTech and for other tertiary institutions to recognise the PCS as an equivalent qualification should the findings of the study prove positive.

Methodology

This information was placed in a database designed specifically for the research and will be updated on a periodic basis for future research. It also serves to assess the validity and reliability of previous findings and the effect of the changes made to the PCS programme in 2002 [7]. The appropriate statistical techniques (averages, standard deviations, ranges, etc) were applied in the analysis to meet the requirements of this research. Some of the information contained in the database is as follows:

- Student name and ID;
- Age at entry into the programme;
- Secondary school attended;
- Qualification at entry including subjects and grades;
- Performance on the PCS programme inclusive of subject grades and GPA;
- Performance in the BEng programme inclusive of subject grades and GPA for each year and each semester.

The performance of students from each of the matriculation paths was analysed and compared at each stage of their progression, ie from high school to completion of the BEng degree. The level of performance to which the students performed within each articulation group was analysed to determine if there was a link between the competence-based outcomes of the PCS to the courses in the BEng programme. The attrition rates were analysed in order to identify weaknesses within the respective matriculation paths that affected student performance.

The database construction consists of five tables, specifically:

1. The registry;
2. High school information;
3. PCS data;
4. BEng data;
5. GPA data.

All five tables are linked together such that information from any combination of tables can be extracted with a single query.

Queries were designed and tested to extract the relevant information from the database as it related to the research questions. The queries were used in the design and generation of the appropriate reports.

CONCLUSIONS

The results of the analyses indicate that although the CAPE/A' Level students' performance is consistently above the PCS students, there seems to be no significant difference between the levels of performances throughout the engineering programme (see Tables 2 and 3, and Figure 2). Therefore, the PCS seems to be a suitable matriculation for engineering programmes at the UTech. Additional data will be added to the database and analysed to further establish the validity of these results.

Table 3: Average four-year GPA and range for PCS and CAPE matriculants.

	4-Year Average GPA PCS	4-Year Average GPA CAPE/A' Levels
Average	2.66	2.95
Minimum	1.39	2.07
Maximum	3.37	3.54

Table 2: Average GPA and range for PCS and CAPE matriculants.

Group		Year 1 GPA	Year 2 GPA	Year 3 GPA	Year 4 GPA
PCS	Average	2.30	2.74	2.65	2.96
	Minimum	1.26	1.65	1.54	1.12
	Maximum	3.06	3.31	3.37	3.74
CAPE/ A' Levels	Average	2.69	2.92	3.00	3.19
	Minimum	3.00	2.25	1.65	2.43
	Maximum	3.51	3.55	3.37	3.74

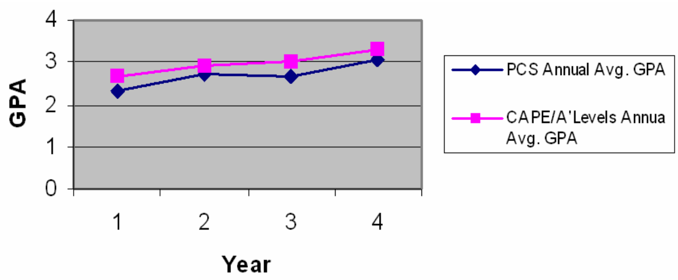

Figure 2: PCS and CAPE/A' Level average GPA.

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Conference Proceedings of the
10th UICEE Annual Conference on Engineering Education
under the theme:
Reinforcing Partnerships in Engineering Education

edited by Zenon J. Pudlowski

The *10th UICEE Annual Conference on Engineering Education*, held under the theme of *Reinforcing Partnerships in Engineering Education*, was organised by the UNESCO International Centre for Engineering Education (UICEE) and was staged in Bangkok, Thailand, between 19 and 23 March 2007, at the Menam Riverside Hotel.

This volume of Proceedings covers a wide selection of various papers submitted to this Conference, which detail a range of important international approaches to engineering education research and development related to the Conference theme, as well as other specific activities.

The 64 published papers from authors representing 25 countries offer an excellent collection that focus on fundamental issues, concepts and the achievements of individual researchers. The papers have been organised into the following sections:

- Opening Addresses
- Keynote Addresses
- Innovation and alternatives in engineering education
- New approaches to engineering education
- International examples of engineering education and training
- Current issues and trends in engineering education
- UICEE Special Session
- Multimedia and the Internet in engineering education
- Important issues and challenges in engineering education
- Case studies
- Effective methods in engineering education
- Quality issues and improvements in engineering education
- Research and development activities in engineering education at the ECUST

The diversity of subjects, concepts, ideas and international backgrounds in this volume of Proceedings demonstrate the global nature of UICEE-run Conferences, as well as its relevance within the worldwide affairs regarding engineering and technology education.

Importantly, all of the papers have undergone assessment by independent international peer referees and have been professionally edited in order to ensure the high quality and value of the Proceedings into the future. As such, it is anticipated that this volume will become a useful source of information on research and development activities in the dynamic and evolving field of engineering and technology education.

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Personality profiles of Malay and Chinese engineering students

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ABSTRACT: In this study, the authors seek to investigate the personality trait orientations of students currently majoring in engineering courses. The samples comprised 432 undergraduate engineering students who had been randomly selected to participate in the study. The NEO PI-R Personality Inventory by Costa and McCrae was used to assess the personality profile. The Malay engineering students in the study were found to have a higher level of Neuroticism ($t=4.061$, $p = 0.000$) and Agreeableness ($t=3.449$, $p = 0.001$) than the Chinese engineering students. It was found that the Chinese engineering students were higher on the Openness domain ($t=-2.946$, $p = 0.003$) than their Malay colleagues. The implication of personality differences on academic achievements and on the future desirable job attributes for prospective engineers are discussed in this article.

INTRODUCTION

Studying the personality dimensions of engineering students is essential from the perspective of the career decision process. Personality provides two important aspects as follows:

- *Suitability*: the matching of a person's personality with his/her chosen academic major or vocational preference;
- Personality is related to the personal qualities desired for future engineers to function better in the engineering profession.

The suitability factor is associated with the person-environment-fit framework pioneered by several researchers such as Crites and Holland [1][2]. Holland theorised that different personality types have different interests, competences and dispositions towards the work environment [2].

An assumption made when this theory is extended to the area of educational choice is that the more suitable and appropriate the matching of one's personality with the selected academic major, then the more likely that the student will be successful and committed.

Some other earlier findings using the Myers-Briggs Type Indicator (MBTI) effectively characterised differences in the ways that engineering students approach learning tasks, respond to different forms of instruction and classroom environments, and formulate career goals [3-5]. For example, it was found that extraverts reacted more positively than introverts when first confronted with the requirement that they work in groups on homework.

As for the second part of the role of personality, it is suggested that personality plays an even more instrumental role in human relation aspects, such as when managing conflicts, persuading and negotiating with colleagues, and when making ethical judgements. Conflict management, for example, requires students to learn to be patient to others and being emotionally stable. Personality is also related to problem-solving skills. For instance, openness to ideas, assertiveness and meticulousness are needed during the problem-solving process. All of these human aspects of engineering soft-skills are rooted back to the personality disposition or traits domain.

Thus, it has now been realised and practised by many current employers that they look not only to the engineering-cum-technical competence, but also for specific personality types to fit certain roles in engineering-related jobs.

In this present study, the authors attempt to look at this aspect using a common psychological method to measure personality trait distribution, especially among Malay and Chinese engineering students. At minimum, the authors shall examine the pattern of the personality traits of enrolled students. Do they possess the personality dimension as desired by the engineering profession?

THE FIVE FACTOR MODEL OF PERSONALITY

In the present study, the authors employed another personality model that has received widespread agreement regarding its universality and usability. The Five Factor Model (FFM) is currently the best model for describing the taxonomy of personality traits [6][7]. It has been proposed that the model's five basic factors constitute the basic structure of human personality as follows:

- Neuroticism (N);
- Extraversion (E);
- Openness to Experience (O);
- Agreeableness (A);
- Conscientiousness (C).

This assertion has been supported using different personality questionnaires, self-reports, peer ratings, factoring procedures and sampling subjects [7].

Few studies use the FFM model. Lounsbury et al studied a sample of information science professionals and found significant correlations between personality traits and career satisfaction (as well as life satisfaction) for six of the seven personality traits studied (ie assertiveness, conscientiousness, emotional stability, extraversion, openness, optimism and tough-mindedness) [8].

Although this sample represents only one general occupational group, Lounsbury et al found that there was extensive similarity in personality-career satisfaction relationships across diverse occupational groups including engineering workers [8][9]. Personality traits correlated with career satisfaction included the FFM traits of conscientiousness, extraversion and openness plus other, narrower traits, such as assertiveness, customer service orientation and human managerial relations orientation.

RESEARCH QUESTIONS

In the current study, the authors attempt to address this basic problem – what constitutes personality differences between Malay and Chinese engineering students? The findings could help in understanding some of the differences in the personality profiles of engineering students from different racial backgrounds.

PURPOSE OF THE STUDY

The present study had the following two main purposes:

- To examine the personality profile of Malay and Chinese engineering students;
- To examine whether there were significant differences in the personality profiles between Malay and Chinese engineering students.

SUBJECTS

The total sample comprised 432 undergraduate students (284 Malay and 148 Chinese incorporating 247 males and 181 females – four data were not included in the final analysis). These students were enrolled in the four major departments of the Engineering Faculty at the Universiti Kebangsaan Malaysia (UKM) in Bangi, Malaysia. Most of the students were in their third or fourth years of study. They were involved in a larger scale of study dealing with personality and academic major decision-making. The students' age range was from 18 to 20 years. All participation was voluntary.

INSTRUMENTS

The present study used a translated Malay version, which was based on an original version of the NEO Personality Inventory-Revised (NEO PI-R) [6]. A psychometric assessment of the translated instrument has been documented [10].

The overall alpha coefficients of the Malay NEO PI-R domain scales were 0.87, 0.86, 0.69, 0.82 and 0.91 for N, E, O, A and C, respectively. This inventory consisted of 240 items that had been developed through rational and factor analytic methods, and measured five major domains of personality, namely: Neuroticism, Extraversion, Openness to Experience, Agreeableness and Conscientiousness. It took about 40-50 minutes to complete the questionnaire.

RESULTS

Mean-Level Comparison between Malay and Chinese Students

Table 1 shows a comparison of the mean scores of the factors and facets between Malay and Chinese engineering students as revealed through this study.

At the factor level, it seems that the Malay students scored higher than the Chinese students on Neuroticism and Agreeableness. On the other hand, the Chinese students scored

Table 1: Means and standard deviations of the domain and selected facets between Malay and Chinese engineering students.

	Malay N=284		Chinese N=148			
Domain	Mean	SD	Mean	SD	t	p
N: Neuroticism	98.8	15.9	91.4	18.9	4.24	0.00
E: Extraversion	107.6	13.9	105.2	15.6	1.63	0.10
O: Openness	102.9	10.0	105.9	12.9	-2.68	0.01
A: Agreeableness	113.4	12.1	109.1	11.3	3.57	0.00
C: Conscientiousness	114.4	15.4	113.2	17.0	0.75	0.45
Facets						
N1: Anxiety	18.3	4.0	16.3	4.4	4.62	0.00
N3: Depression	17.1	4.1	15.7	5.0	3.00	0.00
N4: Self-consciousness	19.2	3.1	16.8	3.3	7.41	0.00
N5: Impulsiveness	17.7	3.8	16.5	3.4	3.40	0.00
E4: Activity	17.3	2.9	16.4	3.1	3.00	0.00
E6: Positive emotions	20.7	3.7	18.9	4.4	4.41	0.00
O1: Fantasy	15.9	3.1	16.6	3.1	-2.28	0.00
O3: Feelings	19.3	3.2	18.1	3.3	3.56	0.00
O4: Actions	15.8	2.6	16.6	3.0	-2.56	0.01
O6: Values	15.8	2.6	18.1	2.7	-8.68	0.00
A2: Straightforwardness	19.1	4.1	18.2	4.0	2.20	0.03

higher on Openness to Experience. At the facet level, Malays scored significantly higher on N1: Anxiety, N3: Depression, N4: Self-consciousness and N5: Impulsiveness compared to the Chinese students.

Chinese students were found to be more open, as they scored higher on most Openness facets than did the Malays, although Malay students scored higher the Openness facet of O4: Openness to Actions. On the other hand, Malays were found to be more Agreeable people than the Chinese students: five of the Agreeableness facets of the Malay students had higher means than those of the Chinese, with the exception being A3: Altruism. A comparison of the Conscientiousness facets has revealed that Malay and Chinese students' scores were almost similar.

DISCUSSIONS

The present study shows that the surveyed Malay students in engineering were more anxious, depressed, self-conscious and impulsive in comparison with their Chinese colleagues. Higher anxiety signals lack of self-confidence and this is not considered a preferable quality of the future engineer. Similarly, higher scores on depression and self-consciousness also imply that Malay engineering students were susceptible to depression, especially during some important academic or work tasks in the future. Being self-conscious or *malu* is again not a desirable personal quality for future engineers.

On the other hand, the Chinese students were more open-minded than the Malays. They were higher on openness to fantasy, which can be associated with creativity and imagination. Lower openness to values among Malay students is expected. Items on openness to values explicitly indicated the idea of flexibility on the moral status of certain conduct. Malays normally perceive this idea as against the values stated by their religion. However, the Malay students were higher on openness to feelings. Higher scores in this facet may be associated with Malays being easily involved in emotion-related phenomena like being in love while in campus.

Openness is indeed a very important personal quality needed for future engineers. Engineers love to figure things out and find out how things are made. It is this mentality that helps propel them through their college classes. Some engineers feel like college was the first time that their curiosity could be satisfied, the first time that they could delve deep enough into a problem, see all sides of how something worked, and obtain a solution. Dollinger found Openness to be positively related to information-oriented identity style, a style possessed by those who prefer to seek out and process information actively before making decisions [11]. Interestingly, this is what is going to be experienced by students in engineering later in their studies and in the work environment.

Engineering education involves teaching students how to think through a problem in order to solve it. The fascinating aspect about problem solving in engineering is that there is almost never a *right* answer. Openness to ideas provides a tendency to identify several different approaches to solve a problem, and then it is up to the individual to show everyone how this solution meets the needs of the design. Chinese students were higher on Openness to Action. According to Costa and McCrae, Openness to Actions is seen as behavioural in the willingness to try different activities, and a preference for novelty and variety, which is also among the characteristics of engineering students [6].

CONCLUSION

The overall findings of this study suggest that female and Malay students seem to be disadvantaged when compared with Chinese students. If female and Malay students were prone to be more anxious, more depressed, and more *malu* and impulsive, then most likely they may be subjected to many negative outcomes. Studies have shown that self-esteem is closely related to these negative traits, which in turn can affect performance-based activities like examinations.

However, female students possess some good personal dispositions in that they were more orderly and dutiful. Future employees should foresee recruiting more female engineers as they are prone to obeying rules and regulation, are diligent at work and make things more orderly. Following procedures could be expected of female engineers.

Chinese students possessed better qualities, especially being open to ideas. They were found to be less susceptible to depression, *malu* and anxiety-related situations, and be less impulsive.

It can be seen that dispositional factors like personality traits play an important role during study as well as during vocational practice.

IMPLICATIONS

The expectation is that students intending to major in engineering should possess the desired personal qualities for the engineering profession. They are expected to not only be competent in their respected fields, but also possess good personal templates so that they can take on multiple tasks at work and engage in frequent interpersonal relations with co-workers and clients. This seems logical, as the nature of engineering requires prospective students to be open to new ideas, technological innovations and new products. Engineers also deal with people in their daily job prescriptions and human encounters. Therefore, the personality test can be the primary assessment tool that may provide more insight into personal disposition in the selection procedure for engineering students at educational institutions.

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Engineering and technological education in Greece: a missing link in cooperation between academics and professional engineers in the faculty of application-oriented engineering

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ABSTRACT: In this article, the author reviews the current position of the higher education technological sector within the structure of the current dual professional institutional system in Greece. The main institutional roles of the Scientific Society of Technological Education of Engineers (SSTEE) are to promote professionalism and equality in the Greek Engineering Model (GEM), and simultaneously secure various benefits for both students and graduates of Technological Educational Institutions (ATEIs). The analysis is based on a missing link for academics: coordination with professional engineers in application-oriented engineering. The appearance of a lack of a proper coordination strategy among academics and professional engineers may result in an enormous loss of labour-hours, money and intellectual input in Greek society, plus a loss of enrolments for ATEIs, especially during a period of rapid semi-privatisation in higher education. The author argues that, in order to bridge the gap, professionals, academics and government bodies should modernise their old-fashioned views, avoid conflict, promote professionalism and effective engineering practice, and speed up the communal recognition of technological engineering professions.

