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Papers published in the Conference Proceedings of the 3rd WIETE Annual Conference on Engineering and Technology Education have undergone a formal and rigorous process of peer review by international referees.

3rd WIETE Annual Conference on Engineering and Technology Education

Conference Proceedings

Contents

Preface

These Conference Proceedings published by the World Institute for Engineering and Technology Education (WIETE), include paper contributions accepted for the *3rd WIETE Annual Conference on Engineering and Technology Education*, to be held at Seri Place Hotel in Pattaya, Thailand, between 6 and 10 February 2012, under the overarching theme *Networking in Engineering and Technology Education*.

These Proceedings include 16 fully peer-reviewed papers that have come from authors based in ten countries, worldwide. Readers will find them to be highly informative, interesting and meaningful attempts to address a wide range of contemporary issues. The papers cover a range of topics, problems and challenges faced by academics involved in engineering and technology education in an era of rapid technological change and global financial problems. It is pleasing to note that strong concern has been expressed regarding the impact of the current situation on the quality of education of future graduates with ever diminishing public support for education. Therefore, it is anticipated that the senior members of academia attending this WIETE Annual Conference will discuss the ways in which the WIETE, through its considerable global network, may be able to use its meetings to air the concerns and offer potential solutions to current problems.

One tremendous challenge that all members of the WIETE network face is to stimulate action by more WIETE members to take an active role in our endeavour to create a strong lobby group. In this way, we will be able to assume effective global leadership for the advancement of engineering and technology education. Hence, we must try to unlock the huge intellectual potential accumulated within our senior members to meet the challenge. Our prevailing motto is: *Serving the International Engineering and Technology Community*, and all WIETE members must identify themselves with this motto by contributing to the further advancement of engineering and technology education.

It is hoped that deliberations at the Conference, whether formal ones based on the presented papers, or those less formal, will create a new momentum in the advancement of our cause. I strongly believe that the papers included in these Proceedings will stimulate an atmosphere conducive to achieving this aim.

Therefore, I would like to take this opportunity to express our sincere gratitude to the authors of the papers included in these Proceedings for their eagerness to share their research accomplishments with other likeminded colleagues, and to the independent international referees, who have committed their precious time to reviewing these papers. Moreover, I would like to thank Dr Ian R. Dobson and Dr Dianne Q. Nguyen for their considerable contribution to the process of preparing these Proceedings for publication.

Zenon J. Pudlowski

Innovations in engineering and technology and the need for innovative curriculum and syllabi revision

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Opening Address

ABSTRACT: Engineering and technology education has always been a challenge for policy makers and institution builders. There are gaps between what is needed and what is taught. Complaints about student quality pour in constantly from industry and the gap is expanding continuously due to new inventions and innovations. In fact, there is a group working to bridge the gap. Science and technology advancement is galloping at a faster speed than the curriculum and syllabus revision. Obsolescence is increasing in every field at every level. This has an impact on stakeholders such as the policy makers, institution builders and the teachers who facilitate higher education, particularly technical education. This paper elaborates on aspects of this problem and on the expected role of these stakeholders about their present role and expected role in technical education in order to bridge this gap.

INTRODUCTION

Policy makers in higher education, and in particular technical education, are normally highly qualified persons, but with out-dated knowledge on current affairs in higher education and on the specifics of technical education. Policy makers are usually people who are outside the academic environment. The academic environment can be defined as the place that teachers, students and researchers conglomerate. These three groups mingle with each other and their interactions will be mainly on academic matters such as course contents, innovations and inventions [1][2].

These interactions will be effective only if there is research and development on the campus. The more research and development there is, the more will be the interactions and knowledge transfer amongst the members of the group. To sum up, one can say that the quality of students, researchers and academic teachers will improve. In such an atmosphere, the policy makers have no role and, hence, the policies framed by such groups are mostly far from reality [3-5].

Policy makers can guide institutions in order to achieve greater funding and improved infrastructure. They can also guide the institution so it has good land and buildings. However, they cannot identify the right kind of leaders to lead the institution in academic matters. To define the right kind of leaders, one can list several attributes a good leader should have. He or she:

- should be a good manager;
- should be a good administrator;
- should be highly educated;
- should be highly interactive with all stakeholders of the institution;
- should have the leadership quality to lead the academics cohesively and have interactions with international universities and R&D institutions for forging ties in order to promote research within the campus;
- should be a person to build an image of the institution across the city, state, the country and the globe;
- should be a representative of the institution;
- should promote interactions between the academic teachers, students and researchers apart from the stakeholders who have a say in the development of the institution.

Research means original research to find the unknown and discover the hidden, and devise new techniques and technologies apart from publishing research papers in reputed refereed international journals. He or she should:

- shoulder responsibility for initiating conferences within the institution;

- look into the welfare of the staff and students of the institution;
- integrate students from variety of backgrounds through cultural arrangements;
- promote discipline and character;
- move the university faster on a progressive path;
- ensure that the students receive the most up-to-date education on the campus.

Apart from all the above, he or she should be IT savvy.

The policy makers must be able to identify such a person as the head of the institution to achieve state of the art education for the students. The policy makers must have trust in the academic head, while academic and administrative matters are being reformed. The administrative head of a higher technical institution needs to understand the dynamics of a floating educational system. He or she must accept responsibility to provide the necessary infrastructure for the courses being offered by the institution and ensure that there is good academic backup for academic staff, students and researchers.

Such heads of institutions have particular problems in maintaining adequate infrastructure to cope with international standards and to be in tune with the market and industry standards. Technology is changing fast with inventions and innovations in both science and engineering and, hence, the expectations of the market, industry and other stakeholders also vary correspondingly.

The introduction of the Internet into the system provides information on the developments in science, engineering and technology on a minute-by-minute basis. Hence, academic heads are perplexed because they have to deal with new technologies, and administer the whole educational system with ageing academics who may not have been adequately exposed to computers and the Internet. These older academics might not be sufficiently exposed to current developments in the field. It might look as if this is a transition.

Unfortunately, all of us have entered an era where the technology and developments will continue to change and perhaps the rate of change will increase every year. Perhaps this rate of change will also change every month in the coming times since innumerable inventions are on the way and, hence, the teaching-learning process keeps redefining them. Accepting that change is a constant, it is essential that heads of institutions devise mechanisms to update the syllabi and restructure the curriculum in tune with international best practice and in tune with best academic institutions in the world.

There is a rule of thumb that academic institutions offer only 20% of what an ideal engineer needs to become 100% engineer. The remaining 80% is being absorbed by the individual while in training, and from society. In the present scenario, both the 20% and the 80% are changing rapidly and, hence, it is difficult to define and keep the same curriculum for many years. In the present scenario, if a student is admitted to a professional course, he or she has to undertake the course with the same curriculum and syllabus for four years.

By the time he or she passes through the institution, the syllabus is four years old. As all will be aware, in a period of four years, many developments can occur and, hence, invariably, the student comes out of the institution with an out-dated syllabus. This is a common phenomenon in higher education institutions around the world. This is where the gap exists between what is offered by the institution and what is expected by industry. In addition to the above, information technology is creating a further gap between the two, which one can call the digital divide.

Since the role of the invasion of the Internet is not limited to the syllabus, the gap widens even further. In the case of academic teachers who are teaching, the courses might not have been updated with the latest advancements in the field. The techniques of offering the developments have also been taken to a new dimension. Therefore, academic teachers cannot continue to use the same chalk and talk method if they have to deliver all the developments in the field.

Furthermore, time availability in the classroom has been reduced to a minimum and, so the teacher cannot use the conventional techniques to transfer the entire updated knowledge to the student. The teacher has to familiarise himself or herself with the techniques and technology to be employed in order to deliver the updated knowledge.

This is called *Class-Room Engineering***.** Through this medium, the academic teacher will have enhanced his/her teaching skill and delivered a lot more information to the student in a shorter period. One has to realise that the student is no longer the same as the ones we became accustomed to in the 1990s and 2000s. Their reception quotient has increased considerably because of multiple channel television and multi-functional cell phones. Therefore, it is essential that *Class-Room Engineering* is implemented in all classrooms and the teaching has to be converted into a facilitation process. Moreover, the teachers need to be highly futuristic in order to carry out the task.

CONCLUSION

Starting from the policy makers, heads of institutions to academic teachers, the educational process has to be highly dynamic in order to incorporate new developments into the educational process effectively and continuously, and ensure a one-hundred percent delivery of latest knowledge in the respective field to the student, as well as to ensure success to the satisfaction of all.

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National assessment of knowledge of engineering and technology topics at the end of middle school - the Slovenian experience

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Opening Address

ABSTRACT: Most educational systems include national assessment of students' knowledge at the pre-higher level of education. Although design and technology is a middle school subject in many countries, national examination of knowledge is rarely practised. In Slovenia, engineering, technology and design topics are taught within different subjects up to the 5th grade. However, from the 6th to 8th grade there is a sole compulsory subject named *Engineering and Technology*. In 2006, the Ministry of Education introduced national assessment for so called *third subject* after the 9th grade. The Engineering and Technology subject was tested in 2008 and 2010 as compulsory for about 25% of all the population aged 15 years. This paper presents the outcomes of the last examination, which was also used in parallel for trainee teachers of technology. Among the findings is that both students and trainee teachers achieved unsatisfactory scores for practical, problem-based questions requiring a high cognitive level. Among a range of content areas, mechanical engineering was the weakest.

INTRODUCTION

National assessment of students' knowledge at the pre-higher level of education is conducted in the majority of countries. Information about national objectives and organisation of assessments of knowledge gathered by INCA - International Review of Curriculum and Assessment Frameworks Internet Archive [1] shows, that there are considerable differences between 19 educational systems in 16 countries on all continents reviewed by INCA. EURYDICE reports many differences in national testing of students within EU countries [2].

More information about the assessment of knowledge in particular countries is available from national organisations such as the NAEP in the USA [3], the National Curriculum Assessment in the UK [4], and the National Assessment Programme (NAP) in Australia [5], etc. Advantages and benefits of national examination of particular subjects are discussed, for example for, mathematics [6] and physics [7].

Despite the unquestionable importance of technological literacy, national assessments of the knowledge of technology and engineering topics are not often included in national (external) testing [8][9]. Analysis of the technology education curriculum of six countries showed that technology topics are generally not tested at the national level, so national examinations in technology would be appreciated [10].

In the USA, the NAEP is the largest nationally representative body and it provides continuous assessment of what students know and can do in various subject areas. However, the first-ever NAEP Technology and Engineering Literacy Assessment (TELA) is currently under development.

The assessment is intended to measure what students know about technology and engineering. The initial assessment, planned for 2014, will be a probe - a smaller scale, focused assessment on a timely topic that explores a particular question or issue. The initial assessment is likely to be limited to particular grades [11][12].

NATIONAL ASSESSMENT OF KNOWLEDGE (NAK) IN SLOVENIA

Slovenian middle school (also known as *junior high school* or *lower secondary*) is coupled with primary school in a unique compulsory elementary school with nine (9) grades for children aged 6 to 15 years. Engineering, technology and design topics are taught by classroom teachers within science and art subjects up to the 5th grade.

However, from the 6th to 8th grade there is a sole compulsory subject named *Engineering and Technology*, similar to a subject named *Design and Technology* in some countries.

In 1991, the Slovenian Ministry of Education introduced national assessment of knowledge co-ordinated by the National Examinations Centre (NEC) [13]. Currently, at the end of the 6th grade, students apply to sit for tests of their own accord in their mother tongue, mathematics and a foreign language (English or German). Results of the assessment give additional information to schools, students and their parents on the students' achieved knowledge and have no influence on the final grade in individual subjects or the students' general achievement. At the end of the 9th grade, the national assessment of knowledge is compulsory for all students.

The knowledge of mathematics and the Slovenian language is tested each year. In addition, each year the Ministry selects four so called *third subjects* out of about 12 possible subjects. Each pupil is, therefore, tested in mathematics and the Slovenian language plus one subject out of four selected by the Minister for a particular school year. The results of the tests have no influence on the overall achievement in primary education; however, it can be considered as a criterion for the selection of candidates in cases of limited enrolment into secondary schools but only with previous agreement of students and their parents.

The basic goal of the NAK is to acquire additional information or feedback on students' knowledge and to strive for better quality in the learning and teaching processes.

NATIONAL ASSESSMENT OF KNOWLEDGE OF ENGINEERING AND TECHNOLOGY

The Engineering and Technology subject was chosen as a so called *third subject* in 2008 and 2010. The outcomes of the national examination in 2010 are presented in this paper. There were 20 written problems from the syllabus of Engineering and Technology taught in the 7th and 8th grades. Each problem was worth one (1) to three (3) points, totalling 33 points for a compete test.

The structure and contents of the problems followed various pre-defined criteria. Ten multiple-choice problems were worth 10 poi nts and 23 poi nts were devoted to various structured problems. About 30% of the points were for straightforward cognitive level questions (knowing facts, definition, etc), 55% for middle level questions (understanding and usage) and 15% for advanced cognitive level questions (problem solving in new situations).

The examination covered several topics divided into four major content areas as follows: man and creation, technological resources, materials and processes and technical documentation.

The test was prepared by a team of four members - two teachers of technology, a representative of the National Institute of Education (who also used to be a teacher) and a representative from higher education (the author of this paper). The test in the Slovenian language is available from the NEC Web site [14].

General Statistical Data

The national assessment of knowledge of Engineering and Technology involved 4,762 students from 121 schools, approximately a quarter of the total population of the 9th grade. The average score was 17.56 (53.2%). The standard deviation was rather large at 17.73%, meaning that there were significant differences in students’ achievements. The distribution of results is shown in Figure 1.

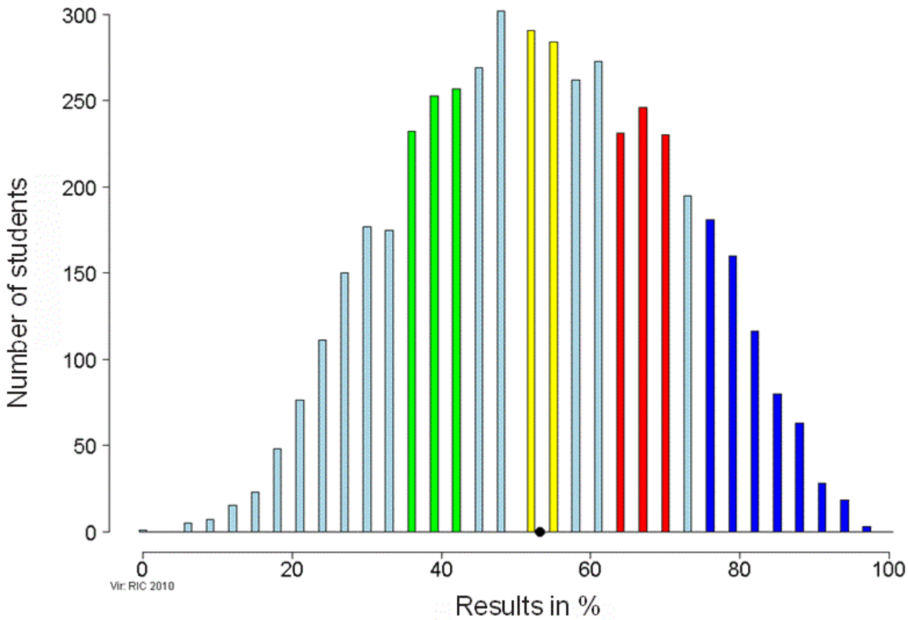


Figure 1: Histogram presenting the distribution of students regarding their score on test in percentage (source: NEC).

When comparing the results regarding gender, it was observed that more boys achieved more than 70% of the points allotted, while the average result does not significantly differ between boys and girls (Figure 2).

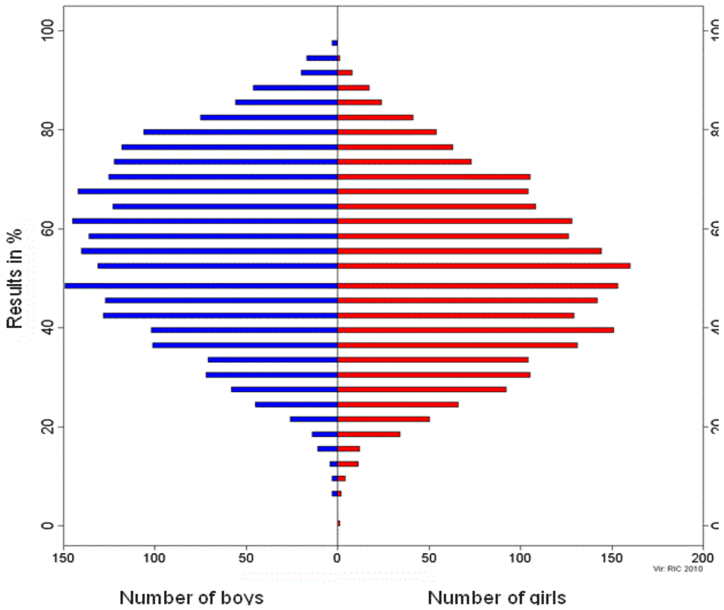


Figure 2: Histogram presenting the distribution of boys and girls regarding their score in percentage (source: NEC).

Achievements for Different Content Areas

In order to explore outcomes of the national examination more specifically, the test has been divided into six content areas, so that the 33 points were assigned to areas as shown in Table 1.

Table 1: Distribution of points between the content areas.

Content areas	Abbreviations	Points
Man and creation: technology and environment, economics, energetic.	M-CRE	4
Information and communication technology: informatics, computers and technology, CAD/CAM.	ICT	2
Design and technical documentation: sketching, orthogonal and isometric projection, graphic expression and graphic design.	DES-DOC	6
Materials and processing: properties and processing of synthetic solids (plastics) and metals, tools and machines for material processing.	MAT-PRO	11
Technological resources - mechanical engineering: mechanisms, mechanical drives, internal combustion engines.	TR-ME	5
Technological resources - electrical engineering: electrical circuits, electric devices, electric control.	TR-EE	5

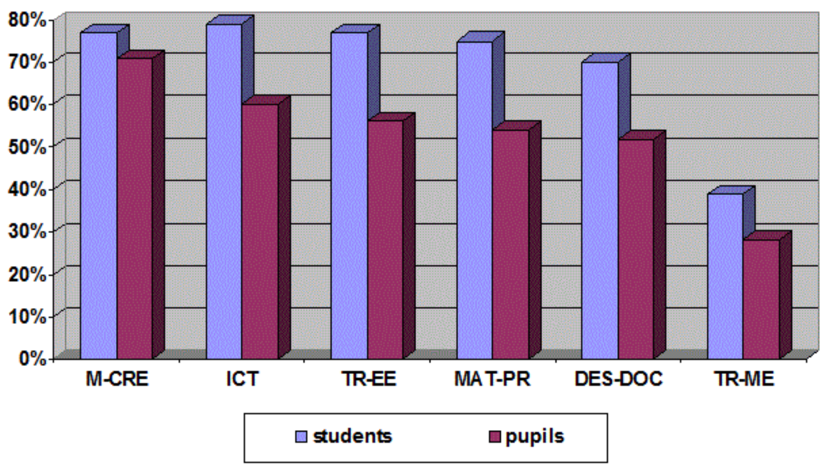


Figure 3: Results of students (trainee teachers of technology) compared to results of school students for different areas of problems (see abbreviations in Table 1).

Before the national examination was available to the public, it was also used to test technology education students - the trainee teachers of technology at the Faculty of Education, University of Ljubljana. In other words, 40 prospective teachers of technology in the 3rd and 4th year solved the same tests as the 9th grade students. Results of both groups are presented in Figure 3.

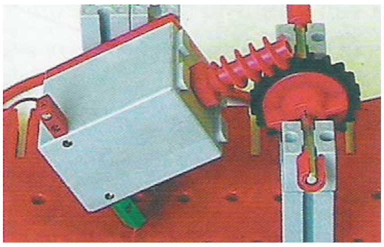
The university students performed better than the school students, but not as much as one might have expected. The next outcome was that results of both group of students were proportional - the lower the knowledge of technology education, the lower the result of the students. Unfortunately, one could not test the teachers - but one could imagine that the results would also reflect the obvious influence of teachers' knowledge on students' outcomes. Concern should be raised about the significantly lower scores for both groups in mechanical engineering.

Examples of Problems with Low Scores

To illustrate problems with unexpectedly low scores, three such examples are presented here. The problems have been translated from the national examination in 2010.

Example 1

The figure below shows a model of a worm gear.



When the screw is rotated for one turn, the cylindrical wheel is rotated by one tooth. Determine the gear ratio for the case where the cylindrical gear has 20 teeth.

Write the answer to the line: ___________________

Answer: 20:1 or 20.
Average score: 18%

Example 2

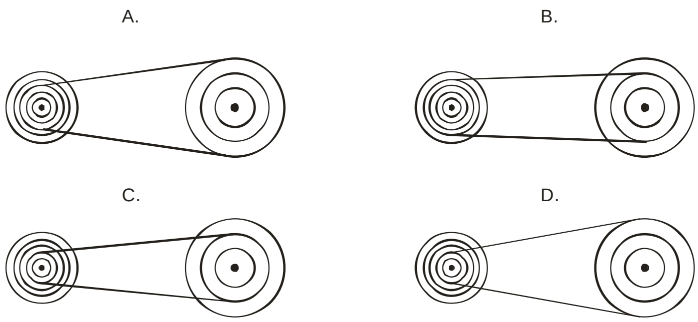
Using a DC electric motor make a model of a lift. To enable the task to be completed, the shaft of the motor must be mounted to:

A. Gear system so that we increase the number of revolutions - the multiplier.
B. Gear system so that we reduce the number of revolutions - reducer.
C. Crank mechanism.
D. Lever.