THE GREEK HIGHER TECHNOLOGICAL EDUCATION SYSTEM

The educational system in Greece offers the opportunity to study engineering at the following types of schools:

- Universities (AEI): public;
- Technical universities (theoretical orientation): public (eg NTUA);
- Technological Educational Institutions (ATEI) (application oriented): public;
- Institute of Occupational Training (IEK) (technical): private and public;
- Hellenic Open University: public (based on fees).

In addition, private educational, training and development institutions currently provide programmes for first, Master's and research degree courses of non-Greek universities (based on the European Directive 36/2005 for the recognition of qualifications).

A very distinctive segmentation of professionals and students is currently taking place within Greek higher and occupational education; this is based on the *branch of science* [1].

Greece has developed engineering courses at technological institutions, technical universities and universities. This segmentation determines the activity of high schools with an emphasis on the national examinations entry system.

After the membership of Greece within the European Union (EU) and especially in the Euro-zone, the development of industry and new technological applications helped to regenerate and promote the foundations of Greek technological institutions, their structure and syllabi, which still exist to this day. This also created a certain vision of a graduate whose basic criteria, as far as the quality of education was concerned, included professionalism and opportunities for further academic development, which was understood as a thorough knowledge of a certain part of a technical field.

Technological Educational Institutions (ATEI) belong to higher education (under the law N. 1404/83 and N. 2916/2001) at the same academic level with universities and technical universities. ATEIs are legal entities under Greek public law and fully self-governed (within the public educational framework). Engineering degrees from ATEIs are academically equivalent to the four-year Bachelor degree in engineering (BEng) in the UK and Fachhochschulen (Diplom Ingeniuere FH) in Germany.

The rapid progress of technology, industrial changes, increased unemployment among young engineers and graduates, the increasing complexity of engineering tasks (which has resulted in a considerable narrowing of engineering specialisations) and professional limitations for engineers of technological education in Greece have forced ATEIs to develop postgraduate programmes in collaboration with universities in Greece (up to 32 recognised Masters degrees) [2]. Collaboration can also extend to be with foreign institutions and universities, and from abroad (eg the UK, USA, Italy, France, etc, with 24 recognised Masters programmes) [2]. Therefore, many graduates follow the postgraduate courses of the Open University (Europe's largest University) in the UK and the Hellenic Open University. The growing demand for specialists, who have both engineering skills and management abilities, has changed the image of an engineer's role in the industrial process, real estate market and technical services (including the public sector).

In this article, the author focuses on a missing link in the level of cooperation between academics and professional engineers in the faculty of application-oriented engineering (public sector).

TECHNOLOGICAL PROFESSIONAL AND SCIENTIFIC INSTITUTION IN GREECE

The Scientific Society of Technological Education Engineers (SSTEE) constitutes the professional and scientific institution of graduate engineers (only), who come from Technological Educational Institutes (ATEIs) and other equivalent engineering schools (eg Fachhochschulen), or other professional engineers, who have graduated from recognised institutions of higher education at the same academic level. Its organisational structure is pan-Hellenic and consists of 47 peripheral departments covering all the prefectures in Greece (see Table 1). The SSTEE's membership exceeds 37,001 engineers with an increasing trend to reach to 40,000.

Table 1: Distribution of the local branches of the SSTEE.

Headquarters: Athens (capital)	Greek Islands: Agios Nikolaos Rhodes, Mitilini, Chania, Chios, Heraklio, Rethymno, Kerkira, Argostoli, Zakynthos, Samos & Lefkada	Evros: Xanthi, Drama, Komotini & Alexandroupoli
Thessalia: Agrinio, Volos, Larisa, Karditsa & Trikala	Peloponissos Patra, Argolida, Loutraki, Sparti, Kalamata, Pyrgos & Tripoli	Sterea Hellada (incl. Evritania): Halkida, Lamia, Leivadia & Amfissa
Hepiros: Preveza, Arta, Ioannina & Hegoumenitsa	Macedonia (incl. Grevana): Kavala, Serres, Kilkis Kastoria, Florina, Kozani, Keterini, Giannitsa & Veria	Thessaloniki/ Chalkidiki: Thessaloniki

The SSTEE's registered members include graduates from schools of technological applications (engineering) at the departments of 12 ATEIs listed in Table 2.

The SSTEE's registered as professional members include graduates from engineering schools of technological applications in the fields shown in Table 3.

It is widely recognised that the national examinations of the Greek Entry System (GES) into higher education suffers from the underperformance of thousands of candidates. New entry limitations are resulting in losses of entries for many departments at universities and ATEIs (especially those that are located in the regions of Arta, Chania, Heraklion, Hegoumenitsa, Larisa, Kalamata, Kozani, Messologgi, Rethymnon, Serres, etc. There is also the threat of closure of various departments in conjunction with the increased entry rates for those passing to the ATEIs in Piraeus and Athens (after the reduction of places).

The objectives of the SSTEE, among others, are as follows:

- The protection and progression of the common goals and interests of its professional members using various legal means;
- The advocacy and elevation of the scientific and technological standards of its members, especially as far as the areas of applied science and techniques are concerned;

Table 2: Technological application specialities.

Electrical Engineering	Geotechnology & Environmental Engineering	Music Technology & Acoustics
Applied Informatics & Multimedia	Industrial Design	Petroleum Technology & Natural Gas
Automation	Industrial Informatics	Pollution Control
Building Renovation & Restoration	Informatics & Communication	Shipbuilding Engineering
Civil Engineering & Structural Work Engineering	Informatics & Computer Technology	Surveying/ Geomatics & Surveying
Computer Sciences and Tele-communications	Informatics Tech-nology & Tele-communications	Technology of Aircraft
Computer Systems	Mechanical Engineering	Technology of Natural Resources and Environment
Electronic Engineering	Medical Instruments	Telecommunica-tions & Computer Networks
Energy & Environmental Technology	Medical Systems Technology	Textile Engineering
Energy Technology Engineering	Mining Engineering	Vehicle Engineering

Table 3: Engineering professions.

Aircraft Engineer TE	Energy Technology Engineer TE	Mining Engineer TE
Architect Engineer TE	Environmental Engineer TE	Petroleum Engineer TE
Automation Engineer TE	Geotechnology & Environmental Engineer TE	Building Restoration & Renovation Engineer TE
Civil Engineer TE & Structural Work Engineer TE	Industrial Planning Engineer TE	Surveyor Engineer TE
Computer Systems Engineer TE	Informatics Engineer TE	Textile Engineer TE
Electrical Engineer TE	Mechanical Engineer TE	Vehicle Engineer TE
Electronic Engineer TE	Medical Instruments Engineer TE	Aircraft Engineer TE

- The contribution in the promotion of know-how and technology transfer generally and in cooperation with other organisations (bodies) for the self-dependent financial, social and cultural development of Greece.

The main activities of the SSTEE are as follows:

- Provision of advice to requests on any matter (related to professional, educational, engineering, etc) that is within its competence;

- Identification of representatives to the Committees of Physical Planning, Housing and Environment – eg ΣΧΟΠ (law nr. 69- Government Gazette 60/A'/9.3.2000);
- Member of the Executive Board of the TSMEDE and participation in the committee of the Constructor Experience Register (MEK) of the Ministry of Housing, Public Works and Environment;
- Member of the National Board of Education (ΕΣΥΠ) and the Board of the Technological Sector of Higher Technological Education (ΣΑΤΕ);
- Participation in a board for the recognition of professional qualifications (European Directive 89/48) and in a committee to define the professional rights for recently-established departments of the engineering specialisations of ATEIs (law nr. 165/2000 Government Gazette 149A'/28-6-2000);
- Participation in the Governmental committees for the processing of legislative plans concerning construction projects;
- Provision of certifications *which can prove the fact that our members haven't committed any disciplinary misdemeanor during the practice of their profession, in order to be able to take part in auctions of the Greek State*;
- Provision of certifications that are requested from both public and private sector;
- Publication of the scientific and technical journal *Techniko Vima*;
- The SSTEE also cooperates with Governmental and national organisations, as well as technological education institutes;
- Subscriptions and membership data;
- The Professional Contact Committee provides certificates to members so that they are able to submit tenders.

THE STATE OF ACADEMICS – TECHNOLOGICAL EDUCATED ENGINEERS COOPERATION

The development of a common syllabus applied by ATEIs are part of a comprehensive strategy for research and development (R&D), and the recognition of professional rights for graduates and professional engineers working in the Greek construction industry under the umbrella of the SSTEE [3]. They are necessary in order to generate and transfer knowledge to industry, create wealth, use CPD programmes, minimise socioeconomic deviations of graduates and promote more sustainable development.

It is agreed that educators need to prepare engineering students to confront real-life issues, especially in the topics of engineering, the environment, construction management and information technology applications. Educators also need to teach engineering students to consciously strive for sustainable engineering practice [4].

Despite the long-term efforts made by the academic community of ATEIs and the Scientific Society of Technological Education Engineers, the Greek higher technological educational system is still lagging behind the EU's announcements/decisions for the European Sector of Higher Education (eg Berlin 2005). Thus, Greek technological education engineers are not able to benefit from internationalisation, research, innovation and development when compared with other European graduates (eg Germans, Britons, etc), as well graduates from universities and technical universities.

In addition, many technological educated engineers with postgraduate or research degrees could not promote, contribute or participate into research projects of ATEIs or other organisations in both the public and private sectors. Moreover, it is very difficult to fund their initiatives.

Molson stated the following:

> *The Greek Engineering Model (GEM) of technological education should not be static, but it should comply with the requirements of international collaboration in engineering and technology education* [5].

This includes the recognition of qualifications and accreditation systems for engineering and technology courses; the transformation of information on engineering and technological applications; the international mobility of academic staff, researchers, graduates and students; and international collaborative programmes and systems. This should also comply with the European Union's Directives and Decisions for the European Sector of Higher Education. Furthermore, it should also promote academia/industry linkages. Molson has further stated:

> *Globalisation has knocked on the doors of the Greek educational system, and under the umbrella of the Scientific Society of Technological Education Engineers, graduates* [especially in the private sector] *can promote their academic objectives and benefit from academia/industry partnership. Further professional recognition delays and conflicts create a negative environment and establish* discrimination *against technologically-educated engineers, which is generated by the current Greek Engineering Model (GEM)* [5].

In order to achieve this common goal, the SSTEE has to establish and implement an agreed plan of action, understand international engineering education development issues and simultaneously overcome possible internal disputes.

Survey Methodology and Analysis

According to a semi-structured interview survey based on tele-survey methodologies, a survey was conducted on 30 of 47 peripheral departments and their Headquarters, asking 30 local presidents for their expert opinions (as individuals) on the major theme of coordination between academics and professionals in the faculty of application-oriented engineers.

The selection of dual-frame mixed-mode surveys combined with telephone conference interviews and face-to-face interviewing (semi-structured interview survey) resulted in the minimisation of the bias of telephone surveys. The relative low cost of telephone interviewing (using mobile phones) and the sample of the special population (representatives of 47 branches) were the key points for the survey's methodology.

Mobile telephones were used to reach the participants. The present levels of mobile telephone coverage imply that *mobile* telephone surveys can, in general, only be used for specific populations [6]. An e-mail survey was not utilised due to limited information about participants' e-mail and Web coverage. A computer self-administrated questionnaire was preferable in use but required a high coverage rate for e-mail and Web surveys. A previous academic work in the field of patents and industry-academia cooperation was used as a reference for the questionnaire design [7].

The feedback data was gathered and analysed from 25 (30) correspondents regarding their expert opinions on the missing link in the cooperation between academics and professional engineers. The data are summarised in Table 4.

Table 4: Survey of experts' opinions.

	Professional Representatives	Conducted Departments	Responded Departments
No.	47	30	25
%	100%	63.80%	53.19%

The response rate was 53.19% due to the regional distribution of departments and the fact that few representatives were not available or else had limited time to correspond. The professionals' expert opinions can be used for the structure of a proper industrial survey in the future. This can be conducted on both graduates and students of ATEIs. This survey could be extended with the incorporation of professionals from the public sector.

It has been recognised by all participants that there is a gap between academic staff's objectives and their culture, and of real-life professional issues of graduates and professional engineers. This gap is often a misunderstanding of the role of higher education versus the requirement for real professional rights in practice beyond university life.

It was agreed by 51.06% of the representatives that the extraordinary growth of the construction and real estate markets in the period 2000-2006 and the opportunities for business in the construction, tourist, industrial and other sectors have created a substantial deviation among theoretical and technically-oriented engineers. This deviation could result in enormous losses of labour-hours in education and losses in places for ATEIs through the pan-Hellenic Entry Examinations System.

It was recognised by many representatives (42.55%) that competition is hard among consulting and construction/ engineering firms in Greece, and that the integration of educational programmes with industrial practice (*placements in an industrial or business environment*) produce very competent technical application-oriented engineers. All participants agreed that their professional rights were limited versus their academic achievements (accredited courses).

It was reported by participants that many engineers of technological education have shown a greater level of maturity, higher project task completion rates, greater commitment to their responsibilities and better understanding of engineering practice, which are significant for their career development. However, barriers that faced graduates in real-life issues minimised their expectations readily (in private businesses).

It was widely recognised by 53.19% of representatives that an accredited engineering programme should lead to professional institutional membership with real benefits to graduates.

Many practitioners' concerns (53.19%) referred to the fact that members of academic community have already gained membership with professional institutions, such as the Technical Chamber of Greece, and avoided cooperating on professional topics beyond the completion of the study stage.

Many participants (53.19%) agreed that the academic community has not made enough progress in the field of academic-professional engineer cooperation in the faculty of application-oriented engineers, especially after their graduation. From the perspective of professional engineers, in order to bridge the cooperation gap, the professionals, academics and government bodies involved should modernise their old-fashioned views about ATEIs, avoid conflict, promote professionalism and effective engineering practice, and speed up the communal recognition of technological engineering professions. The appearance of a lack of a proper coordination strategy among academics and professional engineers may result in an enormous loss of labour-hours, money and intellectual input in Greek society, especially as many students move abroad for studies. This may also lead to a loss of enrolments for ATEIs.

Many participants (48.93%) disagreed that engineering students sustain habits that are inappropriate for their future career (such as a lack of confidence, insecurity, trustiness, culture shock, etc) and that graduates have remarkable rates in employment (especially in the construction sector).

CONCLUSIONS

A missing link in cooperation between academic community of ATEIs and professional technological educated engineers in the faculty of application-oriented engineers is based on real-life issues and from assessments made by both partners (academics and professionals) with different objectives, namely to secure academic positions and external funding versus graduates' professional career expectations for equality and further recognition (professional rights). Further investigation is needed (based on a proper research project carried out by ATEIs) in order to clarify the patents of cooperation and to accelerate the communal recognition of technological engineering professions.

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Education for Sustainable Development Curriculum Audit (E4SD Audit): a curriculum diagnostic tool for quantifying requirements to embed sustainable development into higher education – demonstrated through a focus on engineering education*

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ABSTRACT: There is an emerging global consensus across a range of professions that significant change is required in preparing graduates to play a role in facilitating the societal transition to sustainable development in the coming decades. However, a literature review on curriculum renewal and embedding sustainability within higher education curriculum shows that this process is actually quite fragmented, sporadic and *ad hoc*. Indeed, there is a lack of strategic guidance on how an education programme might make a transition to *education for sustainable development*, or with regard to the timeframe within which a transition might be possible. A strategic and systematic audit process has been introduced called the Education for Sustainable Development Curriculum Audit (E4SD Audit), developed by The Natural Edge Project to address these issues, and is a curriculum diagnostic tool that quantifies the requirements for embedding sustainable development into higher education. The audit context is identified within the need for rapid curriculum change in engineering education, but it is widely applicable. An overview of the E4SD Audit process is provided with a short example of how it might proceed. Comments are given on considerations for facilitating the audit and supporting the implementation of recommendations.