Answer: B
Average score: 24%

Example 3

Jakob is riding a bike with five gears on the rear wheel shaft and three gears at the pedals. Which combination of gears is the best for riding up hills?



Answer B.
Average score: 31%

CONCLUSIONS

School students generally achieved relatively good results for problems ranked as being low cognitive level, where questions mostly require memorising of facts and definitions. On the other hand, low scores were obtained in problem-based questions even if they required solutions to practical, sometimes even everyday situations. Evaluating the results of trainee teachers (university students) being examined with the same test as school students clearly showed a high correlation in outcomes for different content areas. Among the areas, the mechanical engineering content was the weakest for both groups.

The national assessment of knowledge of engineering and technology provided valuable information for both teachers and for teacher trainers in order to improve the efficiency of teaching and learning process for engineering and technology topics in the middle school. Presumably, there might also be some benefits for engineering at the higher education level, as well as for general technology and engineering literacy.

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Embedding innovation in a typical engineering curriculum

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ABSTRACT: The process of innovation must precede the process of entrepreneurship and must involve experts from the business and the legal community. The process must start from students' first day at the college to their successfully seeking placement in a company. The scope of introducing innovation is taken seriously in the College of Engineering and Engineering Technology (CEET) at Northern Illinois University, DeKalb, Illinois, USA, and is introduced in the first course for engineering students. There are several subsequent initiatives undertaken by the College to prepare students on how to respect their ideas and nurture them to conclude in commercialisation. The process of embedding innovation in the engineering education programmes, as well as a philosophical discussion with real examples of initiatives that have been taken by the CEET to embed innovation into the curriculum are presented in this paper. In this paper, the authors also endeavour to raise awareness for a g lobal community to understand and collaborate on facilitating innovation.

INTRODUCTION

Usually, the sequence of creating wealth starts with innovation leading to entrepreneurship. For several decades, the concept of innovation was embedded in research and design activities of a company and was not given an identity of its own. Due to the poor economy and the need to support entrepreneurship, the word innovation has assumed a new identity, which is being universally recognised by academia, industry and government agencies [1].

One can find several solicitations by funding agencies across the world to bring innovation to all professions. Innovation can easily be applied to all professions, as there is tremendous scope in creating novelty and change in every profession.

For example, the teaching profession can use innovation by trying out new methods to satisfy the learning needs of all the students in the classroom. They may embrace innovation either by using/applying new learning strategies or by using new technological tools. Physicians, on the other hand, are always looking for new ways to treat patients and find new cures for diseases. Their profession is also one of the major professions that relies on innovation. Every profession strives to find creative ways to make or do things better, easier, more creatively and faster at less cost.

It is safe to assume that the catalyst for innovation in several fields is technology [2]. The development of the Internet and its ability to bring the worldwide audience closer has paved the way for innovation. Obviously, the mindset is the key to bringing about innovation. Effective use of technology and deriving benefit from technology can only be drawn if people have the mindset to change themselves and their work environment. One profession that can be singled out for having its foundation in innovation is the *engineering profession* [3]. The reasons supporting this claim are listed below.

THE ENGINEERING PARADIGM

1. *The Engineering profession is futuristic*. It is always looking forward and solving problems for the society. Engineers must be innovative in order to look at new strategies, new environments and new challenges to create optimum solutions.
2. *The Engineering profession is the backbone of other professions*. Since technology is a major aid in facilitating innovation, and the engineering profession is the keeper of technology, it has the responsibility of understanding the needs of other professions and, then, must be able to adapt technologies to find innovative solutions to complex problems. This aspect also ensures that engineers must have a broad understanding of societal issues and some information about the needs of other professions. This aspect has been realised by accrediting agencies, such as ABET, because they have incorporated this expectation within their accreditation criteria. Their expectation that

an engineering student will be able to solve complex problems and have an understanding of contemporary issues is a reflection on part of ABET to understand the effective role of the engineer as an innovator.

3. *The Engineering profession is globally portable*: The fact that the engineering profession is portable empowers it to work easily in a global environment and solve global issues. Globalisation has enabled corporations to be located at multiple locations and work in diverse socio-economic and cultural environments. The common language of engineering principles and fundamentals is the key for engineers to work globally without any technical restraints. Their ability to address global economic development issues through innovation is something that is proving to be extremely beneficial. The engineering designs needed to create engineering solutions are the same irrespective of the location. Engineers are in a perfect position to create innovation [4].
4. *Engineers will lead process innovation*: Several of the earlier decades were focused on product innovation. Products such as computers, LCD TVs, Ipods, Ipads, etc, have dominated the world in creating wealth. The global consumer has been targeted for product marketing and wealth creation. The current environment of global challenges has made the US manufacturers understand the need and importance of process innovation. US manufacturers stuck with the high cost of labour have no other alternative but to reduce the process costs to stay competitive and viable. While the US manufacturers are addressing their innovation needs related to optimisation, productivity, effectiveness and safety, the manufacturers in India and China have also begun to understand the concept of process innovation. While it is driven by cost in many cases, it has become a necessary requirement for all participants of the global supply chain to be optimum and effective. The world is concentrating its attention on process innovation and engineers will be the ones responsible to achieve it [5].

INNOVATION IN THE ENGINEERING CURRICULUM

Innovation in engineering programmes has always existed in the form of engineering design and similar endeavours. In the current context, there is a need for innovative strategies to infuse innovation into the programmes. Several initiatives and programmes have been undertaken at NIU to embed innovation into engineering curricula. The process starts from the first course students enrol in as freshmen. The course is titled: *Introduction to Engineering*. The College has done several iterations of the course to incorporate innovation in the course.

For three years, the course had fundamentals of nano-technology and its applications for freshmen students. The course was supposed to excite students about emerging technologies and introduce them to future trends in engineering. Students were required to make presentations and discuss their ethical dilemmas while studying nano-technology principles.

Currently, the course has been modified to include design engineering principles. The academic staff from different departments teach the course in a team format and synergise learning in the classrooms to enable students to learn a systems approach to engineering. The activities in the classroom encourage students to think out of the box and come up with unique solutions to simple technical problems.

NEW DEGREE PROGRAMMES

The fact that discipline-specific degrees provide discipline specific knowledge means that they provide an opportunity for innovation in curricular reform. Industries and employers are looking for students with diverse preparation and with knowledge of more than one field [5]. The trend has been to expect cross-disciplinary knowledge from engineering graduates. CEET at NIU works closely with 200 companies and has five different industrial advisory boards. Most of them have expressed a keen interest in interdisciplinary subjects and curriculum.

Consequently, NIU-CEET has developed several overlapping curriculum materials in the past five or six years. Some of the areas include systems engineering, mechatronics, simulation and modelling, reliability, nano-technology, health systems engineering, sustainable engineering, engineering management, biomedical engineering, environment and energy, etc. This innovative approach has enhanced the marketability of students in the region and has facilitated a transformation of curriculum. The students graduating from these programmes are better prepared to handle challenges of a technological society and are innovative in their approach to finding engineering solutions due to their understanding of diverse fields and their needs.

One of the unique curriculum developments has been to combine two degrees sequentially. The engineering and law schools have worked together during the past two years to come up with a six year engineering law degree. The salient feature of the programme is that it allows programmes to provide dual credit for courses and the students graduate with two degrees: engineering and law. The degrees are still accredited by ABET and the American Bar Association (ABA). This innovative approach was used by the College in response to a need expressed by the legal community to have better-trained intellectual property lawyers. The students prepared by the six-year engineering law sequenced degree will have expertise in engineering as an ideal preparation to pursue a degree in Intellectual Property (IP) law.

In addition, to enable students to understand the importance of protecting one's intellectual property, an Innovator's Club was started in the Academic Housing Unit of the Science Engineering and Technology (SET) House. There are 250 students in the SET house from various engineering, science and technology disciplines. They were invited every week to an informal meeting to discuss their ideas. Experts from IP law, technology transfer and patent processing were, then, invited to meet with the students to educate them on the journey from perceiving an idea to converting it to a commercial product. The information included differences in the IP laws as they exist in different parts of the world and strategies to protect one's original idea. NIU-CEET has partnered with an active group of student-led research companies that are in the process of exploring commercialisation ventures in advanced areas of engineering design [6].

RECENT INNOVATIONS AT NIU-CEET

The infusion of direct assessment into teaching and learning at NIU has introduced innovation in several courses within the engineering programmes. The academic staff are using innovative methods to teach due to their involvement in the Institute of Teaching and Learning (ITL) launched by the College. Seven academics were trained to understand and utilise one or more of the 22 teaching pedagogies into their classrooms. The teaching and learning in those classrooms has changed for the better and has resulted in innovative ways of teaching, evaluating and learning.

The formation of research clusters from different departments and colleges is giving academic staff members an opportunity to write innovative grants to seek federal funding. A recent grant involving several stakeholders from industry, business, and government brought in US$2.4 million from federal agencies to accelerate innovation and research in an industrial cluster. These are a s ample of things happening at NIU-CEET to promote innovation and creativity.

CONCLUSIONS

Innovation is an essential element of being an engineer. What is done and what is expected is nothing else but innovation. If the academic programmes do not integrate innovation into teaching and learning, it could be disadvantageous to the functionality of the students.

Knowing fundamentals and learning formulae is not enough. The engineering curriculum must be participative and should include the innovative use of technology and theory. The programmes must include experiential learning into the programmes at the course level to enable students to bridge theory with practice through innovation. The engineering leaders of tomorrow will be the practitioners of innovation.

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An environmental catastrophe and its incorporation into the environmental engineering curriculum at the University of Pannonia

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ABSTRACT: Red mud storage, Cassette No. 10, ruptured on 4 October 2010 during the daytime in Hungary. About one million cubic metre of red mud sludge burst and covered a territory of about 1,017 hectares. The caustic sludge flooded the surrounding settlements and polluted the nearby Torna stream, which flows through the Marcal and Raba rivers into the Danube. The red mud sludge exhibits alkaline properties, therefore, this environmental disaster resulted in an extremely serious situation. Immediately after the catastrophe, the University of Pannonia, Veszprém, Hungary, set up an emergency response team to carry out environmental monitoring and to devise red mud sludge clean up technologies. This paper deals with the results of the environmental monitoring and the emergency measures taken and with the incorporation of this very serious event in the environmental impact assessment course programme. The key issues of the disaster, the history and the life cycle of the red mud reservoir are explained in detail. The processing and reutilisation of the red mud in order to avoid events like this are also dealt with.

INTRODUCTION

Red mud sludge is a solid waste by-product of the Bayer bauxite processing works and it is highly basic with a pH of about 12-13.5 (sometimes up to 14) [1]. Bayer technology is used for the manufacture of alum earth. During this procedure, the bauxite is treated with concentrated NaOH solution. The bauxite contains alumina in the form of tri- or monohydrates, which are dissolved in concentrated sodium hydroxide solution.

The slurry obtained after the dilution is a mixture of the caustic aluminate and the red mud sludge. The separation of the aluminate solution from the red mud sludge can be carried out in press filters, Dorr settlers or in centrifuges.

According to Hungarian Government Decree No. 240/2005 (X.27.) on the rules of the trans-boundary transportation of hazardous materials [2], which is in harmony with the International Basel Convention of 1989 on the control of trans-boundary movements of hazardous wastes and their disposal [3], bauxite residue (red mud) with a pH < 11.5 is considered to be non-hazardous. In the case of the red mud at the waste disposal site close to Ajka, the pH value of the red mud was higher than 11.5, which is very dangerous for the environment and human health and should be treated as hazardous waste.

The MAL Hungarian Aluminium Production and Trading Company, based near Ajka, is the only company in Hungary processing bauxite and refining the ore to produce alum earth and alumina. During the past several decades, the Company produced products of high quality and parallel to this, a significant amount of red mud and red mud sludge were generated in Ajka. Both dry and wet disposal technologies were used. The red mud and the caustic sludge were stored in cassettes.

RED MUD CATASTROPHE AND ACTIONS TAKEN

The containment wall of red mud waste reservoir (Cassette No. 10) burst on 4 October 2010 during the daytime in Hungary. The catastrophe occurred near Ajka in the Central Transdanubian Region, about 50 km from Lake Balaton and 130 km from Budapest. About one million cubic metre of red mud sludge spilled and covered a territory of about 1,017 hectares. The caustic sludge flooded three villages (Kolontár, Devecser, Somlóvásárhely) and contaminated the rivers and streams including the nearest, the Torna, which flows into the Marcal and Raba rivers into the Danube (Figure 1).

During this tragedy, nine persons died, dozens of people were injured, mainly suffering from burns after coming into skin contact with the alkaline sludge, and 300 houses were flooded by the red mud sludge. Red mud sludge exhibits strongly alkaline properties, therefore, this environmental disaster resulted in an extremely serious situation.

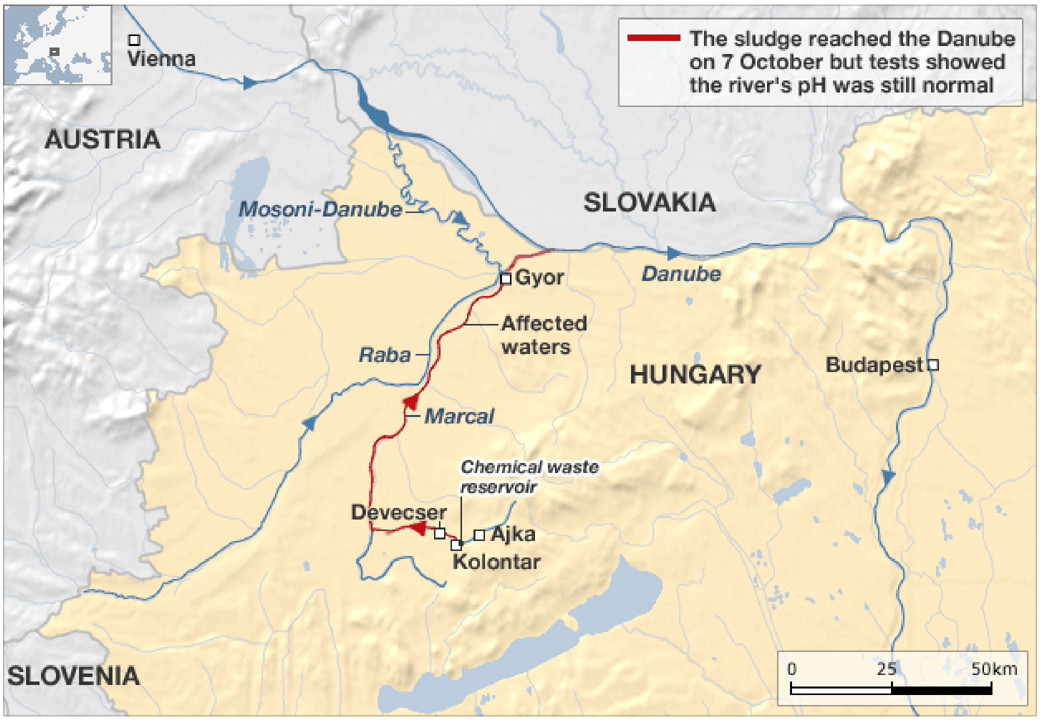

Figure 1: The cathastrophe site near Ajka, Hungary, and the area contamintated by red sluge surface water from the Danube [4].

ENVIRONMENTAL MEASURES AND MONITORING

Immediately after the catastrophe, the University of Pannonia set up an emergency response team to carry out environmental monitoring and impact assessment, as well as to devise red mud sludge clean-up technologies. Experts took water, air and soil samples and established monitoring activities. Toxicity, pH, dissolved oxygen content, conductivity and surface water monitoring were carried out. The heavy metal content of soil samples taken from the critical points was also investigated. Air monitoring included particulate matter concentration, wind direction, air pressure and temperature measurements.

After the occurrence of the disaster, it was obvious that saving human lives is of vital importance and this was followed by the protection of the surface waters. It meant that the neutralisation of the caustic sodium hydroxide (pH = 12.5-13.0) had to be accomplished. Since there is no such thing as an environmentally friendly neutralisation agent from the environmental point of view, a novel solution had to be devised.

The conventional neutralisation of the sodium-hydroxide with acids (e.g. hydrochloric acid) could not have been allowed, and other less drastic acids (citric acid, acetic acid, maleic acid) were not available in large quantities. It was concluded that a salt of a strong acid and a weak base had to be used. Other theoretical solutions e.g. use of peat with an acidic character or sea water were not real options.

Since gypsum was available in significant quantities from coal-fired power plants as a waste material exhibiting a slightly acidic character, the use of gypsum was recommended to the Emergency Response Team, to be used at several points along the Torna stream, and the Marcal and Rába rivers. In addition to the gypsum, acetic acid was also used in controlled quantities at certain locations for the neutralisation.

Due to the extraordinary catastrophe, the Central Transdanubian Inspectorate for Environmental Protection, Nature Conversation and Water Management ordered water quality preparedness (3rd level) that included disinfection, averting and neutralisation the polluted surface water.

The decrease in pH value of the surface waters from 13 to 8 was achieved by gypsum addition into the Torna, Marcal and Raba, which was started within six or seven hours after the accident. Gypsum originating from the neutralisation of stack gases of a coal-fired power plant was added under controlled conditions and under continuous monitoring at several points along the streams and rivers.

In addition, acetic acid was added to the extremely contaminated water to adjust the pH level of the surface water. During the neutralisation action, 17,000 tonnes of gypsum and 4 m^3 of acetic acid were used up. Barriers were erected in the riverbed to slow down the flow of the Torna to provide sufficient time for neutralisation and settling of the residues. The primary objective, the protection of the Danube was successful as a consequence of the gypsum addition [4][5].

INCORPORATION OF THE DISASTER INTO THE ENVIRONMENTAL ENGINEERING CURRICULUM

The University of Pannonia offers BSc and MSc programmes in the field of environmental engineering. The Ajka red mud disaster case has been incorporated into the course programme on environmental impact assessment. The technology of bauxite processing and red mud storage technologies are explained to students and the emergency measures taken are given with practical insight into the monitoring and follow up actions. The efficiency of the emergency measures are assessed with the students and on-site monitoring is provided.

Students are taken to the site of the catastrophe and provided with an opportunity to carry out on-site measurements at different sampling points. Finally, the students are requested to devise remediation technologies and the outcome of their work is assessed by the group.

Moreover, students of the environmental engineering programme worked voluntarily after the disaster with the emergency team, after being granted a special permit to work at the contaminated sites, and provided help in cleanup and rehabilitation operations (Figure 2a).

They carried out surface water monitoring and soil sampling (Figure 2b) after the catastrophe, as well as monitoring and processing data on surface water quality parameters for several months after the accident. The data obtained have already been utilised in case studies, diploma work and in papers presented at conferences [6][7].

a) b)

Figure 2: Students at the catastrophe site: a) taking part in cleanup and rehabilitation actions; b) taking soil samples at the residual area of the village of Kolontár.

CONCLUSIONS

The bursting of the wall of the red mud storage facility near Ajka focused the attention of state agencies and the public on that technical and engineering inspections should be reconsidered in order to prevent future disasters.

It is recommended that emergency preparedness and procedures, the emergency response system, as well as the cleanup technologies should be checked continuously and updated regularly by national environmental authorities, especially in companies dealing with hazardous materials and technologies. Work on the reconstruction of the red mud sludge-containing waste disposal facilities has commenced.

ACKNOWLEDGMENTS

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Enrolment of women in engineering and technology degree programmes in Australia

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ABSTRACT: Increasing the number of women in engineering and technology education has been a real challenge for many engineering and technology schools in Australia. The national trend and participation of women in engineering courses by field of education across universities in Australia in the period 2005-2009 is presented and discussed in this paper. The statistical data gathered here indicate that the female rate of participation in engineering and technology courses, comprising all academic levels, currently stands at more or less 15 percent. Although universities have managed to retain this current rate, it is still regarded as unsatisfactory considering that women make up approximately 50 percent of the general population. The statistical data provide evidence that more work is required, beginning at primary and secondary school levels, to increase the number of women seeking to enter engineering and technology courses at the tertiary level.

INTRODUCTION

The enrolment of women in engineering and technology courses across Australian universities remains consistent but at the same time there has been no indication that the female participation rate in engineering and technology will exceed the peak of 15.7% achieved in 2008. While it is pleasing to observe that over the last three decades more women have chosen engineering and technology as an option for tertiary education, the fact remains that women still represent only 15% of the total enrolment in engineering and technology.

Considering that women constitute slightly above 50% of the general population, they are greatly under-represented in the engineering and technology profession [1]. Clearly, more work is required on the part of the universities to encourage more women to enrol in engineering and technology.