INTRODUCTION

Sustainable Development in the Face of Climate Change

While few would argue that the scale and nature of society's impacts on the Earth's biosphere could previously have been predicted, the last 30 years have seen a growing awareness and understanding of the complexity of the problems that are being faced. The launch of the *Fourth Assessment Report* by the Intergovernmental Panel on Climate Change (IPCC) in April 2007 provided an unequivocal link between climate change and current human activities, especially burning fossil fuels, deforestation and land clearing, the use of synthetic greenhouse gases, and the decomposition of wastes from landfill [1]. This link was also confirmed by the 2006 release of the UK *Stern Review*, which stated that global emissions of greenhouse gases must stabilise by 2015 for the world to have any chance of limiting the expected temperature rise to two degrees [2]. A two-three degrees average increase in the global temperature is predicted to result in dangerous levels of climate change, including significant ice and glacier melting, sea level rises, the increased frequency and severity of natural disasters, and greenhouse gas release from vast tracts of thawing permafrost across Siberia [3].

It has become clear that it is inevitable that society will need to adapt to a new climate regime as a result of a rapid increase in greenhouse emissions since the Industrial Revolution. There is a parallel and crucial requirement to focus on both reducing the emissions of greenhouse gases and therefore stabilising the corresponding increases in global temperature, and to also prepare for a certain level of adaptation by society and the environment to an altered climate regime, assuming the appropriate stabilisation is achieved. This interest in practical solutions is expected to continue to increase as governments, companies and institutions in Australia, as well as around the world, are beginning to set their sights on targets to reduce emissions in the order of 60% by 2050 [4]. A study by the Dutch Government published in 2000 on the scale of change required stated the following:

> *In setting a time-horizon of 50 years – two generations into the future – it was found that ten to twenty-fold eco-efficiency improvements will be needed to achieve meaningful reductions in environmental stress* [4].

The Brundtland Commission's 1987 report titled *Our Common Future* – although written 20 years ago – provides one of the best supporting documents for international guidance for achieving such mitigation and adaptation efforts [5]. The report's inclusion of the term *sustainable development* is now one of the most widely used references to describe the type of global development that can meet the needs of today while also addressing our responsibility to future generations.

The Role of the Engineering Profession

The incoming president of the World Federation of Engineering Organisations (WFEO) and former president of Engineers Australia, Barry Grear (AO), has questioned:

> *What aspirational role will engineers play in that radically transformed world? ... An ever-increasing global population that continues to shift to urban areas will require widespread adoption of sustainability. Demands for energy, drinking water, clean air, safe waste disposal, and transportation will drive environmental protection* [alongside] *infrastructure development* [6].

*The authors are part of The Natural Edge Project (TNEP), which is an independent sustainability think-tank based in Australia. TNEP is administratively hosted in-kind by Griffith University and the Australian National University.

Indeed, it is very likely that future engineering and design will contain very little to do with creating fossil fuel-based products and services. While the first principles underpinning engineering and design (such as thermodynamics, fluid mechanics, structural mechanics, etc) will remain the cornerstone of engineering education, the knowledge used to explain them and the cases used to apply them will require rethinking. These first principles underpinning engineering for hundreds – if not thousands – of years need to now be rapidly reapplied to a range of significant 21st Century engineering challenges. These include providing electricity and energy, industrial processes, transportation, built environments, and water and sanitation.

According to the WFEO, it is critical that engineering graduates are equipped with the relevant knowledge and skills to effectively address such sustainable development challenges in society [7][8]. This message has been reinforced in various ways within guiding documentation like policy statements, charters and code of ethics statements from a growing number of national professional engineering bodies, including for example the UK's Royal Academy of Engineering, the Institution of Professional Engineers New Zealand, the Institution of Civil Engineers (UK), the American Society of Civil Engineers and Engineers Australia [9-13].

PROGRESS IN EDUCATION FOR SUSTAINABLE DEVELOPMENT IN ENGINEERING

The definition of core terminology is as follows:

- *Course* and *Programme*: a *course* in this article refers to a unit of study that usually has a unique code and name/ title. A student may study between 30-40 *courses* in an undergraduate degree *programme*;
- Within the higher education sector, the term *learning and teaching* is often interchanged with *education*. In this article, the authors use *education* given the popularity of the term *education for sustainable development*;
- In this article, the authors use the collective term *staff* to refer to anyone employed in the higher education system to teach or manage (eg convene) some aspect of teaching (in addition to their other research and service requirements).

Increasing Global Dialogue

The global call for change towards *education for sustainable development* in higher education has been building, with particular resonance over the last 20 years. In 1987, the Brundtland Commission advocated all types of education to *reach out to as wide a group of individuals as possible, as environmental issues and knowledge systems now change radically in the space of a lifetime* [14]. A decade later, following declarations such as Talloires, the Thessaloniki Declaration and alliances such as the GHESP Global Alliance, the 1998 UNESCO World Conference on Higher Education produced a *World Declaration on Higher Education in the Twenty-First Century: Vision and Action* [15-17]. This Declaration stated the following:

> *Higher education it-self is confronted therefore with formidable challenges and must proceed to the most radical change and renewal it has ever been required to under-take* [18].

2005 marked the commencement of the United Nations Decade of Education for Sustainable Development (2005-2014), which has acted as a further catalyst for global dialogue [19].

There has been a number of significant engineering education conferences, workshops and fora around the world over a similar timeframe that have focused on the specific need for engineering education for sustainable development; several of these are highlighted here.

In 1994, an international workshop of educators from the Asia-Pacific region examined the *Fundamentals of Environmental Education in Engineering Education*, concluding that *all* engineers needed to be environmentally educated so that they understood the issues involved in sustainable development and cleaner production [20][21]. A decade later, the 2002, 2004 and 2006 *International Conferences on Engineering Education in Sustainable Development* all emphasised that engineering education, especially higher education for the training of decision-makers, researchers and teachers, should be oriented towards sustainable development and should foster environmentally-aware attitudes, skills and behaviour patterns, as well as a sense of ethical responsibility.

The 2004 conference declaration (the Declaration of Barcelona) reaffirmed the following:

> *Engineering has responded to the needs of society and without a doubt, today's society requires a new kind of engineers ... There is evidence that sustainable development has already been incorporated in engineering education in a number of institutions around the world ...* [22].

The 2007 *Australasian Association for Engineering Education Conference* (Melbourne, Australia), the 2007 *International Conference on Engineering and Education Research* (Melbourne, Australia) and the 2007 *International Conference in Engineering Sustainability* (Perth, Australia) all feature engineering education for sustainable development as topics for dialogue and deliberation.

Limited and *Ad hoc* Implementation in Engineering Education

Although dialogue on the topic of education for sustainable development in engineering is increasing, a literature review of the topics and papers presented at engineering events provides a sobering picture of sporadic, fragmented and largely *ad hoc* approaches to curriculum renewal. In reality, there has been a lack of significant action on making the transition to education for sustainable development in engineering.

Conference themes and journal topics include issues affecting the ability of engineering education to be changed (ie organisational, resourcing, funding, timeframe and content issues). By far the most prolific papers were on the topic of single champions or small teams discussing individual and unconnected initiatives in the subject area of education for sustainable development. Some papers documented the success of strategically embedding case studies and flagship courses (predominantly in the first year and at the postgraduate level), but these efforts have rarely been documented as part of a longer-term strategic plan for curriculum renewal. Few papers discussed methods to integrate sustainability theory, knowledge and application across programmes and across disciplines. There is a general lack of literature on strategically and systematically *planning* and implementing a holistic curriculum renewal process in engineering education to embed sustainable development.

A Time Lag Dilemma and Rapid Renewal Imperative

The authors have outlined the need for significant and immediate action to address the issues of climate change and sustainable development. As engineering educators consider how curriculum might be transitioned to education for sustainable development, it is important to realise that a *wait and see approach* is not an option. Figure 1 summarises the *time lag dilemma* currently facing engineering education.

In the *wait and see* or *laggards approach*, the education institution delays any transition until the merits of such a transition are proven in the market (ie by data from other institutions), supposedly to reduce their risk exposure. However, such an approach actually exposes the institution to potential accreditation difficulties with professional engineering bodies, the potential for reduced demand for graduates and the potential for falling student enrolments.

In the *business as usual approach*, the education institution adopts an *ad hoc* approach to curriculum renewal whereby courses are updated to include sustainability content at the individual staff member's discretion. Here, the transition is likely to be fragmented and there is significant potential for overlapping curriculum development, gaps in the curriculum, and new curricula that do not meet the immediate needs of graduating students or future employers.

In contrast to these two approaches, the *lock-step approach* involves a rapid successive embedding of sustainability principles, knowledge and application across the programme(s) offered. It relies on a systematic and strategic approach to assess, plan and implement the curriculum transition to education for sustainable development. The risk management focus of this approach minimises the potential for mismatching or mistiming the transition, with regard to industry demands, student expectations and budgetary constraints and opportunities.

Within the *lock-step approach*, a number of common *elements* of rapid curriculum renewal are emerging from literature review and informal enquiry within the authors' higher education academic network. The preliminary grouping of elements is listed below. Ongoing research and trials are intended to further inform the elements prior to full publication in the *International Journal of Sustainability in Higher Education* in September 2008.

The elements of a rapid curriculum renewal process (preliminary grouping) are as follows:

- Awareness-raising activities;
- Scoping workshops with key staff;
- Education for Sustainable Development Curriculum Audit (E4SD Audit);
- Curriculum – existing course renewal (integrated approach);
- Curriculum – new course development (flagship approach);
- Outreach and bridging (recruitment/professional).

In summary, each element plays an important role in achieving the curriculum transition to education for sustainable development. The omission of an element may slow the transition and can also negatively impact on the quality of the curriculum renewal outcomes. However, it should be noted that the elements are not intended to be implemented in a linear manner, nor are they exclusive; one element may contain similar activities to another and elements may be repeated or reviewed at various stages in the transition. The elements are used on an *as required* basis, considering the needs of the programme.

Within the identified elements of curriculum renewal, it can be seen that there is an element called the Education for

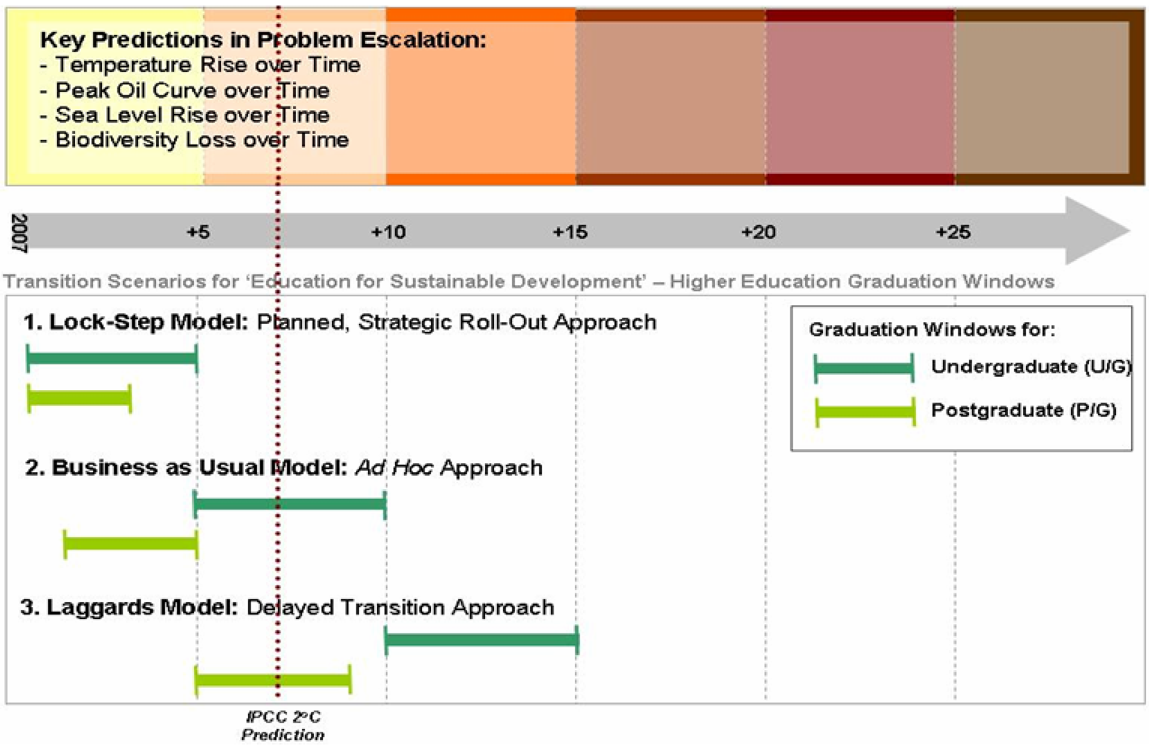

Figure 1: The time lag dilemma for higher education.

Sustainable Development Audit (E4SD). This element provides management with an opportunity to scope the needs of the programme(s) to inform decision-making and planning for the transition to education for sustainable development.

THE E4SD AUDIT

Aims and Objectives

The E4SD Audit process provides a strategic opportunity to systematically review the programme of study, facilitating a *risk management* approach to the curriculum renewal process. It aims to provide structured recommendations on how rapid curriculum renewal for E4SD can be viably achieved through the following objectives:

- Provide a detailed diagnosis to inform efforts to deliver an effective enhancement of the existing offering to engineering students, both across (breadth) and within (depth) programme curriculum;
- Identify areas within the existing curriculum that omit or conflict with recognised sustainability principles, theory and application;
- Identify inconsistencies across and within courses in each degree programme in the language and message about sustainable development theory, knowledge and application;
- Consider the relevance of E4SD to specific graduate attribute requirements specific to the institution including areas of recognised strengths and niche offerings;
- Acknowledge efforts already undertaken in curriculum renewal for sustainable development and identify ways to build on these efforts.

Method Summary

The E4SD Audit is undertaken by an Audit Team comprising (depending on curriculum needs), at a minimum, an E4SD Auditor, the programme convenor, an expert in sustainable development for the discipline area, and a staff member trained in providing learning and teaching support.

The E4SD Audit process comprises the following components:

- An initial *meeting* with management and the programme convenor to confirm the audit method and logistical details for the audit process (ie to ensure that it is as non-confrontational and collaborative as possible);
- An *introductory session* with the staff responsible for the delivery of courses to explain the scope and audit intentions. This session may also include a *graduate attributes workshop* to explore how E4SD is perceived and the preferred manner in which to embed its principles and practices into the programme curriculum to align with the programme's intended graduate attribute outcomes;
- A series of *semi-structured interviews* with the staff responsible for course delivery, to inform the *assessment and classification* of courses in the programme by the E4SD Auditor or an equivalently credentialed auditor. This might be undertaken on an individual level or in a group format, depending on the programme's size and preferences;
- A *SWOT analysis* (Strengths, Weaknesses, Opportunities and Threats) led by the Auditor of the preliminary audit findings for each course to identify the recommended content for inclusion;
- Collaborative *mapping workshop(s)* with individual staff or small groups of staff responsible for delivering each course to discuss the preliminary results of the assessment and classification process, as well as opportunities and constraints for addressing the preliminary recommendations for each course (and providing learning pathways to and from other courses);
- The production of an *audit report*, which contains the course classification summaries and recommendations regarding suggested content (where relevant) for curriculum renewal;
- A *scoping of resource and timing requirements* based on the diagnosis and recommendations to address areas of focus in particular courses across the programme, such as existing course renewal and new course development/ replacement.

Diagnosing a Course: Assessment and Classification

In the E4SD Audit, each course is assessed by the Audit Team on the following three items of focus:

- *Fundamental Principles/Base Theory*: the Audit Team assesses the course content's fundamental principles and base theory, considering how well the scope of the theory underpins application to contemporary, and emerging applications and challenges;
- *Knowledge*: the Audit Team assesses the information provided during the course, considering how well this knowledge explains the relevance and context of the base theory and prepares students with an understanding of issues and processes related to sustainable development;
- *Application*: the Audit Team assesses the course examples (ie case studies, worked calculations, assessment items, etc) considering how well the examples demonstrate the relevance and implementation of the base theory and knowledge to contemporary and emerging applications and challenges.

When assessing the course base theory, knowledge and application, the Audit Team is informed by the *Audit Checklist*, which has been developed from relevant professional body accreditation requirements on sustainable development content, key declarations and global commitments by the relevant institutions and professional networks for the discipline area.

The criteria for course classification are scaled from 1 to 5, as shown in Table 1, where a higher classification reflects a higher level of risk with regard to the course's sustainable development profile in the programme. A classification of 1 reflects the full integration of sustainable development theory, knowledge and application with no further work required. A classification of 5 reflects minimal to negligible integration of sustainable development, knowledge and application, where course replacement or overhaul is the most likely outcome.