Although the Australian national statistical data have revealed that chemical engineering (e.g. process and resources engineering) is a relatively popular choice among women, the opposite finding, surprisingly, was reported in most countries of the European Union (NSP-EU, 2001) [2]. In Australia, of the classical engineering and technology fields, programmes in automotive engineering and technology, maritime engineering and technology, and mechanical and industrial engineering and technology appear to be the least appealing to female students, attracting about 10% of the female population, compared with the average of about 15% female presence overall.

Similar findings were also reported in most countries of the EU. It was reported that women represent about 25% of the total number of enrolments in engineering courses (NSP-EU, 2001) [2]. This number is still very small in comparison with the number of women enrolling in science courses, especially in the humanities and the social sciences. It is clear that more work is needed to increase the participation of women in engineering and technology.

The statistics for engineering and technology do not compare favourably with the sciences and other related disciplines. Although the overall enrolment in science disciplines has fluctuated, the level of enrolments is still satisfactory. Earlier studies conducted by Nguyen have shown that female students are more likely to enrol in science courses at universities [3].

One reason why women prefer science to engineering and technology could be due to their lack of exposure to engineering or engineering-type subjects in secondary education. Physics and mathematics are the closest subjects to engineering and technology, and these two subjects typically attract male students, with women typically enrolling in chemistry or biology. The early exposure of female students to these science disciplines is, then, reflected in their pursuit of science at the tertiary level.

It has been observed that

> *…for women, early exposure to physics in particular appears to be a key factor in the later choice of engineering as a course of study. Poor preparation in science and mathematics limits the appeal of engineering to these groups and increases the attrition among those who do study engineering, especially among minority students. Educators should develop strategies to increase the size of the initial science/mathematics pool of minorities and to reduce attrition all along the educational pipeline. Such strategies should include innovative ways to increase the appeal of mathematics and physics for female students* [1].

It has been found that the engineering curricula contain more hard components, which could be a major factor in discouraging women from entering the field. Science, on the other hand, is structured differently and has a greater balance between the hard and soft components, including both non-technical and technical subjects. This could be a reason for its attraction to women.

STATISTICAL DATA ANALYSIS

The overall picture showing the participation of women in engineering and technology education can only be understood by examining the long-term changes in the enrolment of women in engineering and technology courses. Figure 1 presents statistical data showing the overall trend in national enrolment in engineering and technology in Australia in the period 2005-2009.

WOMEN IN ENGINEERING EDUCATION

It can be seen from Figure 1 that while enrolments in engineering and technology courses at Australian universities have increased slightly each year from 2005 to 2009, the huge gap between male and female participation has not been reduced significantly because the level of participation of women in engineering and technology education has not increased proportionally. Briefly, the key observations concerning the enrolment in engineering and technology courses between the genders are as follows:

- Exponential growth can be observed in the overall enrolment in engineering and technology courses in 2005-2009.
- The rate of participation of women in engineering and technology courses from 2005-2009 has improved slightly but is still very low when compared to the male enrolments.
- From 2005 onwards, the enrolment of men in engineering and technology has outnumbered that of women.
- The enrolment of women reached its peak of 15.7% in 2008.
- There is a huge disparity in the distribution between the gender groups in engineering and technology education.
- Engineering and technology is predominantly a male-dominated discipline.

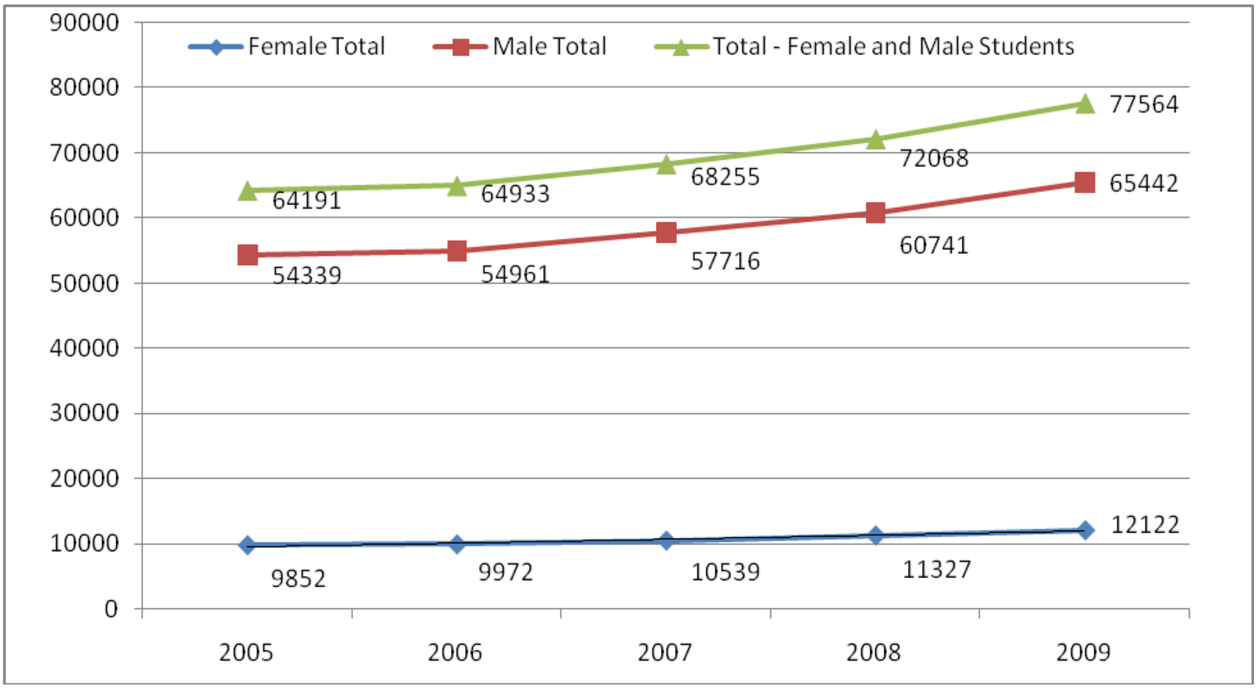

Figure 1: A line graph showing the overall changes in the national enrolment in engineering and technology disciplines in Australia (2005-2009).

In addition to the number of enrolments of women in engineering and technology courses, an even more interesting issue was the engineering and technology specialisations that attracted the highest female enrolment and this was also looked at and examined in detail. Figure 2 shows the enrolments of women in engineering and technology courses in Australia by the field of education over the period of 2005-2009. The key observations concerning the enrolment in engineering courses by the field of education are as follows:

- Engineering and related technologies appears to be a favourite amongst the women attracting the highest number of female enrolments. This narrow field of education includes sub-engineering disciplines such as environmental engineering, biomedical engineering, fire technology, etc.
- The second most popular choice amongst women is process and resources engineering also showing a s teady increase in enrolment number over the period of 2005-2009.
- Ranking in third place is electrical and electronic engineering. However, the enrolment of women in this narrow field has shown a decline over the period of 2005-2009.

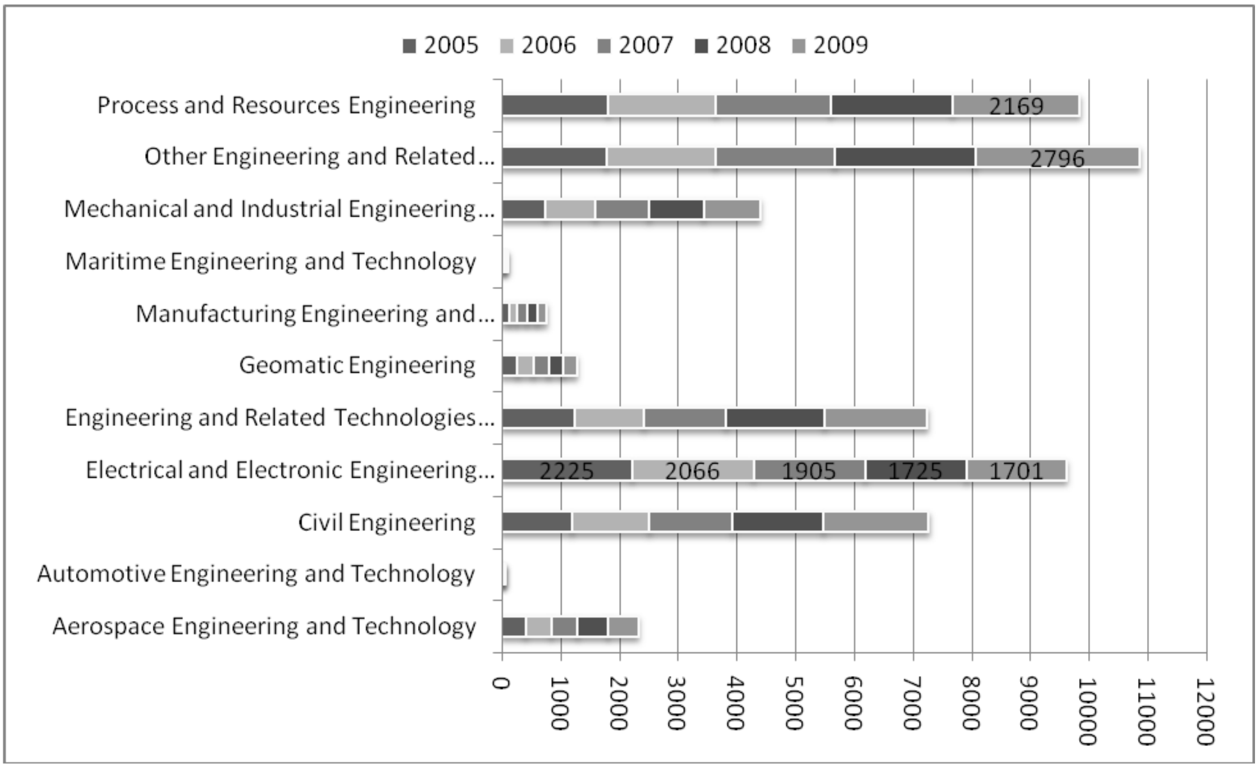

Figure 2: The enrolment of women in engineering and technology courses in Australia by a specific field of education (2005-2009).

POSSIBLE FACTORS DETERING WOMEN FROM STUDYING ENGINEERING

It is particularly important to determine the reasons why women do n ot choose engineering and technology as a profession. The authors are of the opinion that capability and aptitudes are not important issues because female engineers and technologists have demonstrated that they are just as capable as their male counterparts are. However, as the statistics confirm, engineering and technology is predominantly a male occupation, and women, who are in the minority, will always have difficulties fitting into the male-dominated and oriented environment.

It has been observed that often women do not feel a sense of belonging, or have not developed the confidence to work in such a male-orientated environment. Many women find engineering and technology schools to be stressful environments in which they experience a sense of isolation and a lack of acceptance on the part of the faculty staff and the male students [1].

The design of engineering and technology curricula has also been viewed as a critical factor that may discourage and disadvantage female students, as curricula have been devised and developed to suit, primarily, the needs of male students, grossly neglecting the needs of female students. For instance, in India, girls undertaking engineering and technology disciplines admitted that they were slightly handicapped due to their lower physical strength, when working in some of the laboratories and workshops [4].

Another reason could be of a psychological nature. For example, women are taught to think that they do not possess the essential qualities and skills to become engineers and technologists. A common perception is that because engineering and technology is a technical area, it is, as such, more suited to men. For example, Minton and Schneider have pointed out differences in the qualities of the sexes. According to them, women tend to be superior to men in verbal fluency, reading comprehension, finger dexterity and clerical skills, and that men tend to surpass women in mathematical reasoning, visual-spatial ability, and speed and co-ordination of large bodily movements [5]. In part, these findings are a function of differences in the ways in which boys and girls are treated in our society. Girls are usually expected to be more accomplished in linguistic and social skills and boys are supposed to be better at mathematical, mechanical and other problem-solving tasks [6]. In more general terms, women are thought to be non-technical and men more technically focused. Since engineering and technology are considered to be technical study areas, embracing mathematical, mechanical and problem-solving tasks, the statistics, indicating that 85% of enrolments in engineering and technology are male should come as no surprise.

Studies conducted earlier at the University of Sydney by Ballard and Pudlowski on a group of secondary school students present some interesting observations about the performance of male and female students on simple electrical engineering tasks [7]. Students were required to perform a number of exercises during a daylong workshop that was designed to introduce high school students to electrical and electronic engineering. In the first exercise, students were asked to build a simple crystal radio set by following instructions given in their workbook and, then, to assemble the radio on a plug-in electronic breadboard, with the electronic components being supplied. After testing and demonstrating its operation, they followed instructions on how to enhance its performance through use of an operational amplifier, a speaker and a power supply.

It was found that the majority of students performed this task very well, although it was noticed that the majority of girls were inexperienced in the kind of construction and manual operation techniques necessary for this type of work.

The second exercise required students to investigate the operation of the basic logic elements that form the building blocks for digital circuits. Electronic components were subsequently supplied to design a simple car alarm. Again, it was found that girls required support to overcome their inhibitions in utilising unfamiliar equipment and components, but, then, adapted well to solving these quite abstract problems.

The third exercise was to experiment with a digital logic trainer, which required the possession of more abstract problem-solving skills to be successful. The girls were rated very highly in this experiment in which they demonstrated high levels of understanding and accomplishment in contrast to the boys, who found this exercise far more difficult.

The last exercise was *An Electrical Engineering Aptitude Test* (EEAT). The test places particular emphasis on electrical circuit theory through pattern recognition. It endeavours to measure the visual ability to recognise circuit components and fundamental circuit topology and structures taught in high-school physics. In evaluating the EEAT, the boys indicated that they found it to be extremely difficult. The girls too assessed the EEAT to be difficult, but found it more beneficial than the boys and were satisfied with their accomplishment. The girls achieved slightly better results than their male counterparts, suggesting that the girls had better problem-solving skills and that they were more logical in following instructions and putting things in sequential order than the boys did.

Moreover, the results indicated that the girls had a higher visual-spatial ability than the boys did, which contradicts Minton and Schneider's findings.

What is demonstrated by this research is that although the girls initially experienced problems, in particular in those exercises that required motor and manipulation skills and fundamental assembly techniques, their overall performance was equal to their male counterparts. When the girls became more familiar with the knowledge, technology and techniques used, they even rated higher where intellectual and abstract skills were required. This indicates that girls were at least as capable of doing electrical and electronic engineering as boys [7]. It can be generalised that female engineering and technology students could bring a range of new skills, attributes and attitudes to engineering and technology education.

Another critical issue for engineering and technology education is its general failure to address human issues, which may explain why most women in engineering and technology congregate around those disciplines viewed as *soft engineering*. As a discipline, engineering and technology has been almost entirely isolated from the humanities and as such, has been taught outside the social context. A greater number of women would probably be attracted to engineering and technology if changes were made to curricula to include topics, concepts and ideas from the humanities, which would make engineering and technology more relevant to society as a whole.

While more and more universities today are recognising the need for a balance between technical and non-technical content in engineering and technology, it is believed that it will take a long time before such changes can be implemented effectively into engineering and technology curricula.

Several important factors, which may influence women to study engineering and technology have been identified by Rosati and his associates in their surveys conducted in 1988 and 1993 [8][9]. The identified factors were helpful in the formulation of the issues and views, concerning the attitudes of female students when choosing engineering and technology studies. In addition, they provided some background for the formulation of the conclusions drawn in this paper.

POSITIVE OUTLOOK

The slow growth rate of women enrolling in engineering and technology has raised concerns among many engineering and technology educators. Nonetheless, the scene is not all bad and some positive initiatives have been undertaken to promote the participation of women in engineering and technology.

For example, in 1996, an important women-centred initiative undertaken by the then UNESCO International Centre for Engineering Education (UICEE), which was based at Monash University, Melbourne, Australia, was the introduction of a *Women in Engineering Education Scholarship Scheme*. Scholarships under the scheme have provided significant support, opportunity and encouragement for women to pursue research in engineering and technology, and in engineering education in particular. Several higher degrees have been achieved as a result of this scheme.

The paramount objective of such scholarships was to increase the number of women as academic teachers in engineering and technology, who would be role models for female secondary school students, as well as for engineering and technology students who have already chosen engineering and technology as their profession.

Previous studies have shown that environmental engineering courses have proved to be successful in attracting female students. Following on from this success, perhaps one solution would be to integrate environmental units into general engineering and technology curricula to make them more appealing to women.

Other activities that help to promote women in engineering and technology include the establishment of centres for women, the running of women in engineering forums and conferences and the setting up of women in engineering and technology project officers across universities in order to deal with the underlying issues. If universities are aiming at increasing the participation of women in engineering and technology courses, the establishment or continuation of such activities is vital for the future of engineering and technology.

CONCLUSIONS

It has been found that increasing the enrolment of women in engineering and technology depends very much on the manner in which the message about engineering and technology is conveyed to students at the secondary level of education. Teachers need to be more responsive. They need to be more sympathetic, supportive and encouraging of female students studying engineering and technology. There needs to be a longer introduction to engineering and technology units or subjects at the secondary level to raise female students' awareness of engineering and technology.

At the tertiary level, more effort needs to be taken in designing engineering and technology curricula to include the humanities and non-technical content and to remove those aspects of curricula that deter women from undertaking engineering and technology courses. Furthermore, engineering and technology departments should devise more aggressive strategies to attract female students to engineering and technology courses, for instance, by organising special seminars for secondary school students.

Such seminars can provide students with the opportunity to learn about a p articular branch of engineering and technology, making themselves familiar with the technologies and processes used, as well as research achievements. Academics must go out to young students with a message about what engineering and technology involve and why women should become engineers and technologists, particularly as women can bring different dimensions, qualities and skills to engineering and technology.

Generally, more studies need to be devised and carried out on the existing population of female engineering students to learn about their personal experiences. This could assist in finding more effective ways to attract a greater number of women to engineering in the future.

As the statistics confirm, and taking into account the historical perspective, engineering and technology is predominantly a male occupation. Hence, it is not surprising to find that 85% of the students enrolled in engineering and technology courses in Australia are men. Women, in the minority in these courses, always will have difficulties fitting into the male-dominated and oriented environment. Therefore, prompt action is required in order to remedy this critical situation.

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The role of cluster initiatives in educational systems in the improvement of engineering and technology education

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ABSTRACT: The role of all school system levels in the education of qualified workers, particularly vocational school graduates, the users and exploiters and engineers and technologists (technical university graduates), the creators and initiators of technology and innovation are presented and discussed in this paper. The research questions discussed are: what is the Polish experience and perspective in engineering and technology education and how can the education system be improved to become an object of an innovative economy. The paper highlights the attitudes of particular levels of the educational system, indicates the advantages and threats, and describes the essence of creation cluster initiatives in the area of education, as a proposal to adapt education match the needs of the innovative economy. The proposal is based on integrated research and monitoring of the cluster initiative's participants.

INTRODUCTION

Polish engineers support the process of innovation and that is why the Polish economy can become more innovative, especially through technology transfer. Innovation and competitiveness are determinants of functioning and developing companies and the economy. Particular workers with their individual qualifications, knowledge, attitudes, skills and ability to work in teams can stimulate or disturb innovation and competitiveness. They are:

1. Qualified workers (vocational school graduates) - users and exploiters of technology and innovations; and
2. Engineers and technologists (technical university graduates) - creators and initiators of technology and innovations.

An innovative economy needs both groups of workers and both groups have a great influence on the creation of an innovative climate. First, new technologies, products and ideas are mostly designed by well educated, qualified and skilled university graduates. Second, no sector of industry will manage without qualified workers (unqualified workers make mistakes and generate losses). The workers most required in industry are (accordingly to the authors' research): welders, metalworkers, electricians and electronic specialists [2]. Maintenance services are (or should be) based on workers' qualifications and skills in a particular industrial company and in authorised services. Engineers cannot be substituted with economists, sociologists, financiers, politicians and entrepreneurs [1]. One characteristic of engineers' work is that it involves innovation in the current work and is continuously focused on new ideas and solutions. Moreover, their work is connected with high risk, responsibility and the need to make quick decisions.

The research questions in this paper are:

1. What is the Polish experience and perspective in engineering and technology education?
2. How can the education system be improved to match the needs of an innovative economy?

From this background, it is necessary to discuss the role of the school system and if there is any, engineering and technology education.

EDUCATION FOR AN INNOVATIVE ECONOMY

Education for an innovative economy is carried out in every type of school. Formally, universities of technology are responsible for the education of engineers, but the whole process begins at primary school, or even in kindergarten and at home. Students' natural interest in the world and environment can, and should, be used in the construction of educational systems. Independently of educational programmes, schools and their directors have a considerable autonomy and have the opportunity to create a climate of creativity and innovation at schools.

To discuss the research questions there is a need to begin with a short description of the Polish educational system (the school level):

- *Primary school* (six years), six-year-old children begin school education.
- *Lower secondary schools - gimnazjum* (three years).
- *Basic vocational school* where students have to attend for a minimum period of two or three years. On completion, they have to pass a practical examination in acquired skills to obtain a diploma.
- *General secondary schools* (three years). On completion, school students can sit for the matriculation examination.
- *General secondary schools with a profile* (three years). On completion, school students can sit for the matriculation examination. This type of school was very unpopular among lower secondary school graduates and these schools are being closed systematically.
- *Technical and vocational secondary schools* (four year) offer a broader scope of general education, as well as a technical diploma, students can sit for the matriculation examination.

According to the research carried out by the authors, the most important problems in management in the area of vocational education are [2]:

1. Increasing numbers of lower secondary schools graduates choosing general secondary schools and willing to continue education at universities.
2. Decreasing interest in vocational education.
3. Lack of information of labour market requirements and insufficient cooperation between the labour market and the educational system.
4. Graduates' qualifications, skills and attitudes do not meet the labour market needs.

The popularity of general education caused the increase in the number of general schools. Local governments, which are responsible for educational management concentrated on organisational, merit and financial supervisory, were likely to open general school and closing vocational ones, for two main reasons.

First, they fulfil students' educational needs, and second, they save money, because vocational education is more expensive. Presently, general secondary schools are divided into two groups:

- Top level general secondary schools (as they have been for decades) with a high level of education, creative teachers, graduates studying at top universities according to their choices.
- Other general secondary schools, created in place of closed vocational schools, with poor examination results. Directors and teachers (a group of 278 interviewed in February - September 2011) stated that many of those students should not attend general secondary school, and that vocational schools would be more appropriate for them than theoretical study at a general school.

Most secondary school graduates who passed the matriculation examination go on to study at university. Some local governments realised the problem and supported vocational education and cooperated with local labour market, with good results. Others seem not to understand labour market requirements and do not develop vocational schools. In that case, scholarly indicators increase, but not the quality of education.

School-level education prepares students to became exploiters and creators of technology and innovation in the future, whereas university-level education creates such engineers.

Who are the good engineers and how should they be educated? That is the basic question for universities of technology. Profiles of graduates contain descriptions of theoretical knowledge, practical skills and specific attitudes, but it is more difficult to achieve this profile than to write about it in university marketing materials.

Who is (should be) an engineer?

> *An engineer is a professional practitioner of engineering, concerned with applying scientific knowledge, mathematics and ingenuity to develop solutions for technical and practical problems. Engineers design materials, structures, machines and systems while considering the limitations imposed by practicality, safety and cost. Engineers apply techniques of engineering analysis in testing, production, or maintenance. Analytical engineers may supervise production in factories and elsewhere, determine the causes of a process failure, and test output to maintain quality. They also estimate the time and cost required to complete projects. Supervisory engineers are responsible for major components or entire projects. Engineering*

analysis involves the application of scientific analytic principles and processes to reveal the properties and state of the system, device or mechanism under study. Engineering analysis proceeds by separating the engineering design into the mechanisms of operation or failure, analyzing or estimating each component of the operation or failure mechanism in isolation, and re-combining the components [3].

An encyclopaedia definition indicates particular engineering skills and the abilities to work in dynamic, uncertain, risky but creative fields that are full of challenges and provide an ambitious work environment [3].

How are engineers educated?

Polish universities of technology educate engineers in a two-level system. The first level covers three and a half years of study and ends with the preparation of an engineering project and sitting for a complex examination. Students that complete all requirements receive the title *engineer*. The second level covers one and a half years and is completed by preparing a Master's project and Master's examination.

Education is a process. The level of graduates of university of technology depends on both:

- The education process at university; and
- The knowledge, skills and abilities of first year students (an important part of the entrance data of the educational process).

The worse is the knowledge and skills of first year students at university, the more difficult it is to educate a good engineer.

The following advantages of the Polish university system have influenced engineering education:

- Autonomy in the creation of programmes (syllabuses).
- To complete subsequent semesters, students must prepare projects in various subjects. They involve careful study, are concentrated on improvement of existing results and seeking new ones - creative and innovative.
- Cooperation with business (industry), ability of students to undertake vocational training in companies from a wide range of sectors of the economy.
- The strong position of career offices at Polish universities. They play the role of recruitment offices, cooperate with employers, organise training and offer vocational advice.
- Creation of skills such as independence, creativity, decision making and dealing with risk during the study process.
- The increasing role of technology parks (transfer of technology).
- Promotion of enterprise among students (spin-off and spin-out businesses).

The most important threats to an innovative economy are demographic gaps and the lack of an entrance examination (recruitment is based on matriculation examination results). A demographic gap, presently existing in primary schools, will eventually become visible at the university level. Despite the educational boom (*everybody is going to study*), the structure of universities is very wide and universities try to recruit as many students as possible.

The number of places at university depends on the structure of employment and is mostly constant but the number of good candidates (with good results at the matriculation examination) is decreasing accordingly with demographic trends. The entrance knowledge and skills of future engineers (first year students) has been declining for 10 years, since the first lower secondary school graduates (completed secondary school education) entered universities.

The current situation in Polish education has been formed by the *Educational System Reform*. The new school system was introduced in 1999. The essence of the *Educational System Reform* was to introduce the new school system (new types of schools: lower secondary school and general school with profile, the length of education in particular types of schools has changed) and to give tools to local governments to achieve the following:

- to increase the number of graduates at secondary and tertiary levels;
- to equalise educational opportunities; and
- to improve the quality of education.

In engineering education, the reform of programmes has introduced and initiated threats. Attitudes to the educational system (at the levels of lower secondary and secondary school) have a negative influence on the future education of engineers and, generally, on the economy, because of:

- insufficient amount of teaching in mathematics and the natural sciences,
- education with insufficient pressure for creativity, looking for solutions and solving problems,

- students' and parents' belief that almost everyone can obtain a university degree and that not much is required to achieve it,
- completion of the matriculation examination with 30% of correct answers; it is easy to pass the examination at the basic level.

The decreasing skills of secondary school graduates has been caused by more than the educational system reform, particularly by a small amount of mathematics and environmental sciences. A demographic gap has also appeared at the school level. School directors avoid teachers' redundancy and local governments are afraid to close schools.

The system of financing the educational system is based on payment per student. The more students at school, the less the risk of teachers' redundancy. Unreasonably, maintaining of poor schools (especially general secondary schools), supported by educational needs (and the belief that *everybody can learn in general secondary school*) causes a lot of damage to education.

EUROPEAN INNOVATION SCOREBOARDS VS EDUCATION QUALITY

The problem of measurement of innovation has been widely analysed and the methodology (especially particular indicators) are constantly being evaluated in Europe [4-8]. The most advanced is a proposal of the European Commission (used since 2000): The Innovation Indicator Scoreboard used and developed till 2009, and the Innovation Union Scoreboard in 2010 (EUS). In the EUS report 2010, indicators are grouped into three areas and eight dimensions (Table 1).

The overall innovation performance of each country is summarised in a composite indicator (the Summary Innovation Index). The methodology is divided into following steps [8]:

- Identifying and replacing outliers.
- Setting reference years.
- Imputing for missing values.
- Determining maximum and minimum scores.
- Transforming data if data are highly skewed.
- Calculating re-scaled scores.
- Calculating composite innovation indexes.

Table 1: Innovation Union Scoreboard 2010 [8].

Areas of innovations	Dimensions	Indicators
ENABLERS	Human resources	New doctoral graduates
		Population completed tertiary education
		Youth with upper secondary level education
	Open, excellent and attractive research systems	International scientific co-publications
		Scientific publications among top 10% most cited
		Non-EU doctoral students
	Finance and support	Public R&D expenditure
		Venture capital
FIRMS' ACTIVITIES	Firms' investments	Business R&D expenditure
		Non-R&D innovation expenditure
	Linkages & entrepreneurship	SMEs innovating in-house 30.3
		Innovative SMEs collaborating with others
		Public-private co-publications
	Intellectual Assets	PCT patent applications
		PCT patent applications in societal challenges
		Community
		Community designs

OUTPUTS	Innovators	SMEs introducing product or process innovations
		SMEs introducing marketing/organisational innovations
	Economic effects	Employment in knowledge-intensive activities
		Medium and high-tech product exports
		Knowledge-intensive services exports
		Sales of new to market and new to firm innovations
		Licence and patent revenues from abroad

The complete and advanced methodology allows innovation to be measured and compared with particular countries, and indicates those elements which are important in the creation of an innovative climate. On the basis of research and the authors' experience, there is a need to discuss the first three indicators of human resources in the area of enablers:

- New doctoral graduates.
- Population completed tertiary education.
- Youth with upper secondary level education.

Polish indicators have improved and seem to be getting better. An indicator of the number of graduates from particular types of school does not give full information. It is also important to measure education quality, but it is impossible to measure with the quantitative indicators mentioned above. External examination results are satisfactory in Poland (Table 2) and, so far, they are treated as the most important indicator of educational quality. The Ministry of Education has introduced a measurement system of a value-added educational indicator, based on the comparison of results at the beginning and end of education at a particular school. However, they are still internal measurements being used, which do not contain elements of labour market research.

Table 2: Results of matriculation examination in Poland and in the Silesia region between 2006 and 2010 [8][9].

	2006	2007	2008	2009	2010
Percentage of passed examinations in Silesia region	80.07%	89.99%	80%	81.18%	79.37%
Percentage of passed examinations in Poland	79%	90%	79%	81%	81.50%

On the other hand, employers are not satisfied with graduates with secondary school qualifications, skills and knowledge [1]. Universities' lecturers have also observed a decrease of students' knowledge.

CONCLUSIONS AND FURTHER RESEARCH - THE IDEA OF CREATION OF CLUSTERS INITIATIVES IN EDUCATION

The educational system is not an island and an innovative economy demands good cooperation between the labour market and the educational arena. This is understood at the university level, where cooperation between science and industry develops quickly and effectively. Local governments and school directors understand the necessity of cooperation with employers, recruitment offices and labour market institutions. Cooperation between vocational schools and employers is mostly connected with vocational training. The educational system is afraid of any external measurement based on labour market and graduates' opinions.

The authors have worked out the idea of supporting cluster initiatives in the educational system. Creating a cluster initiative in education should be spontaneous, not confined to artificial procedures and bureaucracy. The suggested concept has a double role. First, it will help to create the cluster initiative, and second, it will help with educational management and measurement of the quality of education, decision making, implementing processes and activities in cluster initiatives to develop it.

Potential participants of the cluster initiative (students, local governments, educational area, employers) will take part in integrated research, mainly:

- Collection of research-based information on labour market requirements.
- Collection of research-based information on students and the educational arena, and the requirements and abilities of local government and the labour market to fulfil those requirements.

Knowledge will be converted and transformed by the expert system. The basis of research is the monitoring and analysis of needs and requirements of all potential participants of cluster initiatives. Research will also provide information about abilities to fulfil this requirement. Pathways and ways of communication between these four groups will be created. A tool - the expert system - is a kind of *toy* for participants of the cluster initiative. Participants will use the tool, create ideas to develop it, communicate with each other and make decisions in accordance with the knowledge generated by the expert system.

The innovative economy cannot afford to have a bad educational system and educate graduates who will not enter the labour market and become unemployed.

Perspectives of further research are connected with following theoretical and practical recommendations:

- There is a need to continue exploring the labour market and educational needs.
- There is a need to create a complex measurement system of educational quality, not only based on quantitative indicators.
- Educational research should be created with the help of scientific experts. This will help to create tools of educational management but not just documents with requirements (e.g. an expert system to support the creation of cluster initiatives in education in being prepared by the authors).
- The educational environment (local government authorities, directors, teachers, educational experts) should realise the importance of educational research and use the research conclusion in making their decisions.

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Education of logistics according to engineering and economic considerations

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ABSTRACT: Presently, the role of logistics is becoming more acknowledged in production and service activities and, hence, the demand for logistics professionals in Europe has increased. Logistics education is linked to two disciplines: the training of technical engineers and of economists. The contemporary economy expects logistics experts to be able to plan, operate, control, supervise and optimise logistics systems. An outstanding logistics professional is proficient in both the engineering and IT fields, and has the knowledge of economics and legal matters. Imparting these many kinds of knowledge to students requires a structured and well defined educational programme. Important and critical issues for logistics education are presented and discussed in this paper.

INTRODUCTION

Workplaces and equipment providing technology and service operations are complemented by material and information flow systems. The optimal design of these material and information flow systems allows for the improvement of production and service systems. Material handling systems are based on material handling machines (i.e. machine systems) and their operation is ensured by information flow systems. It is the integration of the techniques and technologies of these two systems which leads to engineering logistics. The design and operation of logistics systems can be handled by theoretical methods, which require descriptive mathematical methods and the application of computer-aided mathematical models and methods. In the logistics processes, product identification and product management activities are determining factors. To solve these problems, IT and automation skills are indispensable. In order to investigate the economics of logistics systems, abstracting ability is necessary in order to model economic impacts and the various factors that affect costs.

DEFINITION OF MATERIAL AND INFORMATION FLOW SYSTEMS

Logistics systems can be divided into defined material flow systems. From the perspective of education, it is very important to give not only verbal information about logistics systems, but to be able to give a mathematical description of them. This is extremely important since systems can only be handled with time dependent numerical data. From the perspective of education, the notion of the logistics system should be defined. The logistics system is nothing more than a material flow system together with an associated information flow system [1-4].

Description of Material Flow System

Material flow systems are large systems characterised and described by many parameters. The material flow processes inside the system are changing, stochastic processes. Only rarely can these processes be simplified to stationary or quasi-stationary processes. Figure 1 represents the general, simplified model of the material flow system.

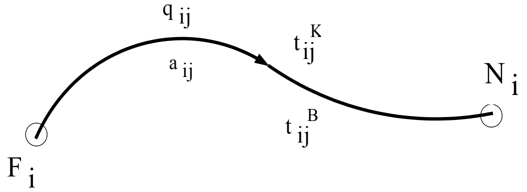

Figure 1: General model for the material flow system.

The connection between two arbitrary points of the material flow system is shown in Figure 1, and the notations are as shown in Table 1:

Table 1: The notations.

F_i	–	The *i*.th source in the material flow
N_j	–	The *j*.th sink in the material flow
$q_{i,j}$	–	The material flow intensity between the source *i.* and sink *j.* (material quantity/time)
$a_{i,j}$	–	The material type identifier between source *i.* and sink *j.*
$t_{i,j}^K$	–	The start time of the material flow between source *i.* and sink *j.*
$t_{i,j}^B$	–	The end time of the material flow between source *i.* and sink *j.*

A material flow connection $\left(Q_{i,j}\right)$ according to Figure 1, is as follows:

$$Q_{i,j} = Q_{i,j}\left(F_i, N_j, q_{i,j}, a_{i,j}, t_{i,j}^K, t_{i,j}^B\right) \tag{1}$$

When one gives for all possible connections *i-j* the connections $Q_{i,j}$ and one summarises them in a multi-dimensional matrix *Q*, then, it is possible to describe the material flow system mathematically. The main problem of this description is that each element of matrix *Q* varies stochastically in time. A reliable treatment of the matrix elements depends on the determination of the density and distribution functions associated with the elements. The structure for the material flow-time function is shown in Figure 2.

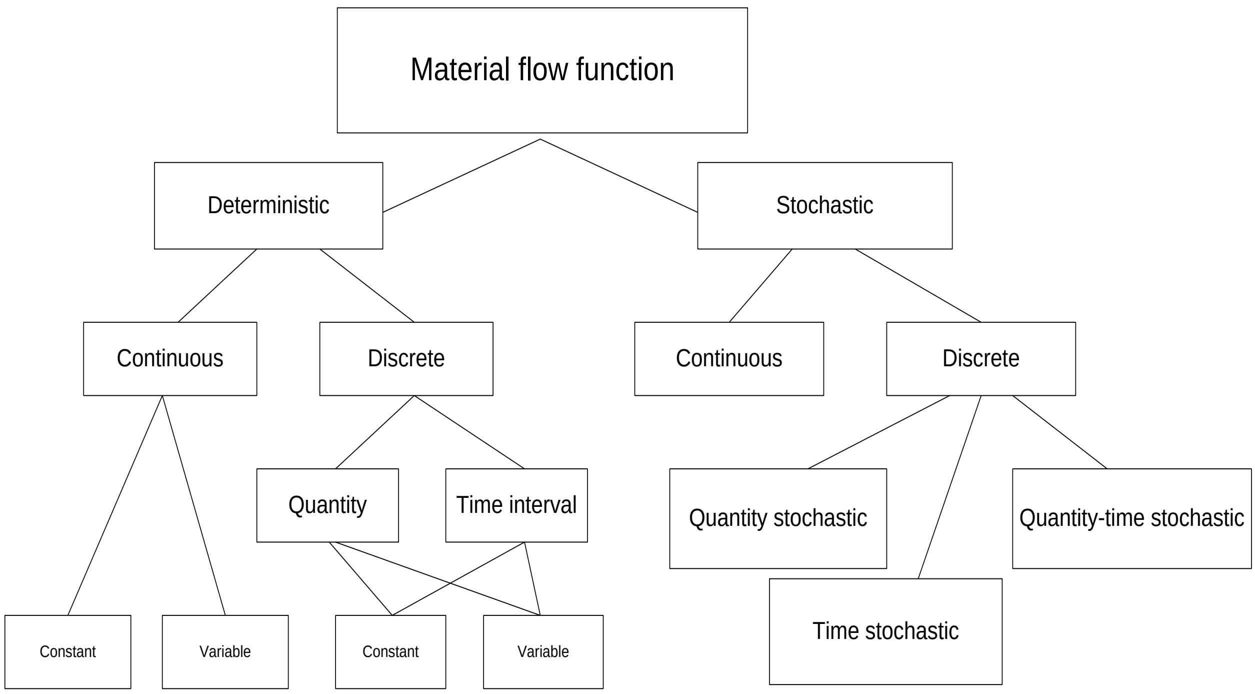

Figure 2: Material flow-time function structure.

The material flow-time functions allow the quantitative scaling of building blocks for logistics systems. Such properties are: storage capacity sizes, tool numbers for transport links, tool numbers for cargo handling equipment, etc.

Description of Information Flow Relationships

In the logistics system, there are several information flows. By definition, this information is tied to the material flow. It is practical to group these many types of information for clarity. The criteria for classification are connected to the material flow. The information set criteria for grouping are the following:

- information set inducing the material flow;
- information set accompanying the material flow;
- information set confirming the material flow.

A simplified model for the material flow connections is shown in Figure 3.

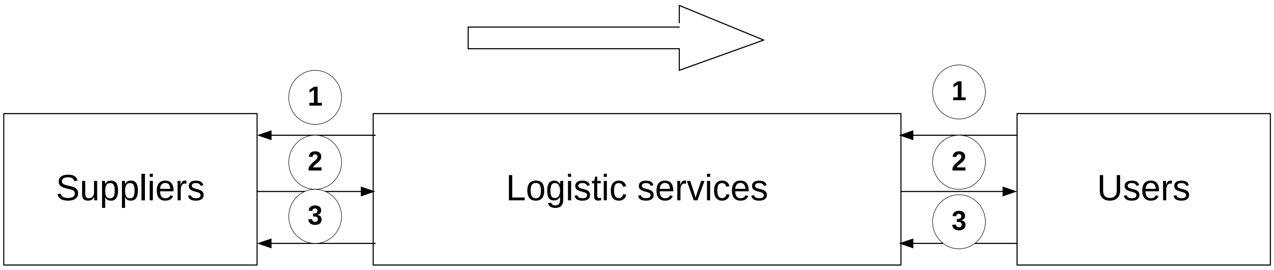

Figure 3: Information flow relationship model.

The notations for Figure 3 are shown in Table 2.

Table 2: The notations.

← (1)	Information inducing the material flow
→ (2)	Information accompanying the material flow
← (3)	Information confirming the material flow
⇨	The material flow direction

According to Figure 3, one can deduce the following:

- The information set inducing the material flow is characterised as it precedes the material flow and its direction is opposite to the direction of the material flow. It is called the primary information set.
- The information set accompanying the material flow is characterised that it flows simultaneously with the material flow in time and its direction is the same as the direction of the material flow. It is used to call the secondary information set.
- The information set accompanying the material flow is characterised that it is generated after the completion of the material flow and its direction is opposite to the direction of the material flow. It is used to call the tertiary information set.

The management of the information flow sets and the logistics system has a continuous connection in time.

Further, the development of information flow in logistics systems is a function of the material flow system. In education, great emphasis must be placed on becoming acquainted with the possible solutions of product identification. The product identification systems affect the reliability of information duration, as well as of the pace of decision making regarding management.

MANAGEMENT OF LOGISTICS SYSTEMS

Due to its complex structures, the management of logistics systems requires the formation of autonomous units and the aggregation of intelligence that is able to solve groups of problems individually. These autonomous groups receive only the information that is relevant for them. This leads to the development of a structure that enables the proper distribution of information. The navigation system of logistics systems is characterised not only by this distribution of intelligence, but also by its hierarchical structure.

As an example, the hierarchical structure of production logistics with the distribution of intelligence is shown in Figure 4. It should be noted that in education, both the navigation systems of the logistics systems and the investigation of the applicable strategies receive a high degree of focus.

SOME METHODS IN THE EDUCATION OF LOGISTICS

Logistics is an integrated science, and as such, appropriates existing methods from other sciences in order to optimise the planning, construction, management and monitoring of logistics systems. The applied methods are as follows:

- To search transport centres by mathematical methods, to choose suppliers by mathematical methods, installation and design by mathematical methods, to form unit loads by mathematical methods and design of different circular flights.
- Flight designs.
- Mathematical design of multi-stage collecting and distributor systems, mathematical treatment of logistics costs, stock management models and simulation methods.
- Quality management methods, etc.