The result of this assessment and classification process is the production of an *E4SD Course Diagnosis* for each course, summarising the findings of the assessment. An example of a diagnosis summary is presented in Figure 2 (see end of paper).

A key component for the success of the E4SD Audit element is the direct interaction of the Audit Team with staff who are responsible for the courses in the programme. This creates a potential for proactive and collaborative discussion regarding opportunities and constraints with the courses being assessed in the audit. Indeed, it is important that this element is understood and implemented as a non-confrontational, proactive and collaborative approach to curriculum renewal, where staff have the opportunity to reflect on the course diagnosis and their ideas for the future.

Table 1: The course classification guide.

1	The course contains content and worked examples that address sustainable development issues and innovations of relevance to the discipline area. Sustainable development content is well integrated into the course (theory, knowledge and application), including representation in the course assessment. The course outline specifically addresses the sustainable development content.
2	The course contains content and worked examples that address sustainable development issues and innovations of relevance to the discipline area. Sustainable development content (theory and knowledge) is well integrated into the course, including assessment, but there is improvement needed in the application sustainable development in the course content/assessment. The course outline specifically addresses the sustainable development content.
3	The course contains some content that address sustainable development issues and innovations of relevance to the discipline area, although the theory and/or knowledge require updating. Sustainable development content is not accompanied by up-to-date worked examples or case studies. Sustainable development issues and/or innovations are addressed somewhat in course assessment. The course outline may include mention of the sustainable development content.
4	The course contains a scattering of content (theory and knowledge) or worked examples (application) that address sustainable development issues and innovations of relevance to the discipline area. The content is presented in an *ad hoc* manner and is isolated rather than integrated. The content and/or application addressing sustainable develop-ment may not be reflected in assessment. The course outline does not address the sustainable development content.
5	There is little to no content (theory and knowledge) or worked examples/case studies (application) addressing sustainable development issues and innovations of relevance to the discipline area. The course outline does not address the sustainable development content.

Although the course's renewal imperative requires rapid action and although the scope of curriculum change in some programme areas will be quite large, the shift to education for sustainable development can provide an exciting opportunity to staff. There is a significant opportunity to be creative and innovative in renewing a curriculum, meeting graduate competence requirements and ultimately contributing positively to society's sustainable development challenges.

Once the assessment and interaction with staff is complete, the report is finalised and becomes a strategic planning document for management. The individual course diagnosis reports also become a checklist for staff as they set about addressing engineering education for sustainable development within their courses.

Example E4SD Audit Scenario

An Education for Sustainable Development Curriculum Audit (E4SD Audit) scenario commences with an initial meeting with the Audit Team and the head of school to clarify logistical requirements (ie documentation, including course outlines, summary of assessment requirements, and meeting room needs). The Audit Team then meets with the head of school and those educators who teach in the programme in order to clarify the purpose and method of the audit. The programme's courses are sequentially summarised over a two-hour workshop in short presentations by the relevant programme/course convenor(s). During this time, notes are made by the auditors informed by relevant audit checklists and clarification questions are asked where necessary. The presence of a number of course convenors and programme convenors also provides an awareness-raising opportunity for staff members in relation to the programme content and how sustainable development is to be built into the scaffolding of the programme and courses.

Over the following two days, the Audit Team then studies the course material provided in detail and undertakes the assessment, classifying each course in the programme according to the level of embedded sustainability content, using the course classification guide and an audit checklist of relevance to that particular discipline area. For each course, a detailed SWOT analysis is undertaken, which includes recommendations for where content may be improved. This information is documented in an *E4SD Course Diagnosis* (see Figure 2). The results and recommendations for each course are checked with the relevant staff member(s) for congruency of information and interpretations. It also provides an opportunity to discuss what the findings mean and what opportunities and constraints there are to moving forward with that particular course. The report is then finalised and the Course Diagnosis reports are submitted to management for planning the curriculum renewal process.

Facilitating the Audit and Implementing the Recommendations

In addressing the need for curriculum renewal in engineering education identified in this article, it is suggested that management will need to consider a range of incentive mechanisms to facilitate the E4SD Audit and to implement the recommendations. This could include the following:

- Making a strong commitment from management to the E4SD Audit and its findings from the outset;
- Including a formal request for staff to participate and acknowledgement of the additional workload. This could include recognition through the staff workload calculation of the time spent by staff contributing to the audit process;
- Recognising staff who have already embraced sustainable development in their course(s);
- Clearly communicating the intent and non-confrontational, proactive and collaborative nature of the audit to staff in order to reduce any staff anxiety about the process;
- Providing research assistance and/or teaching buy-out for staff to address the E4SD Course Diagnosis recommendations. This assistance could include a requirement for staff to include an update of the course assessment and course outline;

- Providing research assistance and/or teaching buy-out for staff to undertake professional development in the new area. This could be packaged with specific requirements, including becoming familiar with the topic area, identifying aspects that can be immediately incorporated into existing curriculum and identifying aspects needing significant new course development. It could also include a requirement for staff to identify material in demand for postgraduate and professional development courses or, for example, in attracting regional/international students faced with sustainable development challenges;
- Providing funding opportunities (eg internal grants) for staff to investigate research opportunities in this area. Indeed, engaging staff interest in sustainable development research topics in their area of teaching has the added incentive of research recognition. It could also increase the likelihood that the course(s) would be kept up-to-date with sustainable development theory, knowledge and application.

CONCLUSIONS

At a time of significant global environmental challenges and an escalating need for sustainable development solutions, higher education institutions face a timely challenge: to equip the profession with graduates who have been exposed to theory, knowledge and applications associated with education for sustainable development. Unfortunately, while the last 20 years have seen a growth in dialogue about education for sustainable development, the reality is that education for sustainable development has been a fragmented, sporadic and largely *ad hoc* experience. Most universities and colleges have yet to seriously address sustainable development issues within curriculum.

From technical design through to policy and strategic planning roles, there is an urgent need for graduates with the knowledge and skills to provide innovative solutions to the issues being faced. In particular, it is widely acknowledged by professional institutions around the globe that the engineering profession has a significant role to play together with other professionals, in addressing climate change and in facilitating society's transition to sustainable development.

Within this context, higher education, particularly engineering education, no longer has the luxury of taking a *wait and see* or *business as usual* approach to curriculum renewal. Such approaches will expose institutions to possible accreditation difficulties with professional bodies, reduced demand for graduates and the potential for falling student enrolments. Instead, a *lock-step approach* to undertaking rapid curriculum renewal is the only real option to address the urgent need for education for sustainable development. This approach minimises the potential for mismatching or mistiming the transition with regard to industry demands, student expectations, and budgetary constraints and opportunities.

The Education for Sustainable Development (E4SD) Curriculum Audit process is an important element in the *lock-step approach* for successful and rapid curriculum renewal. It is a systematic, strategic process that takes a risk management approach to embedding sustainability into education programmes. The key to the audit's success is the commitment by management to the process and implementation of the resultant E4SD Course Diagnosis recommendations.

Readers wanting more information about this article are invited to contact the authors through The Natural Edge Project Web site (www.naturaledgeproject.net). It is noted that this Web site also contains a significant amount of sustainable development content that is freely available and open-source (under a Creative Commons Attribution Licence V3.0) [23-26].

ACKNOWLEDGEMENT

The Natural Edge Project (TNEP) is an independent sustainability think-tank based in Australia and operates as a partnership for education, research and policy development on innovation for sustainable development. TNEP is administratively hosted in-kind by Griffith University and the Australian National University

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Course Name: (First Year) Introduction to Thermodynamics [ENG10XX]
Category Classification for Engineering Curriculum: CATEGORY 2

Course Code	Principles/Base Theory	Knowledge	Application/Practice
ENG101	√ *Clearly explained*	√ *Appears suitable*	~ *Room for improvement*

SWOT Analysis Summary:

- Strengths: the course appears to adopt a systematic approach to teaching momentum, mass and heat transfer. It currently incorporates an overview of some contemporary and recent applications of base theory to a range of emerging engineering innovations, providing a foundation for other courses in the programme. Case studies highlight alternative energy sources (including biofuels, wind power, etc). Note that there is further opportunity to expand on these case studies by introducing industry best practice case studies;
- Weaknesses: the course lacks a *meta-discourse* to contextualise learning within the programme. This could be addressed in the outline for the course through the use of explanatory notes such as the following: *A key component of addressing the goal of sustainable engineering solutions involves a solid understanding of momentum, mass and heat transfer. In order to contribute sustainable engineering solutions to society, students will need a strong grounding in the fundamental principles and base theory provided in this course*;
- The base theory in the course is, in some cases, still explained using unsustainable practices and processes. To address this, the course could use introductory examples of cogeneration and heat exchange, providing the opportunity to both demonstrate application of the base theory and also to expose students to growing areas within sustainable engineering practice;
- Opportunities: this course has a clear opportunity to demonstrate to expose students to a range of sustainable technologies and alternatives to current unsustainable practices. For example, using the example of a traditional wastewater treatment plant to demonstrate systems thinking may leave students with the impression that services such as wastewater treatment can only be engineered in a chemical process, rather than the possibilities of biological solutions (eg living machines), or a combination of biological and chemical treatment. Replacing or augmenting this example with an example of an ecological wastewater treatment system still provides the mechanism to discuss systems thinking while also exposing students to innovations in wastewater engineering;
- Threats: although students are exposed to base theory and knowledge, the course examples appear to include limited applications of contemporary/popular issues in engineering and environment. For example, to demonstrate atmospheric gas heat transfer, the course might examine the range of greenhouse gases, and how they absorb and reflect heat in the atmosphere. See *Additional Comments* for example content that could be considered for integrating into this course.

Additional Comments:

Additional notes and Web site references are provided below to assist the Course Convenor with addressing comments above:

- Sample Lecture: Green Chemistry and Engineering (available at: www.naturaledgeproject.net/essp);
- Sample Lecture: Introduction to the Six Types of Greenhouse Gases (available at: www.naturaledgeproject.net/essp).

Figure 2: An example of a E4SD Course Diagnosis containing a summary of the SWOT analysis for a first year course in an engineering undergraduate programme. This summary is adapted from an audit undertaken for an Australian university's civil engineering degree programme in December 2006.

Proceedings of the 4th Asia-Pacific Forum on Engineering and Technology Education

edited by Zenon J. Pudlowski

Bangkok, Thailand, provided the exciting venue for *4th Asia-Pacific Forum on Engineering and Technology Education*, held between 26 and 29 September 2005. Bangkok itself is a vibrant and varied city that acts a hub, connecting Asia with the rest of the world.

This Volume of Proceedings comprises of 45 papers presented at the Forum, representing contributions coming from 16 countries, including three opening addresses and nine keynote addresses. The Asia-Pacific region is an area that represents great diversity, both culturally and in educational matters, which in turn reflects, to some degree, the national identity and the effects of globalisation on education, and on engineering and technology education in particular. This parallels the diversity of submissions to the Forum, printed in the Proceedings, that all relate to engineering and technology education.

As with previous meetings run by the UNESCO International Centre for Engineering Education (UICEE), the Forum is divided into a number of distinct sessions, each headed by a lead paper that is considered to be most representative of the area under discussion. Topics covered include the following:

- Opening addresses
- Keynote addresses
- Case studies
- Innovation and alternatives in engineering and technology education
- Important issues and challenges in engineering and technology education
- Learning strategies and methods in engineering and technology education
- New trends and recent developments in engineering and technology education
- Quality issues and improvements in engineering and technology education
- Recent developments in engineering and technology education
- Social and philosophical aspects of technology and its impact on modern societies
- Specific engineering and technology education programmes

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The architecture of technology-assisted problem-solving packages for engineering

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ABSTRACT: Efforts to incorporate interactive multimedia simulations in the teaching of mechanical engineering at the University Tenaga Nasional (UNITEN), Kajang, Malaysia, has been initiated. In this article, the author presents an innovative approach based on the principle of Computer Aided Learning (CAL) to design and implement integrated packages known as Technology Assisted Problem Solving (TAPS) packages. The ultimate aim of TAPS packages is to coach students in a step-by-step approach to learn and solve engineering mechanics problems. In this article, the author first illustrates the architecture and key concepts of the TAPS packages followed by their contributing technologies.

INTRODUCTION

Various technologies are coming together to alter the methods used to teach students in the technical field. Multimedia has the potential to create high-quality learning environments [1]. The key elements of multiple media and user control over the delivery of information and level of interactivity can be used to enhance the learning process through the creation of integrated learning environments.

In the context of introductory courses, such as engineering mechanics, which requires students to read and understand engineering structures, such an interactive system can indeed facilitate and accelerate the learning curve by putting the entry-level transfer of information at the disposal of the student. The student can be provided with opportunities to control the pace of delivery, including the option to stop and replay portions of the lecture that seem unclear.

Although one may say that the textbook is there to serve this purpose, experience shows that most students are unable to carry this out, whether for reasons of time, motivation, ability to absorb new information from a printed medium, or others. In any case, a textbook is a mono-medium that has great difficulty in presenting moving or evolving processes.

According to Cairncross and Mannion, the design of a multimedia system must be based on the needs and interests of learners [2]. Interactivity in learning applications merits more detailed investigation and the issue of how best to design learning activities that engage the learner needs to be addressed.

In order to address these issues, an innovative approach based on the principle of Computer Aided Learning (CAL) to design and implement integrated packages known as Technology Assisted Problem Solving (TAPS) Packages is presented here.

The theory and principles of CAL has been well defined in ref. [3]. The preliminary work consist of an architecture to develop a TAPS package to facilitate and assist mainly engineering students in the hope that they will be able to comprehend and gain a better understanding of the subject matter.

TAPS: A NEW APPROACH TO LEARNING, VISUALISING AND PROBLEM SOLVING IN ENGINEERING

TAPS packages are specialised computer programs developed to work as standalone (PC-based) or with Web servers that can supplement student learning, and facilitate revision, laboratory experiments and self-study. In this article, the term *TAPS* is used to represent interactive multimedia CAL in which the student is engaged with a computer tutor in the problem-solving task of the subject matter. TAPS packages offer similar pedagogic values as an experienced human tutor, with the added advantage of guiding students to solve engineering problems in a more flexible mode, ie students have the freedom to work on the problem at their own pace, repeat all or certain steps, spend more time at each or particular step until they are able to understand, and solve the problem. The objective of these TAPS packages is to improve students' understanding of the selected engineering problems by guiding and presenting the problem-solving steps accordingly. The ultimate goal is to instil a sense of independent learning, encourage critical thinking and promote deep learning. TAPS packages include the use of computers to provide most aspects of instruction that a classroom instructor could provide, such as tutorials, questioning, feedback contingent on answers, analysis and testing.

TAPS packages also employ a variety of multimedia elements, such as text, 2D animated and still graphics, 3D animated and still geometric models, audio, video and animations, stereoscopic images, and simple artificial intelligence techniques to develop individualised computer-based learning environments in which the student and computer tutor can have a flexibility that closely resembles what actually occurs when a student and a human tutor communicate with each other. Such suppleness is important because without it, the package cannot be fully adaptive to the individual student's ongoing learning and problem-solving needs during instruction.

KEY CONCEPTS IN A TAPS PACKAGE

There are a number of key concepts that can be applied in the development of a TAPS package. Some of these are similar to Intelligent Tutoring Systems (ITSs) whereby a computer tutoring system incorporates aspects of intelligence, particularly an assessment model (used to monitor the performance of students), and domain knowledge representation. In a TAPS package, these concepts can be divided into three main categories, namely: learning scenarios, knowledge representation and assessment modelling.

A learning scenario is a situation in which the student's learning takes place. When implementing a TAPS package, the criterion for determining the most appropriate learning scenario is based on the interaction required between the student and the computer. The learning scenario selected will therefore be dependent on the type of information to be delivered to the student during the tutoring session, the amount of knowledge the student is expected to gain from completing the problem-solving tutorials and, to a certain extent, on the knowledge base of the TAPS package.

In general, most computer-based tutoring packages are implemented using one of the three learning scenario categories. The most common learning scenario category to be implemented is the explanation of theoretical concepts to the student. In this scenario, the TAPS package must convey predefined knowledge to a student in ways that maximises his/her understanding of the concepts being taught. This is the simplest learning scenario to implement as the main challenge of developing the TAPS package is ensuring that more precise information is presented at the correct level of detail for students to comprehend and learn.

The second learning scenario that is commonly employed in computer-based tutoring packages is the simulation of real-world tasks on a computer. These tasks include the detailed operation of a specific component or the simulation of the process that the student is expected to perform in the future. In any event, the learning scenario must deal with simulating the appropriate real-world properties as accurately as possible on the computer. This is a difficult requirement to implement successfully as the TAPS package must both simulate the process as realistically as possible, as well as have the pedagogic ability to explain the process to the student in the best possible way.

In general, the most difficult learning scenario category to be implemented in a computer-based tutoring package is the discovery of knowledge through investigation and exploration. In this third learning scenario, the student is required to participate actively in the learning experience by manipulating the package and observing the direct response to the student's actions.

The knowledge representation component of a computer-based tutoring package can be divided into two categories, namely: domain knowledge and pedagogical knowledge [4]. Domain knowledge involves issues in the representation of knowledge and refers to the facts, figures and interrelationships between various objects in the domain. Pedagogical knowledge is the sequence of instructions that a computer tutor uses to carry out various tasks in operating a system. Therefore, pedagogical knowledge involves the finding of techniques to solve particular problems. The knowledge components of computer-based tutoring packages contain definite information content and structure, as well as procedures for accessing and utilising the information [5].

In terms of domain knowledge, one of the major limitations with conventional computer-based tutoring packages is that they have a poor structure of knowledge of their domain in the database. The tutoring session typically consists of the presentation of information, problems with which to test the student's knowledge, answers to these problems and, at best, pre-specified branches based on the student's results obtained in the test.

Rickel noted numerous disadvantages with these computer-based tutoring (CBT) packages as summarised below:

- The CBT package is unable to adapt to the requirements of the student;
- There are no facilities with which to assess the student's true misunderstandings;
- The pre-specified branches prevent the CBT package from handling unanticipated answers;
- Pre-specified answers leave the CBT package with no criteria for judging student responses other than correct or incorrect [6].

If human tutors are expected to possess a great deal of domain competence, then this should be the ultimate challenge for TAPS packages.

DOMAIN KNOWLEDGE

The domain knowledge component of a TAPS package should incorporate the necessary information so as to correct the above limitations. This implies that the TAPS package should contain an extensive knowledge database and have the ability to filter out the course material that is not directly relevant to the student. In addition, the TAPS package should have the ability to interact with the student in the same manner as a human tutor. Interaction is perhaps the most difficult part of TAPS package design. A good TAPS package should be able to answer course-related questions asked by the student, as well as present summaries and overviews whenever these are required. Furthermore, the TAPS package should know when and how to present the student with information and be able to determine immediately whether the student has understood this information or not. A good TAPS package should constantly monitor the student and have the ability to automatically offer explanations to match the student's current level of understanding.

The domain knowledge component of a good TAPS package requires a great deal of intelligence and effort to implement successfully. In general, it is for this reason that to date, no computer-based tutoring package has been commercially developed and fully accepted by learning institutions. Even if such packages exist, these packages may be used only for a short period of time. Therefore, it will probably take many years of research in the field of Artificial Intelligence (AI) before an intelligent computer-based tutoring package could be successfully developed. Currently, when developing a TAPS package, it is necessary to compromise on various aspects of the domain knowledge component in order to ensure that a simplified advanced computer-based tutoring package can be physically realised [7].

PEDAGOGICAL KNOWLEDGE

Pedagogical knowledge is an essential component of a TAPS package. Although the domain knowledge component is responsible for filtering useful information from the vast knowledge base, the pedagogical knowledge part is responsible for relating this information to the student. The pedagogical knowledge component decides how to interact with the student, when to interrupt the student and how to address the student while he/she is using the tutoring package.

Although the pedagogical knowledge component is burdened with many responsibilities, the most important of these is determining a strategy to deal with a student's errors. Since students are seldom consistent, a computer tutor cannot simply provide correct answers to a student's mistake. When a student makes a mistake, the TAPS package must select between ignoring the error, pointing it out, correcting it or somehow guiding the student towards recognising the error and correcting it without the explicit help of the computer tutor.

There are numerous trade-offs in correcting a student explicitly, trying to entrap the student into discovering the error without the help of the computer tutor, or simply allowing the student to view the consequences of any mistakes made.

THE ASSESSMENT MODEL

The assessment model is a dynamic model of the student's knowledge and capabilities that is maintained and constantly updated by the computer-based package. Its purpose is to evaluate and account for the student's actions and responses. Human tutors do an excellent work on moderating students' answers in the context of their assumed level of understanding and past learning behaviour, thus effectively adapting their instruction to students' competences and abilities. Although adaptation to students is almost second nature for human tutors, it is an extremely difficult characteristic to implement in a TAPS package.

The function of the assessment model is to provide the student with feedback by comparing the student's actions to those prescribed by the TAPS package. This feedback is used to inform the student which actions are correct and which are incorrect. In this way, the student receives tuition while interacting with the TAPS package.

Conventional (classroom) assessment could occur through a variety of methods, for example quizzes, examinations, oral tests or homework. However, the most common technique used to assess the student in computer-based tutoring package is the assessment of the number of correct and incorrect answers upon completion of a course topic. Adaptation to the student's level of understanding is usually limited to the presentation of pre-specified course material based on the student's responses to the questions of the test. Most available conventional computer tutoring packages do not have the ability to keep track of the student's insufficient knowledge, except at a very basic level. For current tutoring packages, the assessment model will have to be greatly simplified so that it may be practically realised.

The student assessment model represents an overview of the student's capability levels. There are a number of fundamental rules that should be adhered to when developing an assessment model in a TAPS package. These can be summarised as follows:

- The model must be able to represent knowledge, concepts and skills;
- The model must include knowledge that the student has acquired, and which the student has been exposed to and shown some understanding;
- The model must be able to represent the student's misconceptions;
- The model must be able to include a history of the student's problem-solving performance.

CONTRIBUTING TECHNOLOGIES

There are various technologies that have – and will – contribute significantly in the development of TAPS packages now and in the future. It is assumed that with the current level of progress in the field of computer hardware and software, most of these contributing technologies could dramatically change the environment of TAPS packages. Although computer hardware is a contributing technology in itself, technologies that are of greatest interest are those of multimedia and Virtual Reality (VR). Each of these is briefly described below.

MULTIMEDIA

Cairncross and Mannion described three main attributes of multimedia applications, ie multiple media, interactivity and delivery control [2]. These attributes can be further shown with their sub-functions or properties as shown in Figure 1.

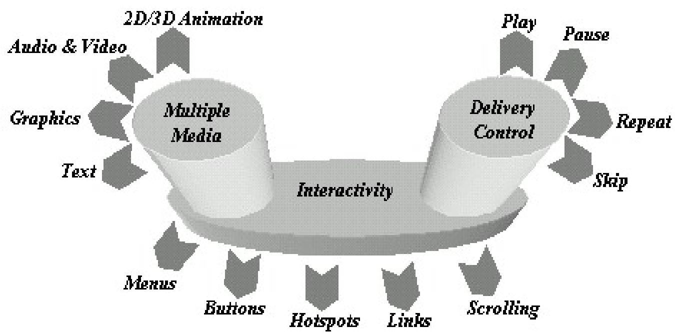

Figure 1: Key attributes model of multimedia.

According to this model, a given piece of information could be delivered using one or more media element. For example, an image can be used to illustrate a text-based description. The information originally presented on screen can be supplemented by the use of audio, video and pop-up boxes. Thus, multimedia has the ability to support multiple representations of the same piece of information in a variety of formats.

The non-linearity offered by many interactive multimedia learning applications provides a learner/user with greater navigational freedom. Users may go to any section in a multimedia tutorial and in any order [2]. Dynamic media such as video and audio can be controlled, ie pausing, playing and repeating clips.

Another attribute is interactivity. Interactivity in multimedia-assisted learning applications should go further than simply allowing a user to choose his/her path, and pointing and clicking at various menus and buttons. Most multimedia applications provide some interactivity in that it responds to user instructions. What makes the difference, even in simple educational software, is whether the software allows the user to work at his/her own pace, in the order desired, repeating sequences at the user's will, manipulate virtual objects on screen, and the simulation of experiments or industrial processes [2].

VIRTUAL REALITY

Virtual Reality (VR) is a remarkable technology that allows three-dimensional artificial worlds to be created on a computer. What makes this technology unique is that it is possible to move about and interact within these artificial worlds in a way that allows all navigational and manipulative movements made by the user to be emulated in this computer-generated environment [8]. This is accomplished using immersive VR input devices, such as the Head Mounted Display (HMD) and data glove. Using this equipment, the user believes that he/she is actually immersed in this artificial world.

On the other hand, there are also Desktop Virtual Reality (DVR) applications that do not require expensive hardware equipments to be used. DVR requires a PC or laptop, some specialised hardware such as a 3D graphics card, 3D sound card, a 6D tracker, a joystick, and software that displays and permits navigation in virtual environments such as *Cortona*™ and *Cosmo*™ viewer, and *Macromedia*™ *Shockwave*. The delivery control features of DVR, as shown in Figure 2, are an extension of the key attributes model of multimedia shown in Figure 1. These new features enable the user to move along any direction on the screen, and have the object displayed continuously and updated instantaneously. Therefore, the user could gain a greater understanding of a given problem. In terms of cost, DVR is cheaper than immersive VR systems.

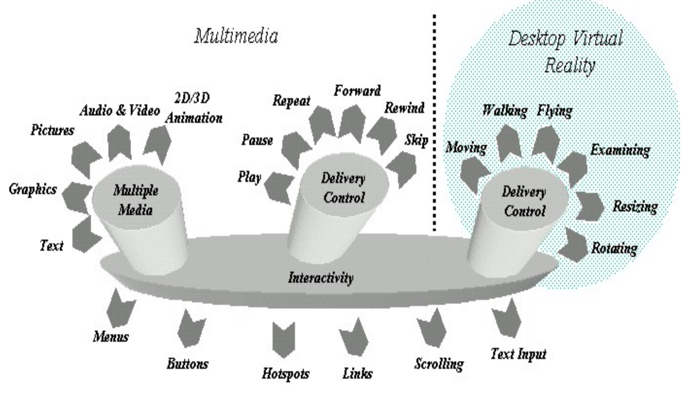

Figure 2: Extended key attributes model of multimedia and DVR.

It can be anticipated that VR will be one of the key technologies to influence TAPS packages in the near future. With constant developments and improvements in the field of computer hardware and software, it will eventually be possible to create immersive VR TAPS packages at an affordable price. Such packages could help students learn and understand better, ie if an environment responds realistically to various inputs given by the student, then the student can observe exactly how the system functions in reality.

CONCLUSIONS

In conclusion, interactive multimedia CAL has great potential and has been widely used across a wide range of courses to promote learning. However, due to the different nature of each field of study, the degree to which computers can be used in teaching varies greatly.

In this article, the author presents an architecture to design and implement Technology Assisted Problem Solving (TAPS) packages and the contributing technologies. The design of a TAPS package requires various key components to be successfully integrated. These include the appropriate choice of learning scenario, comprehensive domain and pedagogical knowledge components, and a dynamic student assessment model. With these components firmly in place, the TAPS packages should have the ability to present relevant course materials at a level of detail ideally suited to the individual style of learning. In addition, the TAPS packages should be able to constantly assess the capabilities of the student and provide adequate feedback throughout the problem-solving process. A good TAPS package demands a great deal of computer intelligence to be incorporated into the problem-solving package. Presently, it is not possible to represent all the characteristics of a human tutor in TAPS packages. Consequently, it is permissible to compromise on the knowledge representation of a human tutor to a certain extent in order to produce a tutoring and problem-solving package that can teach students in a more effective manner than other existing CAL packages.

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Heidegger's thesis on two kinds of thinking: methods to carry out engineering education

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ABSTRACT: In this article, the author deals with the problem of training students in the necessity to foresee the consequences connected with the introduction of technical innovations within the context of Heidegger's ideas about the interpreting thoughtful mood as an extremely important addition to calculative thinking in the traditional educational system. The efficiency of Heidegger's idea is considered at some lengths against the background of the characteristic consequences of introducing new techniques, texts of ancient literary heritage and examples connected with the manifestation of the theory of catastrophe in the fields of power engineering and coal mining industry. Recommendations are given relative to a methodical approach to solving problems when training students at the Bachelor level in the *Electrical Engineering* speciality offered at Donetsk National Technical University (DonNTU) in Donetsk, Ukraine.

INTRODUCTION

At present, technical and technological education is being developed under the conditions of scientific and technical progress, which is characterised by shortening the intervals between the conceptual phase and the introduction of new techniques. Given this condition, the probability exists for the detrimental effects of innovations, for instance, to one's health. At the same time, if the above mentioned innovations have gained widespread acceptance in the everyday life of many people, should the effect be attributed to the state or gain international significance?

The problem being discussed here leads to the question of how the scientific and technical level and the psychological persuasion of graduates from Donetsk National Technical University (DonNTU) in Donetsk, Ukraine, suit to the requirements of one of Heidegger's key ideas [1]. This is under conditions connected with the introduction of new techniques in large quantities all over the world and in all branches of industry.

In relation to the topic under consideration, the question arises of whether there is correspondence between a statement of the problem and the methodological arrangement of teaching the University's students in the context of the problem as it is set.

SCIENTIFIC AND TECHNOLOGICAL REVOLUTION

Down, down, down. Would the fall never come to the end?
Lewis Carroll: *Alice in Wonderland*, Chapter 1

Consequences and Perspectives

As a rule, the armament race excludes the logic of humanitarian thinking. This is in the sense that humanity falls prey to its own scientific and technical progress. One should bear in mind that the outlined situation becomes worse against the background of political conflicts between those states coming into existence as a consequence of economic or geopolitical contradictions.

The increasing interest in energy saving technologies is driven, to a large extent, as a means to reduce working expenses to recover the cost of one or another type of product competing on the national and world commodity markets.

At present, there is a marked improvement in some directions on the industrial scale connected with the development of environmentally appropriate technologies. Solutions to problems connected with restraining detrimental after-effects (requiring, as a rule, the concentration of capital from several countries) commence after the adverse effects have already manifested themselves. Nowadays, the world is saturated by technical facilities, providing reason enough to develop new and highly efficient technologies.

Examples can be found in such diverse fields of power engineering as burning coal at thermal power plants (energy production process) and driving various mechanisms by using induction motors (process of energy consumption).

Thermal power plants with new types of boilers that burn up coal at 900° C (instead of 1,400° C) utilise special constructions that exclude torch coal combustion and the formation of nitric oxides. A result of this innovation is that the efficiency of these thermal power plants increase from 35% to 55%.

The new technology based on the use of die-cast copper rotor cages allows for an increase of induction motor efficiency by 1.5-2.0% [2][3]. It should be remarked that the composition of load includes about 50% of induction motors.

When compared with a die-casting rotor with aluminium bars, induction motors with a die-casting copper rotor are distinguished by the following indices:

- Increase in efficiency by 2-3%;
- Improvement of the torque-slip characteristic by way of eliminating the inherent dip;
- Increase of locked and breakdown motor torques.

Unfortunately, the above mentioned considerable technological improvements were delayed by more than a century.

Messages from the Ancient Literary Heritage

Of particular interest are peculiar kinds of historical messages from generation to generation adduced in the Old Testament of the Bible. Such writings reflect the scope of knowledge and include the following:

> *18 Three things are too wonderful for me for I do not understand:*
>
> *19 the way of an eagle in the sky, the way of a serpent on a rock, the way of a ship on the high seas, and the way of man with a virgin* [4].
>
> *17 And I applied my heart to know wisdom and to know madness and folly. I perceived that this also is but a striving after wind.*
>
> *18 For in much wisdom is much vexation, and he who increases knowledge increases sorrow* [5].

The first and the second quotations cited above contain information on the phenomena being beyond the grasp of the mind (*non-cognizable* phenomena). Indeed, the indicated phenomena associated with the meteorological prognoses (weather forecast) and the mystery of intimacy between the man and woman (which is the mystery of man's essence) have not been cleared up till now.

The first text was written around 932 BC by the King Solomon of the Hebrews, who was famous for his wisdom and his wealth. The second text is also attributed to him [6].

The above lines should be perceived not only as the lack of knowledge but also as an address to future generations to be aware of social danger.

Theory of Catastrophe

An analysis of sophisticated non-linear technical systems, ecological processes, economic regimes, etc, can be inferred using the catastrophe theory [7]. Uneven changes to a system's condition are possible when the system operates at smooth changes and alterations in external conditions. It is significant that the catastrophic violation of stability can lead not only to the intensification of a system's condition but also its optimisation.