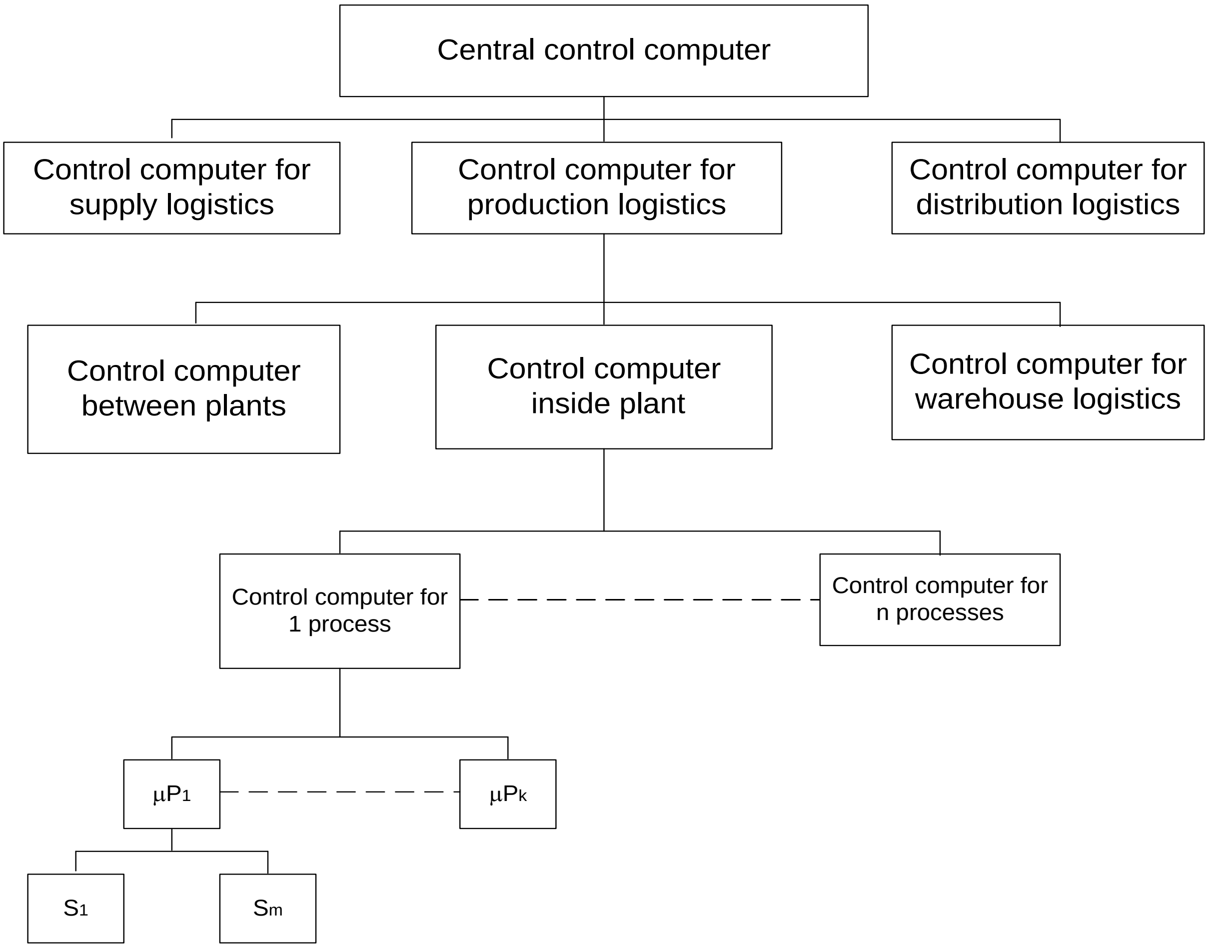

Figure 4: The structure of a hierarchical logistics management system with distributed intelligence.

CONCLUSION

The above-mentioned considerations outline a few of the reasons why the education of logistics requires a structured programme that allows for imparting a constantly changing and complex knowledge base. In order to provide a high quality, up-to-date and modern education, research in the application of industrial and economic uses, as well as networking with international stakeholders must be built in to the curriculum.

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Common, international and academic education in logistics

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ABSTRACT: Academic education should prepare students for their profession in an effective and efficient manner. The most important individual factors for success in the profession as a logistician are: sense of responsibility, customer-orientation, goal-orientation, self-motivation, analytical thinking, problem-solving competence, social competence, creativity, ability to work in a team, good manners, ability to impose the will and persistence, flexibility, decision competence, integrity, self-reflection, ecological thinking, mobility, international skills, learning abilities and management skills. Academic courses in logistics are no longer conceivable without modern teaching methods aided by modern I&C technologies. In this paper, some highlights of the educational programme at Otto-von-Guericke-University Magdeburg, Germany, are presented and discussed. These are management games, Web-based contents and tasks, laboratories with radio frequency identification (RFID) and virtual technologies. These teaching forms are also the result of a long international cooperation.

INTRODUCTION

The 21st Century has been dubbed the era of information and media technologies. As one important result of the widespread use of personal computers and the systematic extension of network computer architectures, the importance of acquiring, processing and disseminating information and knowledge has decisively increased. Therefore, following on from that logistics is no longer conceivable today without modern I&C technologies. This also applies to teaching methods.

In the following, some highlights of the educational programme of logistics are presented:

- The laboratory for analysis of logistical processes and logistics planning with VR technologies.
- The laboratory for order picking and order fulfilment (warehouse).
- Management games and the Fraunhofer laboratory LogMotionLab.

The difficulty is not to teach the content of a method, but rather it is the challenge to teach the understanding of a method in the context of all other activities. Knowledge about methods was transferred only in a theoretical manner in past. However, it is not enough to know what should be better, the logisticians have to change it by their own. That is the reason why the academic education in Magdeburg also uses different kinds of practical training and games to enable students to generate practical experience and competence.

LABORATORY FOR ANALYSIS OF LOGISTICS PROCESSES AND DATABASE OF LOGISTICS METHODS

This computer laboratory has twenty places with one laptop per user. Practical training is provided in process analysis, logistics planning, information logistics with SAP®, modelling, simulation of logistics processes and systems and other lessons and trainings.

Methods in logistics are used all over the world. Therefore, they should also be accessible from anywhere [1]. A multilingual and Web-based database called *mlog* has been developed over the last few years. The method database is a prototype to evaluate the progress and state of research of methodical knowledge in logistics. Its two advantages are: first, is the capacity to be able to validate and verify ideas in method research; and second, to use a new perspective on methodical knowledge to improve research. The core of the mlog method database consists of several widely integrated modules (see Figure 1). The hard-core module is the presentation module for methods. Therewith, it is possible to show the method content as a Web page on the Internet or a Web page for printing. It also allows PDF documents to be created for on-line and offline reading.

Starting from this point, several search mechanisms have been implemented. These include a dynamic multi-language index of methods, a keyword search, a glossary and a branch-related index for the definition of the methods fields of application or branches of usage.

Figure 1: Mlog - a method data base for logistics (www.ilm.ovgu.de/mlog).

An internal messaging system with two main tasks has been implemented. A management module to support the administration tasks of this complex database-driven on-line application has also been developed. Tasks supported by this tool of the actual prototype include the creation and change of content for different kinds of users, such as:

- method content such as descriptions, references, graphics;
- literature references e.g. books, scripts and Web sites (URLs);
- user entries including username, password, statistical data;
- supporting information such as glossary and FAQ; and
- an index as a search tool.

The newest development includes an on-line calculation module. This provides calculation support for a numerical calculation and dimensioning methods in logistics engineering. For future development, the following three steps are to be carried out:

- completion of the development of the on-line calculation tool;
- introduction of method interaction abilities; and
- integration of problem and learning arrangements.

PROBLEM-SOLVING COMPETENCE BY USING METHODS OF QUALITY MANAGEMENT IN LOGISTICS

Quality Management (QM) methods are a major field in logistics. Everyone knows that failures can happen anywhere and that there are many options for improving processes. The task is to use the knowledge of quality management to prevent failures and to solve problems, both effectively and efficiently. This task is not an easy one, especially in logistics networks, where a failure can have many causes. A cooperative project between universities in Santa Clara, Cuba (Prof. Norge I. Coello Machado) and Miskolc, Hungary (Prof. Béla Illés) led to a teaching book being written, which deals with this topic. It was published in German and Hungarian. The Spanish and the English versions will be published in 2012:

Table 1: Common teaching books for teach-yourself studies in Hungarian and German.

	Illés, B.; Glistau, E.; Coello Machado, N.I.: Logistik und Qualitätsmanagement. Teaching book. 1. Edition Miskolc (Hungary) 2007. 195 pages. ISBN: 978-963-87738-1-4 (German) Illés, B.; Glistau, E.; Coello Machado, N.I.: Logistika és Minöségmenedzsment. Teaching book. 1. Edition Miskolc (Hungary) 2007. 195 pages. ISBN: 978-963-87738-0-7 (Hungarian)

Logistics process analysis starts with logistics quality. Logistics quality can be defined as the extent to which a logistics process fulfils the requirements of the customers in the sense of EN ISO 9000:2005 [2]. Customer satisfaction is the most important aspect when discussing quality issues. Customer satisfaction is defined (in Ref. [2]) as customer perception of the degree to which the customer requirements have been fulfilled. Characteristics are the capacity to deliver, the time needed for delivery and punctuality. To assure the quality of logistics processes, it is necessary to deal with failures and defects. Therefore, standard processes need to be developed to realise that in a systematic and holistic way.

The use of well-known QM-methods makes it possible to recognise failures and their causes in order to analyse logistics processes and systems (Figure 2).

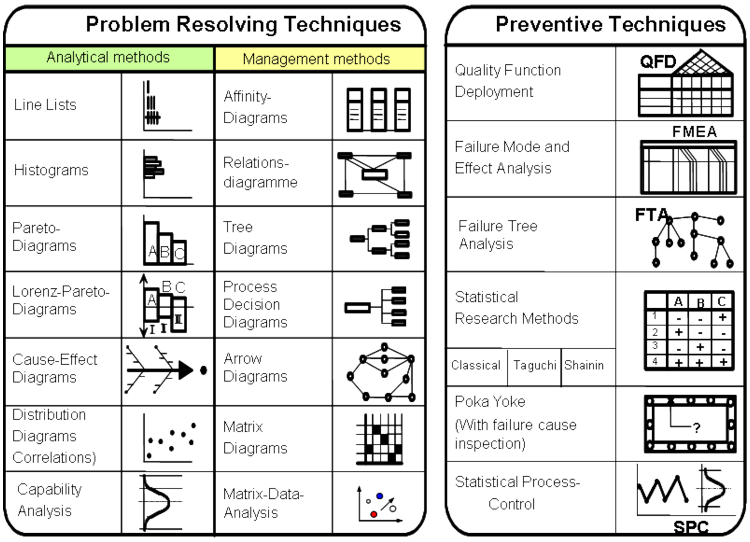


Figure 2: Overview of some important quality management methods [3].

This is a good way to see the causes in a timely and effective manner. After that, the next step is to eliminate the causes.

In the computer laboratory of Otto-von-Guericke-University, all these methods are applied in practical training. Therefore, different standard software is used: Microsoft Excel, Microsoft Visio and SPSS. The main idea is to gain one's own experience to practise problem-solving processes by using these methods and to hold practical discussions about them. After completing the training, the students should have created their own tool-set to solve problems in practice.

The practical education is provided as follows: every student has to download four databases at the beginning of practical training: 1) theoretical background; 2) task; 3) solved example as a reference solution; and 4) own data and space to come up with one's own solution of the problem. In this way, she/he creates and improves her/his own knowledge base. The tutor gives a short introduction and motivation of about ten minutes. A short discussion shows the way to solve the problem by using a reference solution. After that, every student has to solve the task on their own. This can be done in the laboratory with the possibility of being coached by the tutor or it can be self organised at home. The focus of the training is to build one's own competence in practical problem-solving. The solutions of each task have to be sent by e-mail to the tutor. At the following practical training class, collective feedback is given to all students with a short verbal reflection on problems, difficulties, misunderstandings, hints and some new ideas to improve or modify the methods and the problem solving method as a whole.

BICYCLE FACTORY - STUDENT IN THE ROLE OF A CONTROLLER

It is not very exciting to teach indicators. That is why it is useful to do so in a specific manner. Therefore, a computer game is used, in which the student takes on the role of the controller of a factory that produces bicycles (Figure 3).

The story behind the game is that that the boss is awaiting for a new controller's (student) brief report. She/he is interested in how the new controller will interpret the logistics indicators. The controller has to evaluate the current situation. Therefore, indicators are necessary; hence, knowledge is required on the indicators that exist and how to calculate them and which data are required [5-7]. The data are stored in the same database as they would be in reality. Some data are missing and the student has to assume this. The student also obtains some information from a video, other information from reports, and further information drawn from collected data.

The student's task is to:

- understand and accept the task and the role of the controller;
- obtain an overview about the company and about its individual departments;
- make a self study about indicators;
- find or to assume the data which are necessary;

- calculate the indicators in the correct manner [VDI 4400];
- interpret the indicators (with colours like traffic lights: green = o.k.; yellow = attention; red = big problem, alarm);
- evaluate the current situation as a whole and in detail;
- offer suggestions to improve the processes.

The results are Excel spreadsheets with indicators and individual comments.

Figure 3: Bicycle factory (available in German and English).

LOGISTICS PLANNING WITH VR TECHNOLOGIES

Another self-study activity is to create a planning concept for a distribution centre. The students download the task and related data. They receive coaching about the task from tutors. The tutors are students who are close to finishing their studies. For the task, participants are divided into two-person teams.

At first, each team has to do the theoretical work with many calculations. It starts with the goals and the restrictions of the planning task, the description of the various functions and chains of material and information flow, the forecast of the future development and the calculation of process times of the material flow. Both students reach the same results in this step.

The second part is an individual design part. The student has to create a new and individual solution by using VR planning tools. This is a fast way to do it and it provides fast feedback to the student about his or her work. A useful, intelligent and very *nice* solution will make her/him proud of her/his own work and will provide a very good motivation. Important results are the model, the kind and amount of technical equipment and the invest costs of the whole. TaraVRbuilder is a software tool for 3D configuration (see Figure 4) and time-based simulation of conveying, material flow and storage/warehouse equipment using virtual reality technology. The programme is used to visualise and analyse plants. Possible applications exist in the fields of sales support, planning, engineering and documentation.

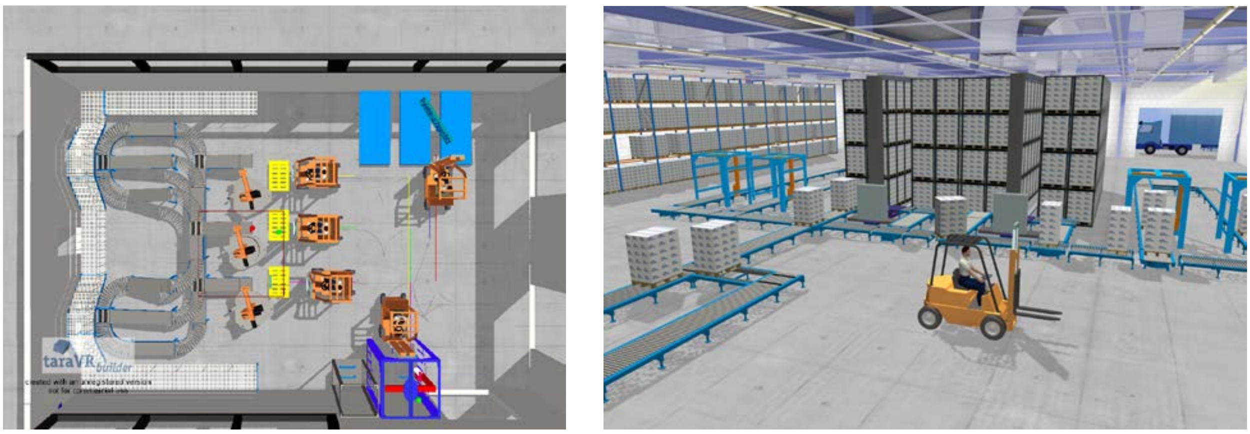


Figure 4: Example of a student solution and a demo by using the VR planning tool taraVRBuilder [11].

The third part is the evaluation of each team's design solution. The students have to define their own criteria, undertake a cost benefit analysis and give a projection which of the two solutions will be the best. This part is a self-feedback of their own work. The students find that this third part is the most difficult, because every student likes their own solution more than the other solutions and it is not easy to accept a better one and to learn how to do it better next time.

LABORATORY FOR ORDER PICKING AND ORDER FULFILMENT (WAREHOUSE)

Ten students and one tutor can make a realistic role-play in a distribution centre. The core roles of the laboratory are picking processes and warehousing (see Figure 5). There are five pharmaceutical products available in the warehouse.

Figure 5: Students and tutors at work in the laboratory.

In this laboratory, the students learn:

- Strategies of warehousing, of order picking and common logistics strategies and rules like KANBAN.
- Methods to optimise processes.
- Methods and different kinds of communication.
- How and where information processes can be automated.
- How is the material flow between factory – warehouse and customer to be organised.
- How are the flows of empty boxes, cartons and waste to be organised.
- How the information flow between the customer and the order taking office of the warehouse is to be organised and which other information flows are necessary to fulfil the order in the right manner.
- The dependence between information flow and material flow.
- How the financial flow is to be organised as a whole.
- Which problems and failures are typical and have to be solved by standard processes.
- Which problems should be solved by fast-tracked problem solving.
- Organisation of working places.

The ten working places with their main tasks are:

1. Customer (gives the order, changes the order, asks for the status of the order, checks the delivery, claims if necessary, pays the order);
2. Order taking office (communicates with the customer, takes the order, verifies the order, collects all data of the order, transmits the data to the dispatch and finance manager);
3. Dispatch and finance manager (disposes the orders to delivery tours, creates the delivery notes and the bill);
4. Commission manager (makes intern orders and gives them to the picker);
5. Picker (pulls the orders, picks the goods according the orders, checks his work by his own, transports the boxes to the packer);
6. Packer (checks the number of goods according to the order of the customer, verifies the completeness of the order, packs the goods, addresses the packaging);
7. Freight forwarder carrier (does the transport of goods to the customer);
8. Producer (produces goods, puts them into boxes);
9. Reception of goods (checks all deliveries, pays for the deliveries);
10. Warehouse manager (manages the puffer stock, realises input in the flow rack, checks the inventory).

LABORATORY FOR MOVING LOGISTICS ASSETS *LOGMOTIONLAB*

The Fraunhofer IFF *LogMotionLab* provides support to face the new challenges in logistics successfully. In the LogMotionLab RFID technologies are tested and neutrally assessed for their practicability for specific business processes. More information about the LogMotionLab is available in Ref. [10].

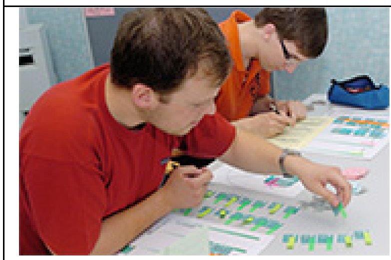
The laboratory is a very useful experience field for the students in Magdeburg as they will become familiar, for example, with:

- data carriers for use in the industrial environment;
- demonstrators for presenting typical RFID scenarios;
- technologies for localising assets indoors and outdoors (RFID, wireless LAN, GPS, GSM);
- infrastructure for piloting and customised solutions;
- devices for communication.

MANAGEMENT GAMES

Playing a management game helps to employ the knowledge acquired with a long-lasting effect [8]. As a rule, a management game seminar involves a 1.5 day course with part theory and part game. There are different management games used in Magdeburg [9]. Some of them are listed in Table 2.

Table 2: Two examples of management games [10].

 Prepares upper level university students as well as experts and executives from industry for the challenge of maintenance and spare parts logistics; 6-12 players.	GINGER - Maintenance and Spare Parts Logistics Management Game The manual management game GINGER tangibly and vividly describes the interrelationships and dependencies between production, maintenance and spare parts supply. In the process, it demonstrates challenges and approaches in the holistic management of maintenance and spare parts logistics. Predetermined, condition based and corrective maintenance strategies are taught with appropriate spare parts logistics strategies.
 Prepares university students as well as specialists and executives from industry for the challenge of Supply Chain Management; 8-14 players.	SILKE - SCM Management Game - Control of Integrated Supply Chains [8]. The management board game SILKE demonstrates the fields of problems and solutions when managing multistage supply chains with intra-company and inter-company processes. Apart from general logistics tasks, such as production programme planning, capacity planning and the MRPII concept, primarily more complex correlations of Supply Chain Management are presented and clearly resolved.

SUMMARY

The mix of special learning arrangements, training, practical experience, self-studies and management games have been delivering optimal performance in practice for some years.

Academic education in logistics at the University of Magdeburg has been evaluated and ranked highly in Germany by several independent evaluation institutions.