The latter consequence is a result of control without the appropriate feedback. In this case, deterioration can occur during the process of gradual motion in the best conditions. From the social viewpoint, it is obvious that catastrophes lead to a drop in the competences or the personal responsibility of specialists for the technical decisions made.

A description of the singularities of slow motions in relaxation systems with slow variables and the classification of local bifurcation in generic dynamical systems has been set forth by Koptikov, Kovalev and Spivakovski [7].

As an illustration of catastrophes, for instance in the field of power engineering, one can refer to a serious nuclear accident in the Ukraine at the Chernobyl nuclear power plant on 26 April 1986 and to heavy faults that have occurred in the USA, particularly, the breakdown of the New York power system on 11 September 1965. Various experts consider that only one of the most essential causes of the latter fault was associated with the insufficient use of operational measures.

In the field of the coal-mining industry, from evidence derived from a statistical analysis of data over the span of 10 years (1988-1998), the degree of risk (quality of explosions in the year unit of time) of the explosions in coal mines of the Ukraine is equal to:

- $5.10 \cdot 10^{-4}$ – in the tunnelling face;
- $1.85 \cdot 10^{-4}$ – in the longwall face;
- $1.45 \cdot 10^{-4}$ – in haulage drift (for a conveyor system) [8].

These figures show that the number of exponents obtained are more than two times greater than the normalised value equal to $1 \cdot 10^{-6}$/year.

Heidegger's Thesis on Two Kinds of Thinking

It is Heidegger's opinion that calculating thinking is being used in the design of technical devices and processes, as well as interpreting thoughtful mood.

There is a good probability that in the case being considered, the dangerous consequences could be foreseen through taking out timely NOT (as a suspended sentence, other than allowing a no appeal verdict) during the process of the comprehensive analyses embracing not only calculating thinking, but also the interpreting thoughtful mood about the consequence of using the decision made.

A peculiarity of the practical implementation of Heidegger's approach lies in that the interpreting thoughtful mood NOT should immediately go after every decision YES.

It is believed that Heidegger's idea has something in common with the above mentioned affirmation adopted from the Bible's Book of Ecclesiastes [5].

At present, the global phenomena occurring in nature, as well as flora and fauna, are subject to a severe comprehending thoughtful mood too. Changes in the mentioned spheres adequately reflect the influence of the scientific and technical revolution.

PROBLEMS IN MOULDING MODERN SPECIALISTS

Well-known methods that are intended for solving inventive problems are destined, as a rule, to achieve positive effects connected with decreasing expenditure. In particular, the textbook by Bekleshov makes the provision to execute the definite demands for technical and economical substantiation in the student's design [9]. These demands focus on the attainment of scientific and technical results, as well as the social efficiency, of the student's project that ought to be estimated by the use of the following indices (maximum values):

- Significance: 0.5;
- Profundity of the look into a problem: 0.35;
- Probability of success: 0.15.

The results with regard to social impact should be evaluated quantitatively in the following manner:

- Air pollution index in the industrial premises;
- Air quality index in the industrial area;
- Safety level of the working conditions;
- Level of noise;
- Degree of illumination;
- Description of waste products;
- Thermal and moisture conditions.

In some instances, as a basis for appraising the obtained social results, the following state/national standards can be used:

- Regulations for safety measures;
- Physical indices of ecological conditions;
- Biological indices of ecological conditions.

It should be recognised that the following accompanying effects can be achieved when solving some social problems:

- Rise in labour productivity;
- Economisation of labour;
- Decline in occupational diseases.

It can be confidently said that the present level of the training of specialists who are well informed about the problems set forth above is the call of duty and dictates of reason. The substantiation of the grounds for the broadening of university courses by utilising new information is shown in Figure 1.

Students should be convinced of the necessity and vital importance of the conclusions made. There is good reason to train students to attempt to formulate the essence of the problem and how to overcome it. As this takes place, it is advisable that design methods, including synectics, be utilised [10][11].

The arrangement of practical work undertaken during the processes of moulding new attitudes to technical equipment and devices ought to be based on the new approach being carried out in the form of the inversion of the traditional purposes. A schematic diagram of this method is presented in Figure 2. It should be noted that the process of developing the interpreting thoughtful mood requires a great deal of effort on the part of tutors, as well as more prolonged students' exercises.

The methodical recommendations that are associated with the implementation of the interpreting thoughtful mood in the form of student's acquired habits are concerned with the disciplines integrated into the processes connected with production, transportation, distribution and the consumption of heat and electrical energy.

Information devoted to the problem under consideration is included in the study hours of the course and are described below.

The first year involves *Introduction to Electrical Power Systems and Networks*.

The second year incorporates:

- *Philosophy* (technology and philosophy);
- *Power Engineering Installations*;
- *Nonconventional Power Sources*.

The third year covers the following:

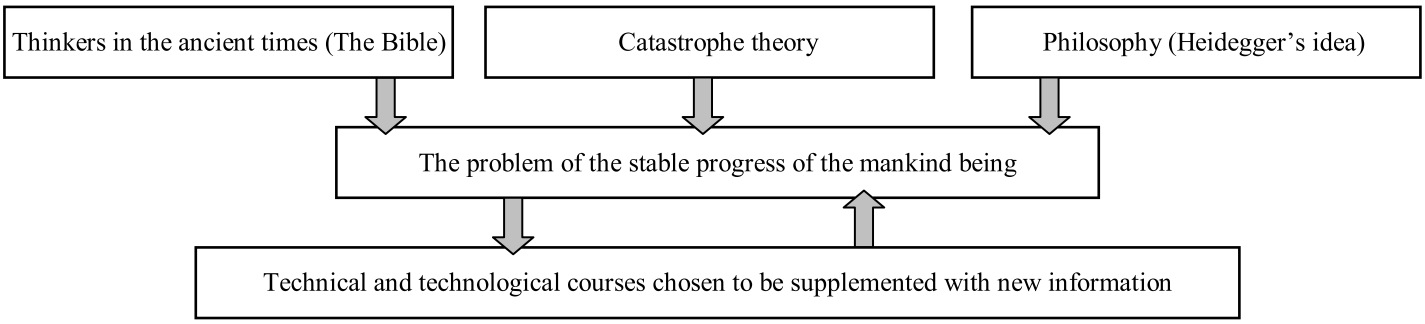

Figure 1: Simplified diagram representing the factors that are related directly to the problem of stable world progress.

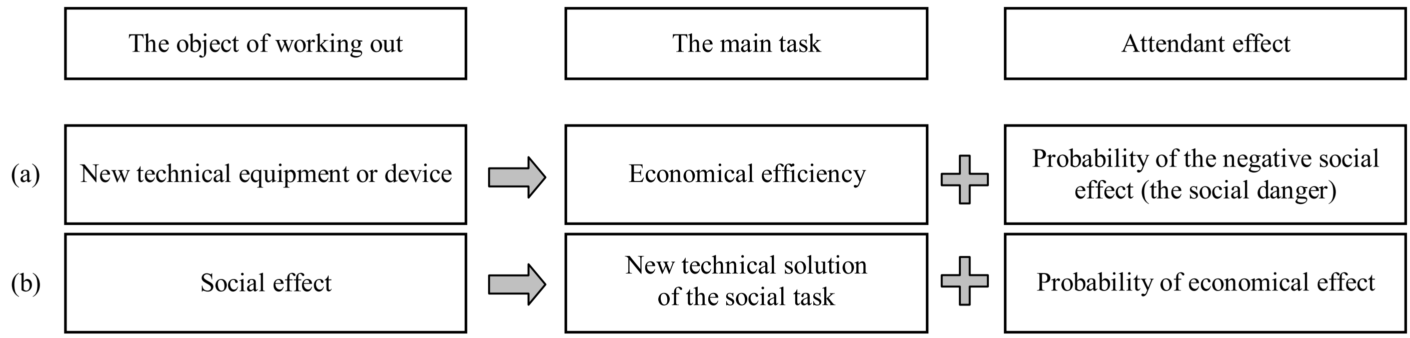

Figure 2: Inversion of the inventive tasks: (a) situation as it traditionally stands; (b) solution of the socially directed problems.

- *Psychology* (overcoming the social and psychological barriers in the course of innovation activities);
- *Sociology* (the social adaptation of personality in the course of innovation activities);
- *Electrical Machines*;
- *Fundamentals of Ecology* (ecological expertise to tackle social and humane problems associated with the introduction of new scientific and technical projects in industry);
- *Electrical Systems and Networks*;
- *Electrical Apparatuses*;
- *Power Engineering Economics* (innovative approaches in economics for scientific and technological advancements);
- *Safety of Vital Functions*.

The fourth year includes the following:

- *Energy Saving Technologies*;
- *Electrical Part of Power Stations and Substations*;
- *Industrial Safety Measures*.

For disciplines appertaining to the humanities in the above list show the lecture subject matter (in brackets) with regard to the direct relationship to the problem at hand.

Recommendations that are directed at developing persuasions that there is the necessity to decide NOT when evaluating the consequences of technical innovations to be brought into use predetermine the following:

- Application of the principle NOT as the dominating idea in determining the direction of the action when analysing the specific situation;
- Perception of the principle NOT as a moral habit necessary to overcome the psychological barrier that may be required to ensure moral norms at any technical and economic situation;
- Use of the principle NOT as a humanising element of techniques directed at attaining the main aim of engineering psychology associated with ensuring the accordance between techniques and the requirements to take into account the peculiarities of the person and his/her activities.

Turning attention from the technical and economic advantages of new technical objects to the social category involves the following:

- Understanding of the social value of the person in the community;
- Profound comprehension of ergonomic problems in the system: person – technique – environment.

The solution of problems of the new trend, as reflected in Figure 2b, extends students' knowledge within the sphere of their vocational guidance. It also leads to students' self-appraisal to enhance their personality.

CONCLUSIONS

The consequences of the technical revolution have convinced people of the truth of the statement that technical and technological innovations are worth consideration from the position of Heidegger's categorical appraisals of YES and NOT.

The all-embracing substantiation of the urgent decision to tackle current problems concerns not only the process of training calculating thinking in the university educational surroundings but also the interpreting thoughtful mood. This should allow graduating students to be able to stop the detrimental effects of technical innovations on the environment and to people's health.

In this article, the author gives recommendations relative to the methodological approach associated with the practical implementation of Heidegger's thesis on two kinds of thinking when training students in the speciality *Electrical Engineering* at the DonNTU.

The moulding of the interpreting thoughtful mood, as a new distinctive feature of the human character when training specialists at technical universities, will promote qualitative changes in their way of thinking and help satisfy the system requirements of technique – person – environment.

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Using NETPAW to advance senior high school students' English acquisition in the context of the Common European Framework

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ABSTRACT: The purpose of this research is to understand students' learning processes, effectiveness and attitudes via an online interactive English learning system created by the National English Test in Proficiency for All on the Web (NETPAW) testing centre of the Republic of China Multimedia English Language Instruction Association (ROCMELIA). NETPAW generated a reciprocal table of the Common European Framework and had it published on the ROCMELIA Web site, as required by the Taiwanese Ministry of Education. The Common European Framework has also been adopted by international English tests such as TOEFL, TOEIC and Cambridge English Tests. This study adopted a quasi-experimental research design, with 217 eighth grade students from central Taiwan participating in the study. The results show that students who learnt English via the interactive learning system online and traditional teaching methods performed better than those students who learnt English via traditional teaching methods only. The study also found that the interactive learning system could not only motivate students to learn English better, but also enhance students' listening and reading proficiency. The results suggest that the online Web-based interactive learning system is a worthy and applicable approach to learning English.

INTRODUCTION

English is the most important international language, as well as a communicative tool, in the modern era of globalisation and global community. Brown observed that *learning a second language is a long and complex undertaking* [1]. As in other areas of Asia, English is used as a foreign language in Taiwan. In Taiwan, many people strive to acquire a good English education at elementary, junior high and senior high schools, as well as at colleges and universities. However, most students still cannot communicate well with English native speakers after studying English for several years [2].

Whether a student is successful in learning a foreign language is determined by many factors. Theoretically, foreign language learners can learn a foreign language well on the condition that they are provided with a good language learning environment, plenty of study time, strong motivation, effective teaching and learning methods, strategies, enough teaching materials plus a thoughtful teacher who knows the learners' needs [3-7].

There are many reports about the effective use of Internet technologies, Web resources and multimedia learning programmes in English as a Second Language (ESL) and English as a Foreign Language (EFL). In Taiwan, English is not an official second language. Nevertheless, the entire student population of Taiwan is now engaged in an island-wide struggle to master English.

The nature of language makes technology-enhanced language learning an optimal instructional medium because language learning requires lots of practice and interaction [8]. Although English teachers may apply different teaching approaches in the classroom, some more effective than others, many students still manage to get high grades in English. In any case, a good English learning environment is very important for EFL learners [9-12].

This so-called English language environment includes everything that the EFL learner hears and sees in the target language. It may include a wide variety of activities, such as conversations with English teachers and peers, reading newspapers, listening to radio programmes, audio tapes, CDs, watching television programmes, movies, video tapes, DVDs, and studying language programmes with multimedia, hypermedia and the Internet [4][13-16].

LITERATURE REVIEW

The advantages of Web-based learning are numerous and varied. Research has confirmed the abundant advantages of Web-based learning, such as time saving, cost reduction and space saving, as well as the increased opportunity for independent and personalised learning [17][18]. Moreover, experts predict that in the next few decades, over 50% of the student population will be educated using online learning and technology. It is predicted that the average class size will be 1,000+ students and that these learners will be taught by an expert in his/her field of knowledge [19].

When compared with traditional instruction, Web-based technologies can provide students with more motivation and interest as they access multimedia and other innovative tools in an interactive, authentic learning context [20-28]. Thus, the traditional classroom must make way for the virtual classroom, and traditional learning must give way to cyber-learning or e-learning, with electronic testing or e-assessment replacing old-fashioned paper and pencil examinations, which may become largely obsolete.

Online learning not only enhances learner interaction and output, but also provides a more positive learning environment for students. Besides, online participants have found that Web-based instruction facilitates the sharing of ideas given the broader scope of people using the World Wide Web (WWW).

When they practice with online exercises, such as multiple-choice questions and short answer questions, their responses will be evaluated instantly and feedback forthwith provided. At the same time, users' data are stored in the back-end server database so that instructors can retrieve and analyse them at a later time [29].

In a study of the effectiveness of using New Horizon College English Online (NHCE) of an online EFL course management and learning system, Da stated that by using the interactive system, an instructor can reduce the classroom time normally devoted to reading and listening instruction, and pay more attention to speaking and writing skills [29]. Such a refocusing of classroom instruction on productive skills (listening and speaking) is feasible. With the help of an interactive learning system, students can learn on their own to acquire receptive skills (reading and writing). Spending less time on receptive skills in the classroom will not adversely affect students' acquisition of these skills. Moreover, the instructor can afford to constantly monitor students' online learning processes via the tracking functions of the online learning software.

The most often cited theoretical basis for Computer Mediated Communication (CMC) based foreign language learning is constructivism, which originated from research in psychology by Piaget, Bruner and Vygotsky. Constructivist learning is based on students' active participation in problem-solving and critical thinking during a learning activity that they find relevant and engaging [8]. Vygotsky divided human knowledge into three levels: *recognition*, *understanding* and *mastery* [30]. The teacher's job is to assist students in reaching the higher levels of knowledge. In terms of language education, students need more exposure to the targeted materials, and more practice to be able to understand and enhance their knowledge before they can achieve the level of mastery [4]. Theories and approaches related to this research are elaborated on below.

Fun, Efficiency and Association Theories (FEAT)

There are three important theories behind efficient language learning. Chuang proposed three theories behind efficient language learning, specifically: Fun, Efficiency and Association Theories (FEAT) [31][32]. This research proved that these theories are useful for language teachers to use to teach their students.

The Theory of Fun promotes the application of interest in language instruction. It is essential to let students learn English happily and naturally, that is, by having them, through the vehicle of inter-language, approximate the social communication of native speakers. As with other subjects, language learning will be more efficient when it is fun. There are three factors that can contribute to making language learning more fun: stories/jokes (whether in narrative or dramatic form), ingenuity and multimedia.

The Theory of Efficiency emphasises efficiency in language learning. In order to help students acquire target language skills efficiently, teachers should make good and creative use of the fun and association elements, as well as utilise appropriate teaching techniques and tools.

The Theory of Association is to make language learners easily remember what they have learnt. Language learning is an elaborate and complex process. There are three issues that should be taken into consideration to make language learning easier. First, the contents should not be too difficult. Second, the four language skills of listening, reading, writing and speaking have to be integrated in each learning session. Third, texts have to be associated with multimedia so that sound, animation, graphics and video can help students understand and remember the text.

Sociocultural Constructivist Approach

The theories of Dewey, Vygotsky and Leont'ev emphasise interpersonal, experiential and process-oriented learning have increasingly influenced people in the field of education [30][33][34]. Vygotsky's social constructive theory, with the view that learning is both socially-based and integrated, has three assumptions. First, learning is a social activity. Second, learning is integrated. And third, learning requires active student engagement in class. Vygotsky believed that interpersonal behaviours are the basis for new conceptual understandings in cognition and communication. Also, he believed that oral and written learning are strongly related. For Vygotsky, students who engage in classroom activities are motivated for literacy learning, and they will have the best chance off achieving such a full degree of communicative competence as to discuss and learn language and literacy skills [30].

In other words, sociocultural constructivism emphasises engaging learners in problem solving, and situational and cooperative learning. The advent of multimedia computer and Web-based technologies have made this shift more attractive although not unproblematic in implementation [35-37].

Behaviourist Approach

Actually, much of today's pedagogies and traditional computer-based learning materials have been greatly influenced by the behaviourist approach derived from Ausubel and based on Gagne's five categories of learning: attitudes, intellectual skills, cognitive strategies, motor skills and verbal information [38][39]. This behaviourist approach regards *learning as predominantly concerned with information processing* [40].

Complementary Approaches

While educators have quite different approaches to teaching students, do behaviourist approaches and Web-based constructivism contradict each other? Borrowing a statement from Felix, a clearer view can be obtained whereby they complement each other [4][40]. Felix stated:

> *On the one hand, we have the ability to expose learners to reasonably sophisticated automated activities that will engage them in autonomous, predominantly cognitive and metacognitive processes, informed by theory drawing on the work of Gagne. On the other, we are in a position to exploit the unique opportunities of networked systems to engage students in authentic constructivist learning, in which students interact and collaborate in process-oriented real-life activities, informed by theorists such as Vygotsky and Dewey. Although quite different, the two schools of thought complement each other well in an online environment, especially if we take some care to*

humanize and personalize the former as much as possible within current technological limitations [40].

NETPAW EFFORTS

The Importance of NETPAW in Taiwan

English has been playing an increasingly significant role in international trade, tourism and telecommunications in Taiwan. Enhancing English proficiency has been gathering more and more momentum. As in many other countries, English is used as the most important foreign language in Taiwan. Increasing numbers of both business people and students are trying their best to gain a good command of English. This is paralleled by the efforts of the Taiwanese Government to expand and strengthen opportunities and resources for English learning, including support for purchasing computers, building the Internet infrastructure and developing multimedia English courseware on the Web.

A baseline for proficiency improvement can be established by national testing. The Taiwanese Ministry of Education understands the importance of online testing. Therefore, they initiated the National English Test in Proficiency for All on the Web (NETPAW) in Taiwan based on the E-era Manpower Development Project, one of 10 projects under Challenge Year 2008 – Important Projects for National Development. The Ministry provided a grant to the Republic of China Multimedia English Language Instruction Association (ROCMELIA) to design online English proficiency tests with the project of NETPAW.

The integration of testing with online computing makes the integration of testing and instruction both easier and more efficient. ROCMELIA, the multimedia English learning and instruction association in Taiwan, offered five national English listening and reading proficiency tests on the World Wide Web before NETPAW, and started to offer the first NETPAW on 6 November 2004. There have been three first-stage and three second-stage tests held so far. The first-stage test consists of listening and reading tests, while the second-stage test includes speaking and writing tests.

The Ministry of Education also supports the potential and current efforts for computer-assisted English testing. In March 2002, the Ministry of Education drafted a call for proposals in which any institute in Taiwan could submit a proposal to build the national English proficiency test on the Web for Taiwan. ROCMELIA obtained a grant. This means that ROCMELIA has to shoulder the responsibility to offer more professional English proficiency tests to people in Taiwan. Their plan is to offer tests in all the four language skills of listening, reading, speaking and writing. For the NETPAW test, there are already five levels of proficiency tests created, namely:

- Beginner;
- Basic;
- Low-intermediate;
- Intermediate;
- High-intermediate.

The advanced and professional levels will be added to the NETPAW test in the near future.

Language instruction consists mainly of the following three components:

- Teaching materials;
- Teaching methods;
- Language acquisition evaluation.

The first two are closely related to language acquisition. Language acquisition evaluation is indispensable for measuring language acquisition. The WWW provides an excellent platform for language acquisition evaluation. It is special in that it can provide multimedia and hypermedia, allowing teachers and students to instruct and learn the target language in a non-linear and creative manner. It helps promote instruction because of its immediate, international and integrative features. Moreover, there is no paper needed for online testing, which contributes to the protection of the environment.

As Web tests enjoy so many advantages, ROCMELIA decided to offer NETPAW in June 2000 for the first time. It has held five national tests. Based on the experiences gained from these five national English proficiency tests, the authors elaborate on NETPAW's purposes below, and illustrate initial statistical analyses in areas such as testing specialties, expected results, testing procedures, testing areas, different abilities, levelling guidelines and the analysis of proficiency tests.

The Purposes of NETPAW

The Government of Taiwan is directing its support to the Policy of Manpower Development and the Policy of Continuing Education for All People. NETPAW is one of the key projects for this workforce development movement.

There are several purposes in offering NETPAW as follows:

- Promoting online English learning for all people;
- Making education and life interesting, informational and international with multimedia;
- Protecting trees from being cut down with the use of paperless tests;
- Saving time due to immediate feedback on students' test results generated by the computer;
- Improving all people's English abilities;
- Enhancing Taiwan's competitiveness in the world.

Testing Specialties

NETPAW is of great importance for Taiwan's future. It will be easier to understand this matter from the following points of view concerning NETPAW:

- NETPAW was designed based on three educational principles, namely: step by step, proactive participation and student-centred;
- NETPAW was created with the three FEAT learning theories in mind, that is fun, efficiency and association theories;
- NETPAW is environmentally friendly since it is digital, can be reused and does not utilise paper;
- NETPAW is a fair test since it was initiated and funded by the Ministry of Education and created by great scholars from Taiwan and abroad. It is also impossible for those being tested to cheat in the test because of the random mechanism in distributing the test questions;
- NETPAW saves a lot of money because it uses existing computers and infrastructure, integrates existing resources

and labour, and is run by a non-profit academic organisation;

- NETPAW is outstanding because it also provides faster access to knowledge through the Internet, hence the quality is better with computing assistance and management, and it shrinks the city-country differences regarding access to information.

Expected Results

The following results are expected:

- NETPAW can be used to increase the application of a computer multimedia network;
- NETPAW can be utilised to provide good and effective English learning materials;
- NETPAW can be used to examine the effectiveness of English instruction and enhance English instruction;
- All people can test their own English abilities on the Web and apply it by interacting with their family members;
- All people can attend the All People English College on the Web to enjoy learning English, and can ask questions of scholars from around the world;
- All people can improve their English abilities interestingly and effectively.

Testing Procedures

Testing and Learning Centres and Seats

There will be at least one English test and learning centre for each county or city. The final goal will be that each school has their own English test and learning centre. Therefore, students do not need to go outside of their schools to take the NETPAW test [41].

Two weeks before a test, the testing centres and seats are broadcast on ROCMELIA's Web site [42].

Scoring

Computer programs are used to score the listening and reading tests, and the scoring for speaking and writing tests is assisted by computers. The use of computer scoring for speaking and writing tests is planned for the near future.

Test Scores and Certificates

The grade scale is 100. The passing score is 70 for the first stage and 75 for the second stage. All people who take the test receive their scores. A certificate is given to those who pass all four language ability tests.

Testing Areas

Listening Comprehension Test

The contents for the beginner, basic and low-intermediate levels are mainly related to daily life. The intermediate and high-intermediate levels include more abstract content. The difficulty increases as the testing level goes up.

Figure 1 shows a listening test question at the beginner level. The student will hear: *talking about a picture*.

Figure 2 presents a listening test question at the basic level where the student hears three options: *(A) I can see two zebras*; *(B) I can see two horses*; and *(C) I can see two elephants*.

Figure 3 shows a listening test question at the low-intermediate level. The student hears: *Look at the two pictures on the left. How much is a clock? (A) It's $75; (B) It's $20; (C) It's $200.*

Figure 1: A listening test question at the beginner level.

Figure 2: A listening test question at the basic level.

Figure 3: A listening test question at the low-intermediate level.

Figure 4 shows a listening test question at the intermediate level where the student hears: *Look at the picture on the left. Which statement is true? (A) The second is larger than the first. (B) The third is larger than the first. (C) The first is larger than the second. (D) The second is larger than the third.*

Figure 4: A listening test question at the intermediate level.

Figure 5 presents a listening test question at the high-intermediate level. The student hears: *Mike:* Why do you think God allows evil to exist on Earth? *Alice:* Well, many people have asked that question, and they have different opinions. *Mike:* Yes, but what do you think? *Question: What are Mike and Alice discussing?*

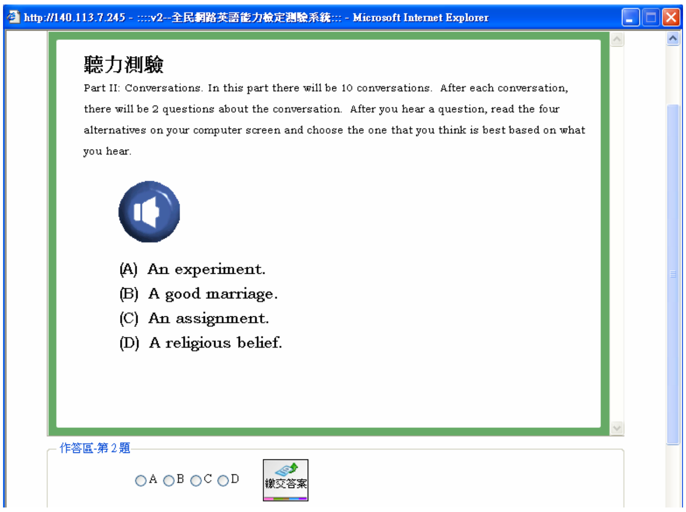

Figure 5: A listening test question at the high-intermediate level.

Reading Comprehension Test

Like the listening comprehension tests, the contents of the reading comprehension test at the beginner, basic and low-intermediate levels are mainly related to daily life. The intermediate and high-intermediate levels include more abstract content. The difficulty increases as the testing level goes up.

Speaking and Writing Tests

A person taking these tests can take them after they have passed both the listening and reading tests. They have to pass both the speaking and writing tests so that they can obtain a certificate to show their English proficiency at this level. Figure 6 presents a speaking test question at the high-intermediate level, while Figure 7 shows a writing test question at the high-intermediate level.

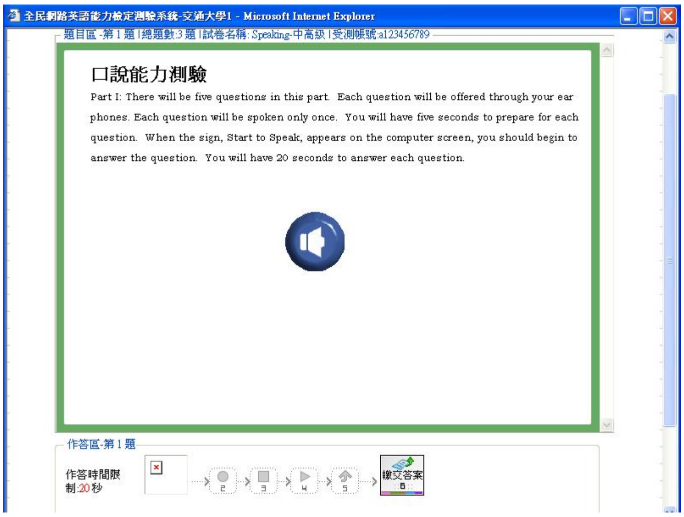

Figure 6: A speaking test question at the high-intermediate level.

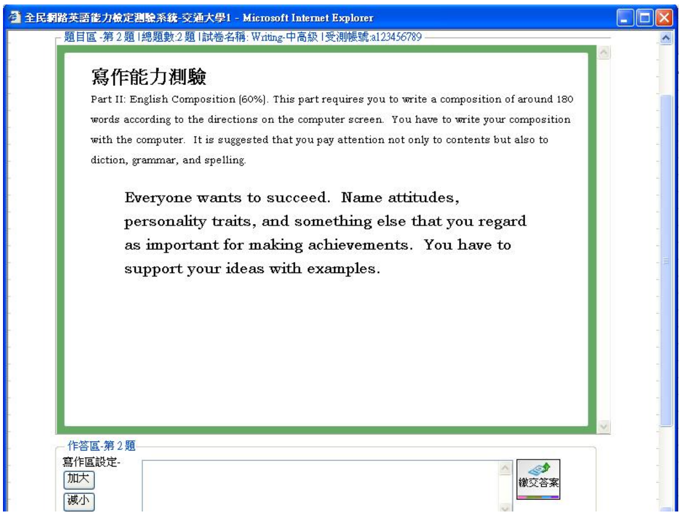

Figure 7: A writing test question at the high-intermediate level.

Test Questions

The NETPAW tests are criterion-referenced. The writers of the NETPAW test question use predetermined criteria to achieve this. A person taking one of the NETPAW tests knows what the standards are for passing by reading the NETPAW Manual or online descriptions. The student competes against nobody else but himself/herself. Therefore, it should be interesting and important to state what criteria are being utilised for the NETPAW test questions.

As mentioned previously, there are five proficiency levels for the first NETPAW tests: beginner, basic, low-intermediate, intermediate and high-intermediate. Each proficiency level uses a graded wordlist. The beginner level uses the ROCMELIA 500 wordlist, the basic level uses the Ministry of Education's 1,000 wordlist, the low-intermediate level uses the ROCMELIA's 2,500 wordlist, the intermediate level uses the ROCMELIA 5,000 wordlist and the high-intermediate level uses the CEEC 6,480 wordlist.

Apart from the wordlists, other criteria are also utilised to grade the NETPAW tests such as grammar, information loading and concept abstractness. For example, questions related to propositions can be divided into different groups based on difficulty. The preposition in 1a is easier than that in 1b – not only because it is used more often, but also because its concept is more concrete. The two are as follows:

- 1a. He lives in this house.
- 1b. Taiwan is known for its electronic products.

Dialogue 2a is more difficult than Dialogue 2b since it uses complex words and its information loading is heavier as follows:

- 2a. (Listen):
  Tom: Where do you come from?
  Mary: I come from Taiwan.
  (Read):
  Question: Where does the girl come from?
  (A) Taiwan.
  (B) Japan.
  (C) Korea.
- 2b. (Listen):
  Tom: Good morning, Mary.
  Mary: Good morning, Tom.
  Could you help me with this math question?
  Tom: It's my pleasure. We are classmates.
  (Read):
  Question: What did they talk about?
  (A) Tom was a teacher.
  (B) Mary was a teacher.
  (C) Mary asked for help.

The NETPAW-CEF Reciprocal Table

The Common European Framework (CEF) has been adopted by the Ministry of Education in Taiwan and international test institutes such as the ETS and Cambridge [43]. The Ministry of Education stipulated that each testing institute should have their reciprocal table as presented in Table 1 that has been published on the Internet. The NETPAW-CEF table has already been published on the ROCMELIA Web site [44]. It indicates that the NETPAW basic, low-intermediate, intermediate and high-intermediate levels are equivalent to the A1, A2, B1 and B2 levels of the CEF, respectively.

Table 1: The NETPAW-CEF table.