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Mathematics in engineering education

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ABSTRACT: Mathematics is a cr ucial language in all engineering courses and research in which mathematical modelling, manipulation and simulation are used. It is widely recognised, though, that engineering mathematics courses are regarded by students as a very difficult part of the engineering education curricula. This is reflected in engineering students' performance at the end of each semester when examinations for these courses are conducted. The main objective of this paper is to overview some concepts, ideas and questions with regard to mathematics as a fundamental subject of engineering studies.

INTRODUCTION

Undoubtedly, an engineer should have a good command of fundamental mathematics. The objective of teaching mathematics to engineering students is to find the right balance between practical applications of mathematical equations and in depth understanding of living situations.

Mathematics is a cr ucial language in all engineering courses and research in which mathematical modelling, manipulation and simulation are used extensively. Therefore, engineering mathematics courses are regarded as difficult courses in engineering education curricula. This is reflected in engineering students' performance at the end of each semester in these courses.

At all levels of education, the traditional method of teaching is lecture-based. The description of a lecture is conducted by using this traditional method. Even though this method is able to provide students with knowledge and produce graduates, the attention of the majority of students is superficial and their focus is on the development of exam-passing abilities.

In teaching engineering mathematics courses to engineering students, it has subsequently been found that they encounter difficulties and act indifferently toward this learning method. Students often regarded engineering mathematics courses as uninteresting and a difficult part of the engineering curriculum. The main problems are first year students' varying levels of knowledge in mathematics and low participation in teaching. Other possible factors are motivation, ability to work independently and acclimatisation to the university study environment.

On the other hand, the impact of mathematical thinking skills on engineers will enable them to use mathematics in their practice [1]. The attitude of engineering undergraduates toward mathematics was studied by Miika et al and this provides a better understanding of engineering students' actual knowledge and the lack of knowledge in mathematics [2].

It addresses long term needs for abilities and skills because these impose strong constraints on secondary and even on elementary education. The goal of higher education is to produce competent engineers. To do this, the university's academic staff need students to bring certain skills with them from high school and develop them further.

Mathematics is a fundamental subject for all engineering courses and research in engineering, but current educational approaches do not provide enough functionality to bring it to life. Current introductions to problems have passive understanding as their goal, rather than getting students to do things with them. A more active approach could be successful in real life settings. An overview of the structure and practice of mathematics was given by Quinn in 2011 [3].

Precision and Functionality

Mathematics has elaborated a set of explicit rules of reasoning. People often have trouble learning to use these rules effectively, because rules in most other systems are sufficiently unclear and ineffective, and precision is a waste of time, whereas in mathematics anything less than full precision is a waste of time.

Students should be taught to record their reasoning in a way that can be checked for errors. Criteria for good work formats are:

- Record enough detail so reasoning can be constructed and checked for errors;
- Be compact and straightforward;
- Help to organise the work in ways consistent with human cognitive constraints.

The most important strategy is the teacher's diagnosis of errors that students cannot find themselves. Wrong answers should be corrected. The student should explain his or her reasoning following his or her written work record. If the record is incorrect, steps were skipped or appropriate templates were not used, then, the work should be redone. If the work record is appropriate, then, it can be reviewed and mistakes quickly corrected.

Definitions and Key Statements

The important objects, terminology and properties should be given by brief and precise formulations:

- The formulations should be constructed primarily by professional mathematicians with education feedback.
- Students should memorise them, so they can be reproduced exactly. Definitions provide key points and functional understanding deepens around the definitions.
- Explanation of what a definition means is best given after the definition, not before. Putting too much explanation first almost guarantees confusion.

Intuition

A great deal of mathematical activity is guided by intuition. Intuition developed by working with a good definition is often effective. Intuition based on the meaning of a physical analogue is almost never satisfactory, but is acceptable if passive understanding is the goal.

In practice, it is not enough just to have good basic mathematics knowledge. An engineer is also required to have good generic skills, such as good communication skills, positive thinking and to be able to work independently. A mathematical model is developed to represent a p hysical phenomenon and this model is analysed and solved mathematically. A mathematical conclusion about the model is reliable when the connection between the physical situation and the model is appropriate.

Mathematics is a basic subject for students of engineering. In structuring the topics, the goal is to teach useful methods to future engineers. For future studies, the methods and simple applications are essential. Considering the main objective of mathematical training at technical universities is to teach students to solve applied problems. Mathematical skills are used to describe and cope with a wide range of problems. These key skills are about:

- understanding when particular techniques should be used;
- how to carry them out accurately; and
- which techniques should be applied in particular situations.

THE APPLICATION OF DIFFERENTIAL EQUATIONS

Many natural laws outline a relationship between the rates of change of various quantities, rather than the relationship between the quantities themselves.

The rate of change of a q uantity is represented by the so-called derivative of this quantity. An equation involving derivatives is called a differential equation.

Differential equations have had a great influence on the history of science and demonstrate that mathematical methods can be applied to the real world. Some of the uses of differential equations are shown below, starting with the origin and, then, showing later applications in other fields of science [4][5].

The subject of differential equations has its primary historical origin in Newtonian mechanics, so it is necessary to begin by saying something about Newton and his results. Isaac Newton was born on Christmas Day 1642. It was a premature birth and according to the tradition, he was *small enough to fit into a quart mug*. From this modest beginning, he became one of the world's greatest scientists. His scientific work was based on differential equations, which he applied successfully to the study of nature.

For example, Newton's second law of motion (force) = (mass) x (acceleration) is a differential equation. When combined with his law of gravitation, Newton's laws of motion enabled him to compute the orbit of the planets, the Moon and comets. He estimated the weight and density of the Sun and Moon. When only the Sun and a single planet are considered, the differential equation obtained by Newton is solvable in an elementary way. As a result, Newton could give a brief derivation of the three laws of Kepler, which Kepler developed through a lifetime of astronomical observations. The problem of determining the motion of two gravitating masses, such as the Sun and a planet, is called two-body problem. The three-body problem is to determine the motion of three gravitating masses, such as the Earth, Sun and Moon. This problem is not elementary at all. Many famous mathematicians haves dealt with this problem since Newton.

Many excellent mathematicians have worked on differential equations. Some of the leading names are Leibniz, Daniel Bernoulli, Euler, Laplace, Lagrange, Fourier, Poincare, Picard, Liapunov and Volterra. These later researchers showed that differential equations can be applied not only to Newtonian mechanics, but to a wide variety of scientific fields. For example, differential equations can be applied to fluid flow, propagation of sound waves and the flow of electricity in a cable.

Fourier's book published in 1822, *The Analytic Theory of Heat,* has been called the Bible of mathematical physics. By using differential equations, Maxwell predicted the existence of electromagnetic waves (radio waves) before they were observed experimentally by Hertz. The theory of geometric optics depends on differential equations, and so does the theory of deformation of elastic structures (beams, membranes, etc). Chemical reactions and radioactive decay can also be modelled by using differential equations.

These examples come from such fields as physics, chemistry and engineering, which are sometimes referred to as the *exact sciences*, where the relevant differential equation can be formulated easily.

There are other fields in which differential equations are also essential. Some of these topics are related to economics, ecology and biology. For example, the successful programme of eradicating smallpox is dedicated to Daniel Bernoulli, who set up a differential equation for the progress of an infectious disease in 1760. His work gave a scientific justification for the risk of vaccination.

Another example, when differential equations can be used, is to study the fluctuations of animal populations, such as the Arctic fox or fish in the Adriatic. Both these examples have played a role in the development of mathematical ecology.

Further examples can be given by the mathematics of heart physiology, the transmission equations for nerve impulses, the growth laws of tumours, etc.

To conclude, it would be a mistake to think that differential equations are important only in connection with other fields of science. The *Mathematical Reviews* publishes abstracts of more than 75 new papers on differential equations per month and the number has been increasing from year to year.

If one wants to describe a movement or process by differential equation first one needs a mathematical model. The mathematical description of a phenomenon always entails some simplification. A more exact representation of a physical phenomenon can be described by a more complicated differential equation, which makes it possible to take additional factors into consideration. Providing solutions to some complicated problems or to characterise their properties are still open for the researchers.

AN EXAMPLE: CHAIN CURVE - CATENARY

Take a flexible chain of uniform linear mass density. Suspend it from its two ends.

What is the curve formed by the chain?

Galileo Galilei said that it was approximated by a parabola. This time Galileo was not correct. This curve is called a catenary. Let us determine the shape of the chain.

Let us denote by P an arbitrary point on the chain and the point on the chain located at the origin of the Cartesian coordinate system is denoted by O. Moreover, let the low point of the chain be the origin. Take a part of a chain in the interval between O and P. It is assumed that the chain is at rest. That means that the net force on it is zero. There are three forces acting on the chain interval OP (Figure 1). One force is the tension on the chain to the left. Call this force $\vec{H}$. It acts in a horizontal direction to the left. There is also a force on the chain to the right, exerted at point P. This force is called $\vec{T}$. Its direction is what needs to be determined, because that will describe the slope of the chain at P.

The third force is the weight on the chain, $\vec{W}$. Since this is a gravitational force, its direction can only be vertical and downward.

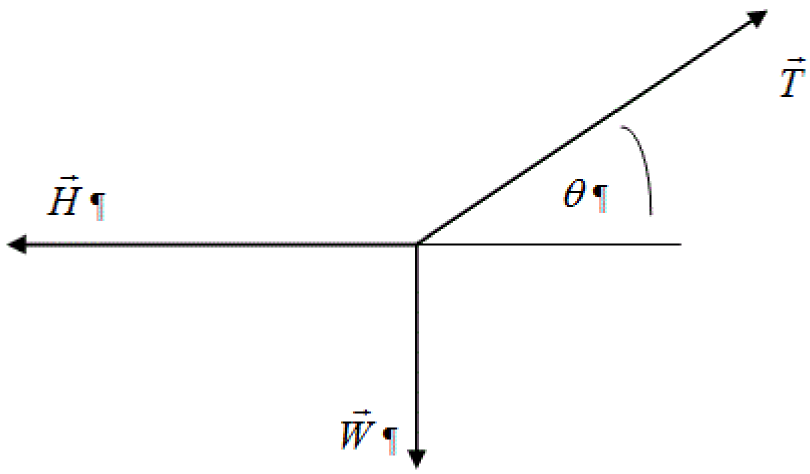

Figure 1: Three forces.

One can see in Figure 1 that the direction of $\vec{T}$, which gives the slope at P. Force $\vec{T}$ has a horizontal component for which:

$$\left|\vec{T}\right| cos\,\theta = \left|\vec{H}\right| \tag{1}$$

and for the vertical component:

$$\left|\vec{T}\right| sin\,\theta = \left|\vec{W}\right|. \tag{2}$$

That means that:

$$tan\,\theta = \frac{dy}{dx} = \frac{W}{H}, \tag{3}$$

where W and H denote the magnitudes for $\vec{W}$ and $\vec{H}$, respectively, and they are not vectors.

The chain carries only its own weight. That weight is proportional to the length of the chain between O and P.

Let us denote by s the length of the chain, where $w\ [N/m]$ is the weight per unit length of the chain, then:

$$W = ws. \tag{4}$$

H is clearly a constant. It is the tension at point O, which is the same no matter what point is chosen for P. W is the weight on the chain between O and P.

Is it possible to show how can it be determined?

Again, the weight is proportional to the length of the chain between O and P. It cannot be computed by simply multiplying the horizontal distance by a constant. Hence the length of the chain between O and P must be calculated.

Let y be the height of the chain. Again, w represents the linear weight density, it is weight per length of chain. If s denotes the length of the chain between O and P, this means that the weight of the chain between O and P must be ws.

One may recall this formula for the length of a curve on the interval (a,b):

$$\int_a^b \sqrt{1+y'^2}\,dx\,. \tag{5}$$

One can use it to find s, the curve length on the interval $(0,x)$:

$$s = \int_0^x \sqrt{1 + y'^2}\, dt \cdot \tag{6}$$

The derivative dy / dx, is itself a function of s:

$$\frac{dy}{dx} = \frac{W}{H} = \frac{w s}{H} \tag{7}$$

and

$$s = \frac{H}{w}\frac{dy}{dx} \cdot \tag{8}$$

Making the substitution for *s* in the integration equation above, one obtains:

$$\frac{H}{w}\frac{dy}{dx} = \int_0^x \sqrt{1 + y'^2}\, dt \text{,} \tag{9}$$

and, further:

$$\frac{dy}{dx} = \frac{w}{H}\int_0^x \sqrt{1 + y'^2}\, dt \cdot \tag{10}$$

Differentiate both sides of the equation with respect to x:

$$\frac{d^2y}{dx^2} = \frac{w}{H}\sqrt{1 + y'^2} \text{,} \tag{11}$$

or

$$y'' = \frac{w}{H}\sqrt{1 + y'^2} \cdot \tag{12}$$

which is a second order nonlinear ordinary differential equation.

Substituting $y' = p(x)$ one gets the following first order differential equation:

$$\frac{dp}{dx} = \frac{w}{H}\sqrt{1 + p^2} \tag{13}$$

and separating the variables, one obtains:

$$\frac{dp}{\sqrt{1 + p^2}} = \frac{w}{H} dx \cdot \tag{14}$$

Let us take the integral of both sides:

$$\int \frac{dp}{\sqrt{1 + p^2}} = \int \frac{w}{H} dx \text{,} \tag{15}$$

and apply the primitives to both sides:

$$ar\,sinh\, p = \frac{w}{H}x + C \tag{16}$$

with integration constant C. Hence:

$$y' = p = sinh(\frac{w}{H}x + C) \text{,} \tag{17}$$

and

$$y = \int \; sinh(\frac{w}{H}x + C)dx = \frac{H}{w}cosh(\frac{w}{H}x + C) + D \text{,} \tag{18}$$

which gives the general solution to the second order differential equation.

In order to determine constants C and D one can apply the initial conditions formulated at the low point of the chain O:

$$y(0)=0, \qquad y'(0)=0.$$

From condition $y'(0)=0$ it follows that $C=0$ and from $y(0)=0$, one obtains:

$$0=\frac{H}{w}\cosh 0+D, \qquad D=-\frac{H}{w}.$$

This means that the shape of the chain can be formulated as:

$$y=\frac{H}{w}[\cosh\frac{w}{H}x-1]. \tag{19}$$

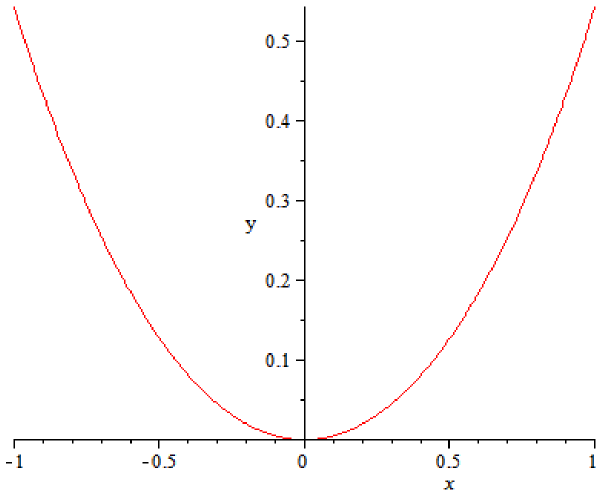

Figure 2: The figure represents the shape of the chain - the catenary.

It should be noted that this curve is very often used in the construction of kilns and gateway arches (See, e.g. *Gateway Arch* in St Luis or Gaudí's *Casa Milá* in Barcelona, Spain).

ACKNOWLEDGEMENT

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The need for business competencies and knowledge for engineering students - an example of the University of Miskolc

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ABSTRACT: The University of Miskolc was established as a heavy industry university in the late 1940s. The whole culture and atmosphere of this institution was based on the fact that only engineering and technology education was in the training programme. After a few decades, the University has grown considerably and now has a wide range of research, education and training activities. An engineering student (whether mechanical, mining or electrical) can no longer obtain a degree without passing several courses related to economics and management. Nevertheless, most of the students do not even think that they will ever attempt to study the subjects of those courses. This study endeavours to show the attitudes and opinions of the students about their training programmes regarding the supportive courses in the field of business and management. The approach is to compare the needs of the labour market, the structure of training, the educational cultural facts and the results of a research questionnaire distributed to engineering students.

INTRODUCTION

Intolerance Towards Business Studies or Inappropriate Curriculum

The aim of this study was to ascertain a clear view on students' perceptions about the courses taught to them by the Faculty of Economics (referred to in this paper as business studies; economics students, business students, students of the Faculty of Economics are used here as synonyms). The results could be used to improve the curricula, especially the courses designed for engineering students.

The Institute of Management was called the Department of Industrial Economics, a part of the Faculty of Mechanical Engineering from 1957 until 1987. This Department was the essential basis for the foundation of the Faculty of Economics, and now, it is part of this Faculty in the organisational structure of the University of Miskolc.

Most of the courses have a strong engineering approach; nevertheless they are not favoured by engineering students. This dislike by the students was only noticeable at the seminars and never examined before. From another point of view, feedback can be given to the respondents about the utility of the questioned skills and competencies.

None of the respondents was aware that the questioned competencies were not selected randomly but they were the ones that employers described as being the most important ones for their future employees [1][2].

The Institute of Management Sciences is committed to the quality improvement of the University's activities and the Faculty of Mechanical Engineering and Informatics is a great partner in that common goal.

The Questionnaire

The survey questionnaire was distributed to 262 students from the Faculty of Mechanical Engineering and Informatics. To collect data for comparison, a survey among the students of the Faculty of Economics was also conducted. There were 81 respondents.

Both Faculties sent requests through the e-mail address lists of the Student Council to Bachelor and Master students, and Bachelors were asked to state the current year of their studies. None of the questions were compulsory. For that reason, the sum of the results does not necessarily total 100%. The structure of the respondents at the Faculty of Mechanical Engineering and Informatics and at the Faculty of Economics is shown in Figure 1.

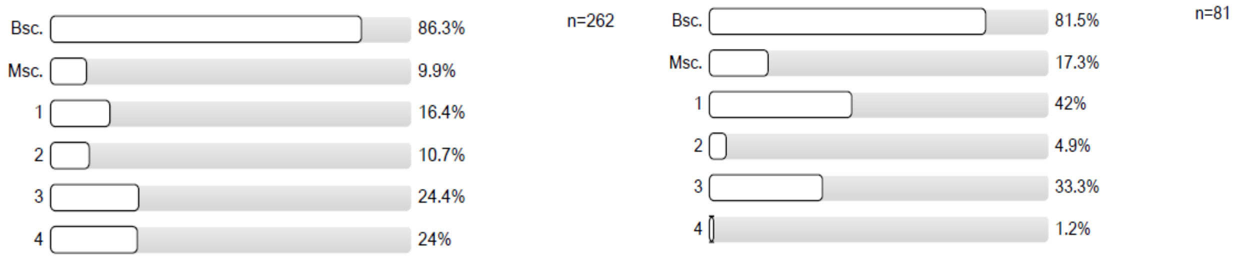

Figure 1: Respondents at the Faculty of Mechanical Engineering and Informatics and at the Faculty of Economics.

In both sets results, it can be seen that more Bachelor students responded to the questionnaire. Among the engineering students, a representative group of students from different school years responded, but more students in their third or fourth study year responded (This was more useful because these students have more experience about the courses). The results obtained from the students of the Faculty of Economics are slightly distorted because they include an over-representation of students in their first year (actually in their first semester before any examinations have been attempted), and students in their third year responded mainly to the questionnaire.

General Questions

A five-point scale was used. In the first part of the questionnaire (general questions), 1 indicated: *absolutely not true* and 5 indicated: *absolutely true*. The general questions were as follows: *The courses taught by (NEn, Ec, NEc) are*:

- *Important to me;*
- *In my focus;*
- *Difficult;*
- *Interesting from a professional point of view;*
- *Useful in my future career;*
- *Useful to get a higher salary in the future;*
- *Giving me a more complex view on the future field of my activity*.

NEn, Ec and NEc refer to the following faculties: non-engineering faculties (NEn), Faculty of Economics (Ec) and the non-economics faculties (NEc). Engineering students were asked about the NEn and Ec courses, and business students were asked about the Ec and NEc courses. Results from the two different samples were not compared for the general questions. Only differences between the answers about Nen-Ec and the answers about Ec-NEc courses were examined in their own context. The results showed that engineering students do evaluate the business studies below average among the other courses taught by NEn faculties. The average values were:

Table 1: Results of the general evaluation among the engineering students.

The courses taught by non-engineering (NEn) faculties are:						
Important to me	In my focus	Difficult	Interesting	Useful in career	Useful for salary	Giving Complex view
2.7	2.4	2.9	2.7	2.7	2.5	2.7
The courses taught by the Faculty of Economics (Ec) are:						
Important to me	In my focus	Difficult	Interesting	Useful in career	Useful for salary	Giving Complex view
2.4	2.3	2.7	2.4	2.6	2.4	2.6

Table 2: Results of the general evaluation among the economics students.

The courses taught by non-economist (NEc) faculties are:						
Important to me	In my focus	Difficult	Interesting	Useful in career	Useful for salary	Giving Complex view
2.9	25	2.8	3.2	3.1	2.6	2.7
The courses taught by the Faculty of Economics (Ec) are:						
Important to me	In my focus	Difficult	Interesting	Useful in career	Useful for salary	Giving Complex view
4.4	4.3	3.9	4	4	3.9	3.8

The engineering and business students rated the subjects outside their own field of expertise similarly. The business students appreciated the courses of NEc as being interesting and useful in their future career more than the engineering students. Of course, the trivial fact that the business students focus more on their own subjects than engineers can be seen.

Expected Competencies

A survey designed by the Institute of Management Science identified the need for several competencies of the employees of the companies that responded to this survey [1][2]. These competencies are:

1. Logical thinking;
2. Sense of reality;
3. Profoundness;
4. Reliability;
5. Professional skills;
6. Ability for understanding the others;
7. Self-development capabilities;
8. Cooperational skills;
9. Honesty;
10. Ability to learn from mistakes;
11. Decision-making skills;
12. Oral communication skills.

(These numbers will be used for identification of the competencies at the figures below).

The companies searching for engineers and economists highlighted these competencies. The demanded general skills and capabilities did not differ significantly between the two professions (except professional skills) so both samples were used. The aim was to examine the ideas and opinions of the students about the selected competencies from two points of view. One was the utility of these competencies in the eyes of the students. The other part was about the contribution of the courses taught by the Faculty of Economics to improving the students' skills in the aforementioned competencies.

All the questions were based on a 5-point scale. The questions were stated as:

How important could these competencies be in your future? 1 meant *not important* at all; and 5 meant *very important*.

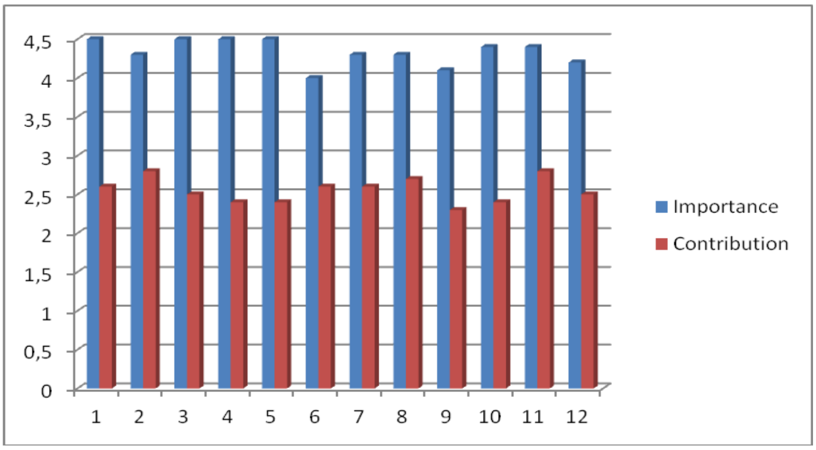

Figure 2: Importance of the competencies and the contribution of the business studies rated by the engineering students.

As can be seen, the engineering students are fully aware of the importance of the demanded competencies (4.5 was the maximum and 4.0 the minimum). The contribution of the Faculty of Economics to acquire them is poor. The best contributions are in the fields of decision making and sense of reality (both averaged 2.8) and the lowest was honesty (2.3). The backround to the results should be examined.

Perhaps the curriculum should be redesigned in order to make it more interesting and more useful. In addition, the utility of the business subjects must be emphasised by the lecturers. Knowledge transfer must occur by explaning the business point of view of the studies but through the eyes of the engineer. The next figure shows the results among the students of the Faculty of Economics. These results provide an opportunity for a more precise approach.

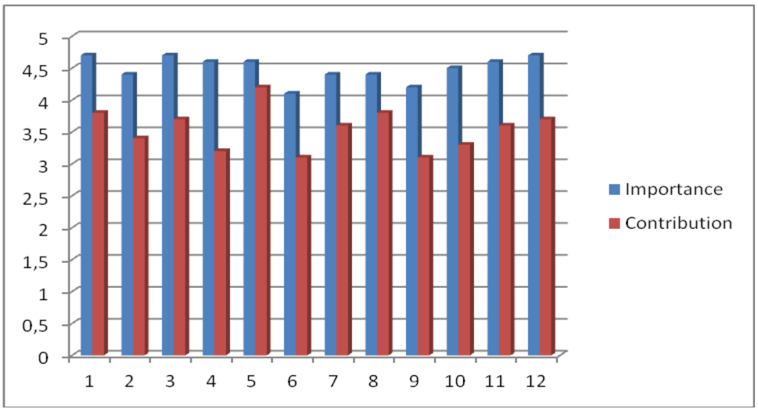

Figure 3: Importance of the competencies and the contribution of the business studies rated by the business students.

The business students also think that the competencies are important to them (4.7 was the maximum and 4.1 the minimum). The contribution here shows a better state. The poorest contribution was by honesty (just as in the engineering students' sample) and the best contributions (not mentioning professional skills with 4.2, which must be the most important of all) were in the field of logical thinking and co-operational skills (both rated 3.8). The biggest difference between the opinions of the two samples about the importance of the competencies was in the field of oral communication. The engineering students do not think that their communicational skills would be so important for the future; nevertheless, there is a n eed for engineers to have excellent communicational skills, especially in foreign languages such as English or German, based on the experience from employment in the North-Hungarian region (Bosch is one of the biggest employers in Miskolc for engineering graduates).

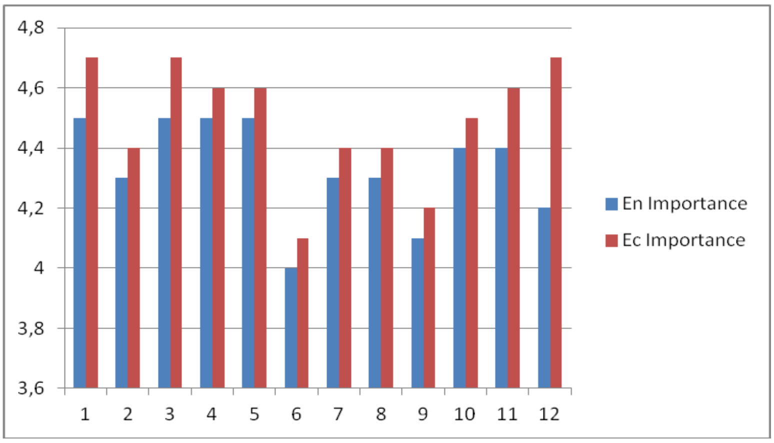

Figure 4: Comparing the results by the importance of the competencies (En: engineering students, Ec: Economics/business students).

The contribution shows entirely different results. This field was relativly poor at both samples (especially by engineering students) but there is a huge gap between them. Perhaps the curriculum should be tailor-made for the engineering students and use different tools, literature and even different methods to help them to get acquainted with the competencies required, throughout the business studies seminars.

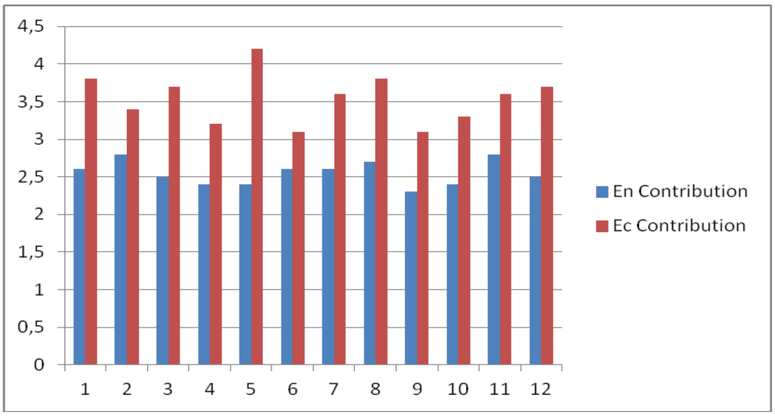

Figure 5: Comparing the results by the contribuiton to the competencies (En: engineering students, Ec: Economics/business students).

CONCLUSIONS

This questionnaire was just the first step to discover the difficulties faced by the academic staff, but it is obvious that there is much to do in curriculum development. Specialisation is needed to satisfy employers' requirements and to encourage the students. Further studies about the special needs of the engineering students from the field of business and economics must be undertaken. Perhaps, this approach is not appropriate for all the students from different faculties, but the tendency is that *...the professions are converging; engineering, medicine, law, and business are moving toward similar project- and problem-based pedagogic frameworks* [3].

Perhaps, the whole structure and implicit idea of the curriculum should be transformed now to provide theoretical and sometimes alternative information that differs from the interest field of mechanical engineers in order to show them the entrepreneurial side of the business studies and encourage them to establish their own businesses. This matter was studied by many researchers, such as Standish-Kuon and Rice [4].

As a competence-based approach, the teaching just started by the University of Miskolc and the Faculty of Economics had its first *Competence Days* where skills, capabilities and knowledge were evaluated by the students. A future goal should be to have continuous competence measurements by incoming students, by those who are still in their studies and by those who have graduated. This system would provide a great opportunity to both the students and academics to improve their personal career and to contribute to improved competencies in a better way. This study is a part of the quality management processes done by the University of Miskolc.

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The *E-matura* project yesterday, today and tomorrow - challenges and opportunities

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ABSTRACT: This paper describes challenges that must be addressed when designing high-availability systems, such as matriculation examinations, which are used by several hundred thousand people at the same time. The methods presented demonstrate how to provide users with continuous and fast access to the system and how to protect this system from unauthorised access by a third party. These issues and topics are presented and discussed in this paper using the *E-matura* project as an example. The *E-matura* system has been designed and built to cope with a heavy load, which is generated by a huge amount of information and data generated by students who sit for the examination simultaneously.

INTRODUCTION

Systems used for providing examinations at a distance must meet stringent requirements for security and high availability from both the programming and from the organisation. To meet this requirement in the *E-matura* project, a range of mechanisms and features that provide a high level of data security have been used. This paper presents the opportunities and challenges faced by the creators of *E-matura*.

A LARGE NUMBER OF USERS AT ONE TIME

One of the fundamental challenges faced in the designing stage of *E-matura* was ensuring high and uninterrupted availability of the examination. During the first attempt to run this examination, access to it was shared by about 3,000 students and the system, with this application, was composed of one application server and one database server. At that time, it was an adequate configuration but it was not sufficient for the future because the number of high school graduates can reach hundreds of thousands.

In cases when thousands of users are referred to the one server at the same time, each connection to this server must be allocated a certain amount of memory and processor time. To ensure the examination availability remains high, the so-called *Load Balancing* solution was used. This solution is based on building server clusters, which can be distinguished in two main parts.

The first part is a computer, which is an access point to the examination. All connections are directed to this computer but they are not served directly but only transferred to computers in the cluster. On the basis of the load management algorithm that is chosen, this server redirects the traffic to the least loaded server in the cluster.

This solution is very scalable and allows unlimited server extensions. The only limitation is the Internet connection at which communication takes place. The additional feature, which this server can meet, is decoding the SSL - encrypted message and passing it forward in the decrypted form, which reduces the load on the target servers, but with large numbers of connections, it can overload the traffic balance server.

Due to the use of the above technique, the scalability of the system is practically unlimited and enables management of thousands of users in a dynamic way. The use of the cluster also ensures the permanent availability of the application because the failure of any of the elements of the cluster does not affect the operation of the system because it can be swapped for another server in the cluster.

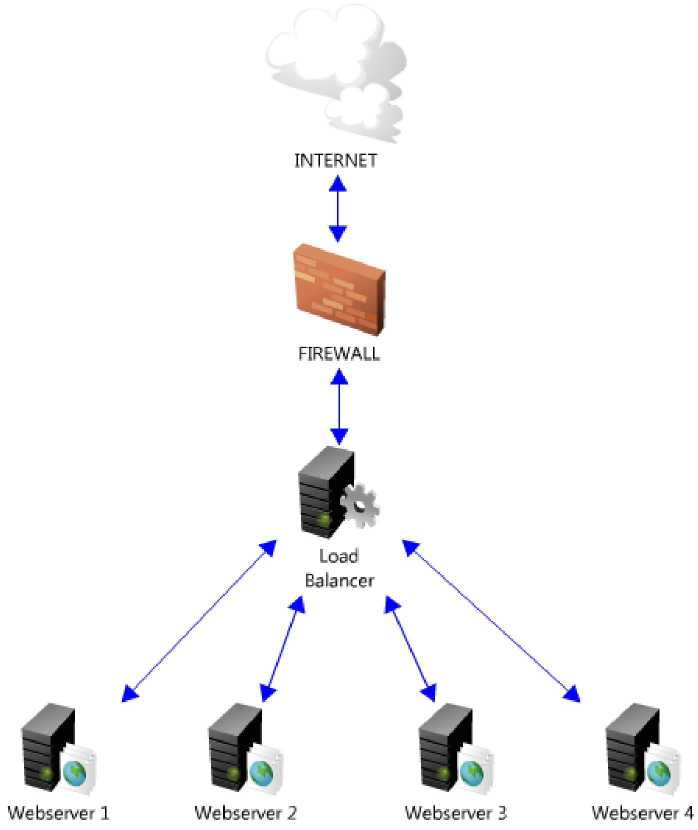

Figure 1: The cluster of servers.

ENSURING PROTECTION

One very important role in designing the examination system is to ensure security during data transmission. To ensure secure communication between the client and the server, SSL technology was used, which helped to secure the system in the two areas:

- Application server verification - each application available through the SSL protocol uniquely identifies the person/system for whom/which a certificate has been issued. Thanks to this solution, the user can check if he/she is acting with the original server;
- Transmitted data encryption - each SSL certificate contains a private and public key, and thanks to this, it is possible to achieve the asymmetric encryption of data transmitted between the client and the server.

The encryption of the connection and the server identification through a certificate, which is issued by the trusted certificate centre, does not provide complete system protection. The user of the system knows that he/she communicates with the original server and the data that he/she introduces does not fall into the hands of a third party. However, the client himself/herself must be properly verified to decide which resources he or she needs to have access to. His/her authentication and authorisation need to be conducted in order for there to be proper user verification. The authentication involves checking if the person is who he/she claim to be, so his/her login name and password are checked. The next step contains the authorisation process that includes checking to which resources/functionalities the user has access rights.

In the *E-matura* system, the authentication for access to the system is built on giving a login name and password, which is checked during logging into the system. If the user gives proper data, he/she is given a specially generated number, the so-called token, which is assigned to the current login session. This token is used as the authorisation in all methods of net service, which is the only communication layer between the client and the server. Because the token is used, the login name and password do not need to be sent at each query to the net service. This improves security by reducing transition of sensitive user data to the minimum.

Having a token lifetime counter provides an additional security layer. Each token has been allocated a life span, which is incremented at each reference to the server. If the time allocated to the token for referring to the system is used up, the token's validity is barred and subsequent access attempts will return an error and redirect the user to the login page. Because of this solution, a token captured on a victim's computer cannot be used on any other computer in a different session.

Because *E-matura* is not an open system, it was possible to add an additional security layer. The registration process begins from the recruiter, who contacts the unit representative, who wants to have the account in the system. This is via personal or telephone contact. Later, the interested person receives a paper form - an application for participation in the programme. By using the traditional verification method at this stage, all persons who want access to the account just to penetrate it have had been eliminated. After the verification of sent data, the interested person receives information, which is required to log into the system. This information is sent to the person by e-mail. The person who receives such an account is then authorised to set up such accounts for the users within his/her unit.

AUTOMATION OF BUREACRATIC PAPERWORK

Conducting the examination for the secondary school certificate is not just an encounter with technological challenges. It is also required to fulfil many formal requirements connected with the storage of personal data in paper form, which must be signed by every examination participant. Without proper authorisation, tens of thousands of students' questionnaires with personal data would need to be supplied to the central registry and manually entered into the system. It would take an enormous amount of time and generate many errors. To avoid such a situation, an automatic management system has been developed.

The teacher, who is responsible for the entering information about students, enters all this information into the system using an administrative module, which is prepared especially for him or her. Next, he/she prints a student card for each student, which must be signed. The key element for this system is the barcode on each card. This solution means that every card has been allocated unique barcode, so that each student can be clearly identified. The cards are scanned by a barcode reader by the central registry, and students' data are marked in the system as verified data.

These data have a paper equivalent with participants' signatures. This solution drastically reduces the amount of work related to the registration of students. Additionally, the number of potential mistakes is also reduced because data are verified while they are entered into the system. Therefore, there are no errors that could be associated with this process.

ELECTRONIC TEST ADAPTATION TO THE PAPER VERSION OF MATRICULATION EXAMIMATIONS

Each examination for the secondary school certificate must meet the requirements of the Central Examination Board. The immense challenge was to analyse and edit questions in such a way that they could be displayed in electronic form and checked automatically on the server. With the help of a friendly institution, which specialises in mathematics and hires people with considerable examination experience, it was possible to achieve mathematics at a basic level, with 95% coverage, which is a very good result according to numerous specialists. Thus, it was possible to overcome barriers with innovative solutions. Such barriers include people for whom the paper and pencil are the only option for taking the examination for the secondary school certificate. Because of good coverage in terms of the content questions of the paper examination for the secondary school certificate and a positive response from students and teachers, an increasing number of people are inclined to attend to an electronic form of examination.

POSSIBILITIES AND CHALLENGES

The *E-matura* system is designed and built to cope with heavy loads, which are generated by the huge number of students who sit for the examination simultaneously. The aim is to prepare the system for the future in order to replace the traditional, trial examination for secondary school certificate with this electronic system. The objective is to apply this system not only to mathematics but also to other examination subjects. The examination for the secondary school certificate, which is conducted electronically, has very high prevalence in comparison to the traditional one, mainly because the costs are lower.

Further, there is no need to employ a large number of examiners to check students' examination results, because the system automatically checks the whole examination and displays the results. There are also no printing costs, which has a very positive impact on the environment. In addition, security is increased because there is no possibility of someone seeing questions before the examination, as was the case when sending and distributing paper-based examinations to carry out traditional examinations for the secondary school certificate.

E-matura is connected not only with savings but also with the possibility of a better analysis of the examination process. Traditional examinations do not provide much feedback, except for student results from each task. The *E-matura* system collects a vast amount of information during the examination such as: the number of attempts at each task and the total time spent on each question or every change of answer. Collecting such data provides the examiners with many options because they would be able to see all the questions that caused students the most problems. Based on this knowledge, examination questions can be better adapted.

The examination for the secondary school certificate, because it is one of the most important examinations in the life of every student, should be conducted in such a way as to make it difficult to cheat. In Poland, this is a fairly big problem, mainly the result of the Polish mentality. The aim is to conduct the examination in such a way as to make it difficult for students to cheat. In the case of conducting the examination in the traditional way, where each student gets the same examination paper, the prevention of cheating is based only on students being watched by examination supervisors. In the case of the examination for secondary school certificate performed using the *E-matura* system, options for preventing cheating are improved.

Nevertheless, examinations carried out with use of the *E-matura* system have many similarities with the traditional examination for the secondary school certificate. The examination is also administered in schools, where students take an examination at the same hour. Order in the class is also maintained by examination supervisors, but instead of using examination papers, students sit in front of computers and answer the examination questions on the computer screen. Students have to log in using their unique login name and password before joining the examination.

What is more, after logging into the system, students enter login names of students sitting close to them. Therefore, the system knows from whom this student could potentially try to copy the results. In addition, not only is it possible to analyse the similarities between students' answers, it is also possible to have the questions and the sequence of answers in a different order.

Cheating is, therefore, more difficult because although the numbers of questions might be the same, the content could be different. It means that even if a student could see the answer of his/her colleague to the question of the same number, he or she will not gain anything because the question might be about a different matter. The only way cheating would be possible is if the other student dictated all the content of question. However, chance of being caught by the supervisors is high. Generally, students are afraid to take such a risk, hence, this system and the solutions applied, discourage them from cheating.

The final protection against cheating would be to place cameras in every examination room to transmit and record vision during the examination. These pictures would be helpful in resolving doubts concerning whether students were cheating or not, and would also oblige and motivate a better examination.

CONCLUSIONS

E-matura is an evolutionary project, which is constantly being upgraded with new functionalities to overcome any new requirements and challenges. This system offers great opportunities in many respects, and has considerable advantage over traditional examinations. One such advantage is gaining results immediately after the examination so students do not have to be under stress awaiting results for a long time. What is even more important is that the analysis of a huge amount of data collected during every examination for the secondary school certificate conducted with the aid of the *E-matura* system, makes it possible to design better examination questions, which are better tailored to the knowledge delivered.

The *E-matura* system still faces many problems and challenges but this approach to the examination provides many opportunities that should not be missed. This is why the system is being constantly adapted and improved. Additional examination questions from other subjects are being added to this system, hence, it is envisaged that examinations for the secondary school certificate in Poland may soon be conducted only using the *E-matura* system.

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E-tutoring as part of the e-examination - the use of data warehousing and data mining to assist the learning and teaching process

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ABSTRACT: For the past two years, students have been using the *E-matura* system to sit for a matriculation examination in mathematics. In this paper, the authors endeavour to demonstrate the projected e-tutoring module, which will become an integral part of the *E-matura* system. Using the latest technologies, a sub-system is being developed that can be used for learning by students, along with the diagnosis of their current knowledge. Moreover, teachers will be able to use a platform to diagnose students' knowledge and ask them to do their homework. All of these issues and topics are raised and discussed in this paper.