Users	CEF	The CEF Can-Do List	NETPAW
Proficient User	C2 Mastery	Can understand with ease virtually everything heard or read. Can summarise information from different spoken and written sources, and reconstruct arguments and accounts in a coherent presentation. Can express himself/ herself spontaneously very fluently and precisely and differentiate finer shades of meaning even in more complex situations	N/A
	C1 Effective Operational Proficiency	Can understand a wide range of demanding and longer texts, and recognise implicit meanings. Can express himself/herself fluently and spontaneously without much obvious searching for expressions. Can use language flexibly and effectively for social, academic and professional purposes. Can produce clear, well-structured and detailed text on complex subjects, showing a controlled use of organisational patterns, connectors and cohesive devices	N/A
Independent User	B2 Vantage	Can understand the main ideas of complex text in both concrete and abstract topics, including technical discussions in his/her field of specialisation. Can interact with a degree of fluency and spontaneity that makes regular interaction with native speaker quite possible without a strain for either party. Can produce clear, detailed text on a wide range of subjects and explain a viewpoint on a topical issue giving the advantages and disadvantages of various points	High-intermediate
	B1 Threshold	Can understand the main points of clear standard input on familiar matters regularly encountered in work, school, leisure, etc. Can deal with most situations likely to arise while travelling in an area where the language is spoken. Can produce and simple connected text on topics that are familiar or of personal interest. Can describe experiences and events, dreams, hopes and ambitions, and briefly give reasons and explanations for opinions and plans	Intermediate
Basic User	A2 Waystage	Can understand sentences and frequently-used expressions related to areas of most immediate relevance (eg very basic personal and family information, shopping, local geography, employment, etc). Can communicate in simple and routine tasks requiring a simple and direct exchange of information on familiar and routine matters. Can describe in simple terms the aspects of his/her background, immediate environment and matters in areas of immediate need	Low-intermediate
	A1 Breakthrough	Can understand and use familiar everyday expressions and very basic phrases aimed at the satisfaction of needs of a concrete type. Can introduce himself/herself and others, and can ask and answer questions about personal details such as where he/she lives, people he/she knows and things he/she has. Can interact in a simple way provided the other person talks slowly and clearly, and is prepared to help	Basic

Research Purposes and Questions

The purposes of this study involved constructing an online interactive learning system, investigating how Web-based interactive learning systems affect eighth graders' learning achievements, as well as attitudes, and providing suggestions for eighth grade English teachers. Two research questions were raised based on the following research purposes:

- Do online interactive learning systems enhance eighth grade students' listening proficiency?
- Do online interactive learning systems enhance eighth grade students' reading proficiency?

The following two null hypotheses were proposed based on the above research questions:

- Online interactive learning systems have no statistically significant effect on junior high school students' listening ability;
- Online interactive learning systems have no statistically significant effect on junior high school students' reading ability.

Research Design and Procedure

The study utilised a quasi-experimental research design. The participants were 217 eighth grade students (comprising six classes) in a senior high school of Yunlin County in Taiwan. The researcher selected two high academic proficiency classes, two middle academic proficiency classes, and two low academic proficiency classes from the whole eighth grade level of students. The researchers divided these six classes into experimental and control groups.

The whole research procedure took about three months. The treatment was via online interactive learning systems. The online interactive learning systems used in this study referred to Web sites offered by the instructors that students could access on their own – whether in class or at home. Thus, the Web sites could be visited in the multimedia laboratory of Mia-liao Senior High School.

The experimental group received instruction that combined both traditional instruction and that via online interactive learning systems. The control group received traditional English instruction only. The instruction period of each class for both groups was the same. All participants were given a pre-test before the treatment and a post-test after treatment.

The tests had already been piloted, and the reliability of the test was 0.931 for the basic listening test and 0.783 for the basic reading test. The two teachers (one for the experimental group and the other for the control group) who participated in the study had two to three years of teaching experience and were professionally similar. Tables 2 and 3 represent the research design.

Table 2: The distribution of proficiencies between the experimental and control groups.

Level	Experimental Group	Control Group
High level (two classes)	H1	H2
Middle level (two classes)	M1	M2
Low level (two classes)	L1	L2

Table 3: The research design model.

Group	Pre-Test	Treatment	Post-Test
Experiment	Y1	P	Y2
Control	Y3	T	Y4

Notes: Y1 and Y3 indicate pre-tests; Y2 and Y4 indicate post-tests; P refers to the experimental treatment (adopting the interactive system instruction); and T refers the control treatment (traditional instruction only).

Figure 8 presents the independent and dependent variables, as well as the control variables.

Students' Basic Abilities

Students' basic abilities included one and a half years of English at the basic level, and one and a half years studying computer-operating skills.

Independent Variables

Teaching Strategy

1. Experiment group: (interactive system + traditional instruction)
2. Control group: (traditional instruction)

Dependent Variables

Learning effectiveness

Learning achievement:

Post-test (English learning achievement test)

Control Variables

Students' Basic Ability	Teachers' Professional Ability	Teaching Materials
3. First grade basic ability 4. Computer skills	1. Teaching experience 2. Professional ability 3. Computer skills 4. Teaching service (2-3 years)	1. Textbook 2. Materials set by teacher 3. Web resources

Figure 8: The list of variables.

Teachers' Professional Abilities

The two English teachers had a teaching certificate. They both had majored in English at the university level and had at least two to three years of teaching experience.

Teaching Materials

Besides the normal English teaching materials, the two English teachers also adapted useful materials from the Web from the ROCMELIA NETPAW site and Live ABC site [42][45].

RESULTS

Two between-subject one-way univariate analyses of covariance (ANCOVA) at the 0.05 significance level were administered in order to evaluate the effects of the treatment on the students' reading and listening achievements. In the analyses, the students' scores in the post-tests (listening and reading tests) were the dependent variables for the two ANCOVA tests.

In both ANOCOVA tests, students' scores on the pre-tests were used as the covariate to reduce the error variance and biased estimations caused by different possible subjects' English proficiency levels between the control and treatment groups, which could not be reduced using the experimental controls.

Listening Test

Table 4 lists the means and standard deviations of subjects' pre-test and post-test scores while Table 5 shows the estimates of the marginal means with regard to the listening test.

As in most educational research, this had a quasi-experimental design. Although the ANCOVA test was robust as to the assumption violation, it was important to test the three important assumptions for the ANOCOVA due to the unequal sample size of the control group and experimental group in this study. The Q-Q plot, Levene's Test of Equality of Error Variances, and the GLM procedure were performed to test the normal distribution, homogeneity of variance and the homogeneity of covariate regression coefficients assumptions, respectively. From the test results, one can conclude that all three assumptions were tenable (Figure 9, and Tables 6 and 7). The data was ready for the ANCOVA procedure.

The results of the ANCOVA showed that there were statistically significant differences in the students' performance in the listening post-tests between the control and experimental groups after adjusting for the covariate with F (1, 145) = 5.011, $p < 0.05$ with the observed power of 0.600 and the 0.033 partial eta squared (Table 8). With the estimated marginal means of 80.24 and 75.27, respectively (Table 5), it can be concluded that subjects in the experimental groups performed significantly better on the listening post-test than those in the control group.

Table 4: Means and standard deviations of the subjects' pre-test and post-test scores.

Group	n	Pre-Test		Post-Test	
		M	M	SD	SD
Control	81	73.65	72.56	25.14	24.55
Experiment	67	79.55	83.51	16.48	17.69

Table 5: Estimates of the marginal means.

Group	n	Post-Test	
		M	*SE*
Control	81	75.27	1.48
Experimental	67	80.24	1.63

Note: covariates appearing in this model were evaluated at the value of pre-test = 76.4358.

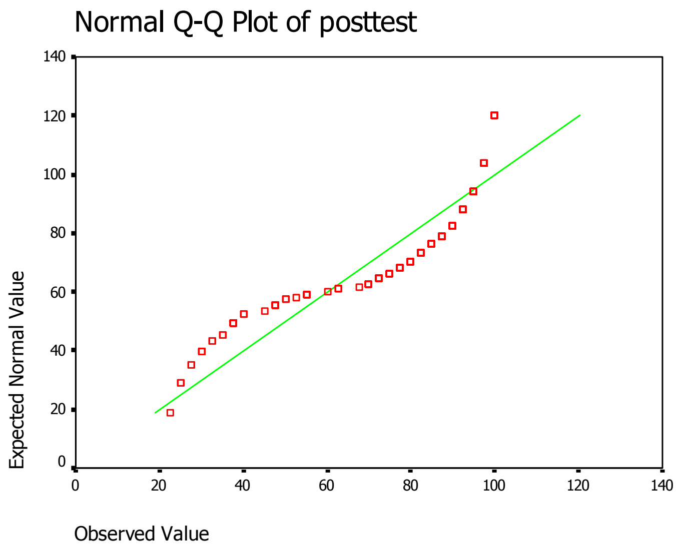

Figure 9: Test of normal distribution assumptions.

Table 6: Test of the homogeneity of variance assumptions using Levene's Test of Equality of Error Variances where the dependent variable is the post-test.

F	df1	df2	Sig.
1.040	1	146	0.310

Table 7: Test of the homogeneity of covariate regression coefficients showing the tests of between-subjects effects where the dependent variable is the post-test.

Source of Variation	SS	df	MS	F
Group	628.657	1	628.657	3.601
Pre-test	27,275.450	1	27,275.450	156.237*
Group*Pre-test	354.411	1	354.411	2.030
Within cell	25,139.176	144	174.578	
Total	72,893.708	148		

*$p < 0.05$

Reading Test

Table 9 shows the means and standard deviations of the subjects' post-tests, while Table 10 lists the estimates of the marginal means. For the reading test, the results of the Q-Q plot, Levene's Test of Equality of Error Variances and the GLM procedure showed no violation of the normal distribution, homogeneity of variance or homogeneity of covariate regression coefficients assumptions.

From the test results, it can be concluded that all three assumptions were tenable (Figure 10, and Tables 11 and 12). The results of the ANCOVA showed that there were no statistically significant differences in students' reading performance for the different treatment groups after the adjustment of the covariate with F (1, 165) = 3.172, $p < 0.05$ (Table 13).

Table 8: ANCOVA results.

Source	SS	df	MS	F	Partial Eta Squared	Observed Power
Between groups, A_{adj}	880.959	1	880.959	5.011*	0.033	0.600
Within groups, S_{adj}	25,493.586	145	1,753,818			
Total $_{adj}$	26,374.545	146				

*p<0.05

Table 9: Means and standard deviations of the subjects' post-test scores.

Group	n	Pre-Test		Post-Test	
		M	M	SD	SD
Control	81	67.59	68.36	22.20	20.13
Experimental	87	66.22	69.17	23.98	21.69

Table 10: Estimates of the marginal means.

Group	N	Post-Test	
		M	SE
Control	81	67.30	1.16
Experimental	87	70.16	1.12

Note: covariates appearing in this model were evaluated at the value of pre-test = 67.2173.

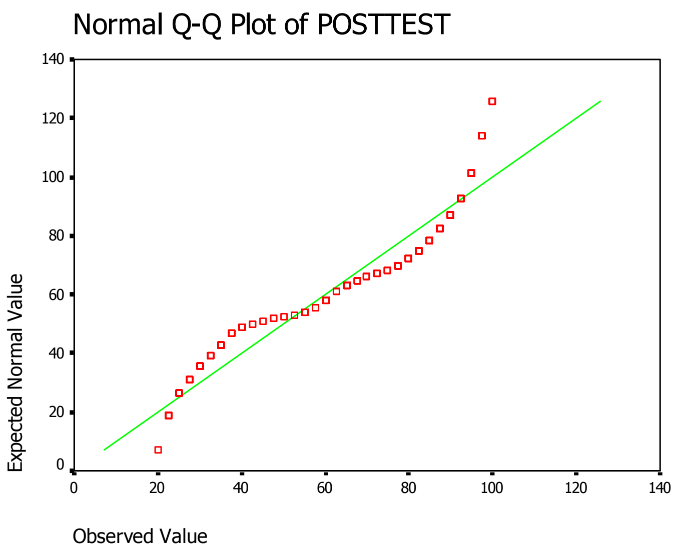

Figure 10: Test of normal distribution assumptions.

Table 11: Test of homogeneity of variance assumptions using Levene's Test of Equality of Error Variances where the dependent variable is the post-test.

F	df1	df2	Sig.
2.285	1	166	0.133

Table 12: Test of the homogeneity of covariate regression coefficients for the tests of between-subjects effects where the dependent variable is the post-test.

Source of Variation	SS	df	MS	F
Group	43.520	1	43.520	0.404
Pre-test	69,478.605	1	69,478.605	645.140*
Group*Pre-test	159.574	1	159.574	1.482
Within Cell	17,662.048	164	107.695	
Total	883,625.000	167		

*p< 0.05

DISCUSSION

This study used a quasi-experimental design to investigate the facilitating effects of online interactive learning systems on students' performance in English listening and reading while using the subjects' English proficiency levels as covariates. Two ANCOVA tests were performed to test the research hypotheses. The ANCOVA test failed to reject the null hypothesis in the reading tests – it seems that the treatment could not elicit subjects' performance differences in their reading comprehension. The ANCOVA results showed that those students who received the treatment performed better than those who did not receive the treatment in terms of their performance in listening, with a 0.033 partial eta squared – the different teaching methods after the adjustment of the subjects' English proficiency level accounted for about 3.3% variance in their performance in the listening comprehension test with 0.60 power. However, from the ANCOVA listening tests, it can be seen that the observed power for the test on the subjects' performance was only 0.60, which did not reach the expected observed power.

As in other research, this study provided evidence that Web-based interactive learning systems can effectively enhance students' English listening skills even though the low observed power reduced the generalisability of the study. On the other hand, different from many other studies, this research failed to offer evidence that Web-based interactive learning systems can enhance students' English reading abilities. From this study's results, it seems that the treatment could help students' with their English listening but could not bring about different

Table 13: ANCOVA results.

Source	SS	df	MS	F	Partial Eta Squared	Observed Power
Between groups, A_{adj}	342.644	1	342.644	3.172*	0.019	0.42
Within groups, S_{adj}	17821.621	165	108.010			
Total $_{adj}$	26374.545	166				

*p<0.05

students' reading achievements compared to traditional teaching methods.

After estimating the value of the interactive learning system, the online courses should also be evaluated and it is important to look at how the language course is being taught. As an online course designer, one must consider e-course objectives, as well as the e-content, e-policies and e-procedures. First, in e-programmes, there is a need to assess the requirements of learners and consider the necessary conditions needed to satisfy them. The course designer needs to consider a few questions: does the curriculum meet learners' needs? Can it help promote language learning efficiency? Secondly, materials should be interesting, authentic and offer content relevant to all participants. Without immediate access to a teacher's books or student workbooks, it is important that students can download materials for practice. Thirdly, the e-teacher should consider the teaching procedures and how to present the teaching content. Fourthly, it needs to be ensured that e-assessment can exactly estimate learning efficiency. Finally, the practitioner needs to maintain and update the information of the interactive system [19].

Besides the considerations above, teachers must take into consideration many different factors including issues such as learners' motivations, cultural backgrounds, language backgrounds and different methodologies that can or cannot be used in education supported by electronic means.

CONCLUSION

This research focused on the English learning effectiveness of an online English learning system for eighth grade students. It was found that the online English system of NETPAW was effective for improving students' English ability. There are several suggestions for further researches. First, a more precise design with the Common European Framework should be undertaken for further research. Second, speaking and writing skills can be also included in future research.

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11th Baltic Region Seminar on Engineering Education: **Seminar Proceedings**

edited by Zenon J. Pudlowski

The yearly *11th Baltic Region Seminar on Engineering Education* was organised by the UNESCO International Centre for Engineering Education (UICEE) and held Tallinn, Estonia, between 18 and 20 June 2007. The Seminar attracted participants from 10 countries worldwide. Almost 40 papers have been published in this Volume of Proceedings, which grossly document and present academic contributions to the Seminar. All of these published papers present a diverse scope of important issues that currently affect on engineering and technology education locally, regionally and internationally.

The principal objective of this Seminar was to bring together educators from the Baltic Region to continue dialogue about common problems in engineering and technology education under the umbrella of the UICEE. To consider and debate the impact of globalisation on engineering and technology education within the context of the recent economic changes in the Baltic Region, as well as in relation to the strong revival of the sea economy. Moreover, the other important objectives were to discuss the need for innovation and entrepreneurship in engineering and technology education, and to establish new links and foster existing contacts, collaboration and friendships already established in the region through the leadership of the UICEE.

The papers incorporated in these Proceedings reflect on the international debate regarding the processes and structure of current engineering education. They are grouped under the following broad topics:

- Opening address
- Education and training for engineering entrepreneurship
- Innovation and alternatives in engineering education
- New developments and technologies in engineering education
- Quality issues and improvements in engineering education
- New trends and approaches to engineering education
- Simulation, multimedia and the Internet in engineering education

It should be noted that all of the papers published in this volume have undergone an international formal peer review process, as is the case with all UICEE publications. As such, it is envisaged that these Proceedings will contribute to the international debate in engineering education and become a valuable source of information and reference on research and development in engineering education.

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