INTRODUCTION

The *E-matura* system was created under the direction and supervision of Professor Sławomir Wiak at the Technical University of Łódź, Poland, under the auspices of the Ministry of Education. Examinations were held in October 2009, May 2010 and April 2011, and they attracted considerable positive coverage in the Polish media. Several thousand students from all over Poland took the matriculation examination in mathematics at the same time via the Internet. IT corporations such as IBM and Microsoft committed themselves to the project, supporting the programming team with professional servers and the required software.

The examination included both a test and open-ended questions. Students valued the application of the latest technologies that enables animations in given questions, as well as the instantaneous availability of results. Teachers received the results of all their students. The characteristics and features of the project facilitate in depth and precise statistical analysis of the answers given by students to improve the quality of education. The project is under continuous development. In 2013, the product will be operational for use on a large scale, but the overarching goal is more than to create a reliable system to conduct examinations at a distance.

Further, based on the results of a mathematical diagnosis, the system will help students and teachers to prepare for the examinations by an e-tutoring module currently under development.

E-TUTORING - PROBLEM DEFINITION

In the e-examination area the following problems are being diagnosed:

- Test results alone do not give enough information to students for the efficient preparation for the examination.
- It is necessary to save results in every part of the programme and present the learning progression over time for students and teachers.
- The possibility of assigning additional tasks to students by the teacher.
- The system provides additional tasks for students in necessary areas for repeating by them, to achieve better final goals.

E-TUTORING MODULE

E-matura provides a computer-aided analysis of graduate characteristics. The *E-matura* system is built to collect as much information as possible in addition to the response, which after processing can be analysed in order to draw conclusions. The system collects information to answer questions such as:

- Which questions were the hardest?
- How much time a student needs to solve a task?
- How many times a student comes back to a question?
- How much time does a student need to complete the whole examination?

The system collects detailed information on each student and each question and stores it in its database. If the student answered a given question several times, or changed the answer, all his/her steps are recorded by the system. The time taken to give every answer, and how many times the student went back to the question, are also registered. During each test, the system records over 500,000 responses for several thousand students. All information regarding the questions and the answers provided are embedded in the context of the user, the class and school.

As mentioned earlier the e-tutoring module is currently being develped. It will support the process of education for both students and teachers. This module will form an integral part of the *E-matura* system.

E-TUTORING MODULE FOR TEACHERS

The current plan is to provide students with additional tasks for the subjects diagnosed by the system as needing to be repeated. Based on this diagnosis of the weakest areas for the student or class, the teacher will be able to assign tasks to a particular student or to the entire class. The system will show who has done their homework and will check the correctness of their answers. The teacher will not have to check the homework. Tasks will be drawn from a pool of tasks from previous examinations or will be generated automatically by the system - in the tasks for which it is possible. Work is currently in progress that will allow teachers to add their own questions to the system so that the teacher will be able to use the system to prepare students for the examination questions.

Moreover, teachers will be able to monitor the progress of each student individually or at the class level. The system will present an overall assessment of students' knowledge, as well as individual parts examined by the program. What is even more, the e-tutoring module will provide access to historical data for each student and class. It is possible to process aggregated data (current and historical) from the *E-matura* system in Microsoft Excel spreadsheets. Furthermore, it is convenient for the user to apply such familiar tools. Figure 1 presents a sample report with the examination results for open questions, whereas Figure 2 presents a sample report with the examination results for closed questions.

Question		Time spent to solve question [min]					Points for question				
Category	nr	avg	min	max	stddev.	median	avg	min	max	stddev	median
Open questions	1	14,7	0,1	322,0	19,54	10,1	0,6	0	2	0,90	0
	2	6,9	0	274,0	10,06	4,1	0,7	0	2	0,82	0
	3	6,1	0	182,2	5,38	5,6	1,0	0	2	1,00	0
	4	6,6	0	33,6	4,92	5,4	1,2	0	3	0,76	1
	5	2,5	0	167,6	4,05	1,9	0,1	0	2	0,48	0
	6	6,6	0	53,8	4,64	5,5	3,4	0	5	1,26	4
	7	7,3	0	117,4	5,64	6,2	1,9	0	4	1,25	2
	8	5,0	0	176,2	7,13	4,1	0,3	0	2	0,74	0
	9	7,3	0	60,7	5,11	6,4	0,1	0	2	0,26	0

Figure 1: A sample report with the examination results for open questions.

Question		Time spent to solve question [min]					Points for question				
Category	nr	avg	min	max	stddev.	median	avg	min	max	stddev	median
Closed questions	10	1,6	0	16,4	1,45	1,3	0,9	0	1	0,33	1
	11	1,0	0	18,1	1,05	0,8	1,0	0	1	0,19	1
	12	1,3	0	16,8	1,35	1,0	0,8	0	1	0,39	1
	13	2,2	0	22,5	2,29	1,5	0,4	0	1	0,48	0
	14	2,1	0	52,0	2,53	1,4	0,3	0	1	0,46	0
	15	1,9	0	53,7	2,41	1,2	0,6	0	1	0,50	1
	16	2,3	0	17,7	2,26	1,7	0,7	0	1	0,46	1
	17	1,7	0	46,7	2,33	0,9	0,6	0	1	0,48	1
	18	1,9	0	18,7	2,06	1,3	0,7	0	1	0,45	1

Figure 2: A sample report with the examination results for closed questions.

Using this system, teachers will obtain answers to questions such as:

- Which questions were the hardest?

If the student answered any given question several times and changed responses, the system records all his/her steps. The time taken to provide every answer and how many times the student went back to the question were also registered. The results of the questions by student, school or country, can be analysed.

- Which parts of the teaching programme should be repeated by students?

Teachers will receive detailed information on the areas requiring additional treatment or repetition.

- The student results against the class, school, city and country.

Teachers will see the results for the whole class with a comparison with the average result for the school, city and country. It will be possible to compare students' results with the results of students attending the same type of school.

Teachers will also be able to carry out quantitative analyses of the results, based on a statistical analysis. The set of parameters that can be analysed as follows:

- Ease of the task/test - the ratio of the number of points obtained by students to the maximum possible number of points for a task or test;
- Difficulty of the task - the ratio of the number of students who have not solved a task properly to the number of students;
- The arithmetic mean of the results - the average score obtained by the test group of students - for example, a particular class;
- Median - the result of the middle set of examination results of a particular population - for example, a particular class;
- Mode - the most common value among a group;
- Area of typical results - results interval on the scale located between the sum and arithmetical difference of the arithmetic mean and standard deviation;
- Standard deviation - a measure of variability or diversity, allowing to determine the range of typical results;
- Variance - a measure of how far sets of numbers are spread out from each other;
- Stanine scores [4][5].

E-TUTORING MODULE FOR STUDENTS

Using the system, students will be able to solve the tasks assigned by the teacher, and after solving the tasks, they will receive their results and the correct answers immediately. The teacher will be able to add some theoretical information to each task. The theory bit will appear should the answer be wrong or at the user's request.

Further, students will be able to join a trial examination at a convenient time. On completion of the trial examination, students will see the results immediately, with information on what they have done wrong in each of the tasks, so that they do not make the same mistakes in the future. In the case of problems with solving the tasks, students will be able to mark all the tasks they want to come back to after the examination. Moreover, students will be able to monitor progress of their knowledge in a convenient form, such as graphs.

What is more, the system will diagnose which part of the programme should have greater emphasis placed on so that students will be able to choose only tasks from that part. If the required number of correctly solved tasks is achieved, the system will mark this part of the programme as completed by students.

TECHNOLOGY

The researchers plan to apply business intelligence (BI) techniques. Business intelligence tools are divided into groups:

- OLAP (On-Line Analytical Processing) - for the multidimensional analysis;
- Data Management - allows storage of data - data warehouses;
- Exploration - data analysis algorithms.

Business intelligence is directly linked to the data warehouse concept through which data are stored in a consistent format without affecting the On-Line Transaction Processing (OLTP) transactional system. OLTP systems are designed for efficient processing of transactions during the current activities of the project. The purpose of OLTP systems is to store data while ensuring concurrency and set the number of transactions (number of transactions per unit of time - usually per second). For large data sets, OLTP servers have a limited capacity for carrying out an in-depth analysis of current data and especially historical data.

OLAP systems (On-Line Analytical Processing) are used for a multidimensional data analysis in enterprises, including the following:

- Trend analysis;
- Financial condition and profitability of the company;
- Human resource management and inventory;
- Predicting customer response.

The data analysis is also related to the concept of exploration/extraction of data - data mining techniques - *move beyond simple data analysis to identify hidden trends, problems, or relationships in the data. After insights are extracted from patterns, clusters, and trends, people can better identify the root cause of problems and predict future outcomes* [1].

A Microsoft SQL Server 2008 R2 is used as a database to collect data during the examination. It is envisaged that the researchers will build their own business intelligence solution using the Microsoft SQL Server. In addition, the researchers do not exclude the possibility of using other software produced by companies such as IBM or Oracle.

CONLUSIONS

On completion, the *E-matura* system will be a tool for more than e-examinations. With the availability of the latest technology, the researchers envisage building an e-tutoring module that will enable support for education of teachers and students.

Since teachers have access to a mathematical diagnosis of their students, they will be able to monitor the progress of students' knowledge and assign a variety of tasks for them to solve. The e-tutoring module will make it possible to test students' knowledge, in the same format as the final test, on this platform.

In addition to completing tasks assigned by teachers, students can solve tasks in those areas that cause them the most problems, and they can monitor their progress and how much more they still have to learn.

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Enhancing STEM awareness and STEM pipeline through integrated pipelines of communication

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ABSTRACT: Students enrolling at universities as freshmen are not well prepared to pursue their chosen majors with motivation and perseverance. In addition, a lack of information is a barrier for students thinking seriously about pursuing careers in science and technology. The universities are attempting to fill the void by aggressively developing programmess to reach out to high schools and to their own student body to inform them of exciting careers in STEM fields. The Northern Illinois University (NIU), like other schools, has an active relationship with more than 300 high schools, several middle schools and Project Lead the Way Schools (PLTW). The College of Engineering and Engineering Technology (CEET) at NIU has developed an active marketing and brand building initiative that could help young students understand the nature and benefit of pursuing engineering and technology careers. The activities undertaken by the college to recruit and retain students in engineering and technology careers are outlined and discussed in this paper.

INTRODUCTION

According to the National Academies Press, the most effective way to enhance science and technology innovation and enterprise in the United States is to improve the teaching of its concepts, the skills of its teachers and to enlarge the pipeline of students with the desire and the correct preparation to pursue science, technology, engineering and mathematics (STEM) at the undergraduate level [1][2]. At the College of Engineering and Engineering Technology (CEET) at Northern Illinois University (NIU), succeeding in this regard is all about communication and extending the appropriate messages and opportunities to middle school students, high school students, current NIU-CEET students, alumni and donors and corporate sponsors alike. In this way, CEET is consistently selling STEM concepts, ideas and opportunities to all its audiences in multiple, integrated ways.

We now live in a world of niche audiences where each unique group consumes messages in multiple, segmented ways. At the same time, standard marketing approaches are still in play: messages must be clear and unified; messages must be consumed multiple times before they are remembered and budgets are tighter than ever.

The CEET has spent the last 12 m onths creating and now implementing a marketing plan. This plan breaks the audiences into segments according to the desired content and engagement pipelines; it integrates the messages, utilises new media and measures the mix of ideas and tactics that will extend STEM professions to audiences as young as eight years old. However, it will also continue to increase CEET enrolments and position the College as a key stakeholder in the efforts to increase economic vitality in the region. This is a national problem in the US and the colleges are struggling to sustain and enhance STEM enrolments. The high schools are not preparing students to understand and eventually pursue academic careers in STEM fields.

IDENTIFYING STAKE HOLDERS

Over the past five years, the focus of marketing has shifted from being product based to audience focused. The most important subject of any marketing piece is now the audience member consuming it. In this way, the ideas and information delivered must be central to what each audience group wants to discover not what CEET wants them to discover. CEET uses several integrated tactics for each group, and does not prioritise one over the other. Understanding this, CEET segmented the audiences into several groups, each with similar but uniquely different interests or needs.

For example, the middle school student may not be interested in the latest grant funding or vital research project, but instead may get excited watching a Y ou Tube video of a Formula Team racing crashing one of its vehicles during a failed trial.

In the past, this would not have been marketing material, yet today it demonstrates the fast paced, hands on opportunities students experience once they come to NIU. Even more, it demonstrates to a small child how engineering is exciting and practical. Several integrated tactics for each group, and do not prioritise one over the other, were used. Some groups, such as alumni, require even more segmentation to be discussed later in this paper. The audience and the Engagement Pipeline are presented in Table 1.

Table 1: The audience and engagement pipeline.

Audience	Engagement Pipeline
Middle & high school students	Recruitment
Middle & high school educators	Partnership
NIU admitted undecided students	Recruitment
NIU admitted CEET declared/undeclared students	Retention
Registered CEET students	Retention
Alumni & donors	Partnership
Business & industry	Partnership

OUTREACH GOALS

- *Increase the awareness* of the College of Engineering and Engineering Technology with a concerted focus on CEET's practice-based education, quality of its programmes, commitment to research, obligation to student retention and ability to place students.

Over the past 10 years, CEET has grown exponentially. Even in this precarious economy, where universities and colleges alike struggle to maintain enrolments, CEET managed to increase its undergraduate enrolments by 11% in 2010. However, public relations, brand management and the overall extension of the products, services and opportunities CEET provides its region, were virtually absent. The programmes offered by the College are accredited by ABET and the partnership with approximately 200 companies provides excellent placement opportunities for the students.

The College promotes its position statement of *Bridging Theory with Practice* into most of the materials and some of the logo versions. What is more, the whole philosophy of engineering being a socially relevant field is promoted to instil the excitement of engineering especially to the younger audiences. Students and adults alike connect to the concept of *changing the world* or *creating a better, healthier, greener world*.

Engineers' role as innovators needs to be highlighted. The awareness and educational process of redefining engineering is facilitated through multiple tactics, such as You Tube videos, social media, print materials, events. Students from high schools and middle schools are also invited to visit the College and witness experiments in the laboratories to expose them to the innovative world of engineering.

- *Nurture multiple audiences*: There are two critical steps to nurturing each of the College's audiences. The first is to gather prospective students, donors or partners that might become key stakeholder for CEET. Through open houses, the Web site, and events, CEET captures interested parties who are willing and ready to hear the messages. From the first *meeting,* leads, which are defined as a person loosely interested in our products or services gather the messages and begin the process of *getting to know us* [3].

Next, the lead is nurtured through consistent and specific messaging that allows the person to gather more information about our products and services. With tight budgets, social media and e-mail marketing are key to the nurturing process. Each audience pipelines reads e-mails from the College highlighting information specific to their needs at least six times throughout the year. At the same time, social media (You Tube, Facebook, Flickr, Word press, Linked In, and Twitter) provide the opportunity to connect with leads at the very moment he or she is ready to consume the information. It is timely, fast, less formal and fun.

- *Alumni engagement*: Understanding that a lead must hear, see, or read a message about seven times before the buying process closes, CEET takes measures to distribute its messages in multiple, equally critical ways. Each audience engages with products and services in different ways. Communication must, therefore, change and suit each audience accordingly. A new company may need to visit the facilities, hear a presentation or meet for lunch multiple times before deciding to partner, whereas a prospective high school student may watch a video, attend an open house, search our Web site and decide to apply within a few weeks.

It is critical to be in all places at all times during the buying cycle to ensure the return on investment is as high as possible. In the same way, delivering CEET's message in clear, concise ways also extends STEM ideas in to the minds of people who may not otherwise have considered these disciplines [4].

- *Retention strategies*: With such focus on lead generation and nurturing, it is important to remember that it is always more cost effective to keep a customer than it is to generate one in the first place [5]. Retention is always a difficult issue for engineering schools with their rigorous attention on mathematics and physics. What is more, at NIU, the freshmen and sophomore students typically do not take many classes in the engineering building until they become upperclassmen. Therefore, it is a challenge to build rapport and create community with the younger students.

In 2011, the college hired two employees to help with retention issues. The student success specialist is now on hand to communicate, advise, engage and support all students, with specific attention to scholarship recipients, students falling behind and those involved with student organisations.

A new undergraduate advisor, available to any student in need of direction, is equipped with years of experience working with student athletes, a skill that can be applied to students with hefty workloads. The focus of this position is to identify early indicators of failure, work together with the students to solve them and promote quality life skills that will ensure a move towards graduation.

All engineering and engineering technology majors must begin their undergraduate journey with an interdisciplinary engineering and engineering technology class called UEET 101. This offers each student the opportunity to familiarise themselves with the University, meet other students with similar goals, enhance communication skills as they learn to speak in public places, practice time management techniques, discover the relevance of engineering in an innovative society and uncover the countless professions that will be available to them upon graduation.

At the same time, a new focus on cross promoting all of the credit and non-credit opportunities allows seamless pathways to graduate school or into the workforce to be created. Alumni may benefit from non-credit opportunities, and existing students can enhance their resumes by taking OSHA safety training or earning a certificate in Lean Manufacturing and Six Sigma.

- *Promote engineering professions* and the opportunities they provide. Promoting engineering professions should not be as difficult as it is. After all, eight of the top highest paying undergraduate degrees in the United States last year were engineering degrees. However, creating a larger pipeline of potential students who will continue the journey throughout their undergraduate career is all about communicating what engineering really is.

In the state of Illinois, NIU is the only university certified to offer college credit to high school students in certain classes. This Project Lead the Way programme allows NUI to work with schools all over Illinois promoting engineering and engineering technology. Students are involved in the right courses; learn valuable techniques early in the process and most shockingly, 95% of them will become engineers.

At the same time, students in middle and high school are offered the opportunity to attend summer camps, visit the facilities and experience hands on activities while learning from current academics and students. Teachers from the region also utilise summer camps, visiting NIU and learning state of the art techniques and experiments that transcend what is currently being taught.

The partnership with the NIU STEM Outreach office extends engineering and engineering technology principles to young people throughout the state. In partnership with CEET, the STEM office hosts an annual STEMfest, where students, parents and educators experience the reality of innovation. In October 2011, over 4,000 participants attended the event, where they interacted with over 400 NIU volunteers, 40 NIU departments and student groups and participated in exhibits like dissecting cow eyeballs, playing with lasers, learning from robots, and a whole lot more. The College of Engineering and Engineering Technology sent many student organisations, academic staff and students to participate, and encouraged participants to visit the engineering and engineering technology facilities and laboratories.

PROMOTIONAL OBJECTIVES

Achieving our goals requires clear objectives with a keen focus on measurement and return on investment. The following objectives each require an integrated promotional strategy to deliver the desired effect.

1. Promote the CEET identity, which utilises the NIU brand.
2. Build strong Web presence and interactive communication opportunities.
3. Develop communication pipelines for each audience using e-mail and social media where applicable.
4. Automate communication pipelines, using dynamic content, Web forms and RSS feeds.
5. Increase public relations opportunities using blogging, social media and NIU Today.
6. Cross promote undergraduate, graduate, professional development and camp opportunities throughout the College and with other university groups, such as Outreach.
7. Host ongoing open houses where people of all ages can visit and learn about CEET.
8. Provide opportunities for students and alumni to stay engaged with CEET, through the Student Advisory Community, clubs and events such as the College Bowl.

TACTICAL APPROACH

Branding and Identity

Over the past year, the College decided about specific logo use, branding and identity statements and began its efforts to filtrate these concepts into all on-line and print materials, as well as all public relations pieces. Like any branding initiative, it will take about 18 months for the initiative to conclude. The overall acceptance of this initiative is overwhelmingly successful, as the large part of the College recognises that the whole is always greater than the sum of its parts.

Public Relations

With over 200 c orporate sponsors, students competing in and winning international competitions, academic staff partaking in research projects generating millions of dollars, utilising many PR fronts is crucial to creating and maintaining CEET's reputation. In order to do so, at least two articles are written and posted on the University blog each month.

At the same time, a dedicated CEET blog is currently being created so that students, academic and other staff members and others can post and generate interest in their current activities. Ambassadors and alumni of the College may also utilise this initiative to discuss their current issues.

Examples of articles:

- CEET Students Continue to Impress Employers (http://www.niutoday.info/2011/11/10/ceet-students-continue-to-impress-employers/);
- Higher Education, Economic Development Team Wins $2.4 Million for Local Aerospace Industry (http://www.niutoday.info/2011/11/10/ceet-students-continue-to-impress-employers/).

Web site

Over the past year, CEET has contemplated, designed and created a new Web site with student and research focused content that is easy to navigate and promotes the constant two-way communication necessary to engage audiences. The new Web site was developed using current Web building strategies and relied on Web data taken from the old site. CEET hopes to launch this new site in late November and will continue to watch Web analytics and make adjustments each month to ensure each audience is finding the appropriate information. Search Engine Optimisation (SEO) is also needed to pull more search traffic from the parties who may not know CEET exists.

The new site not only acts as the foundation for all current and planned initiatives, but it also directs visitors to related social media sites, where interested parties can find more information, respond to the College as a service provider and meet other interested parties.

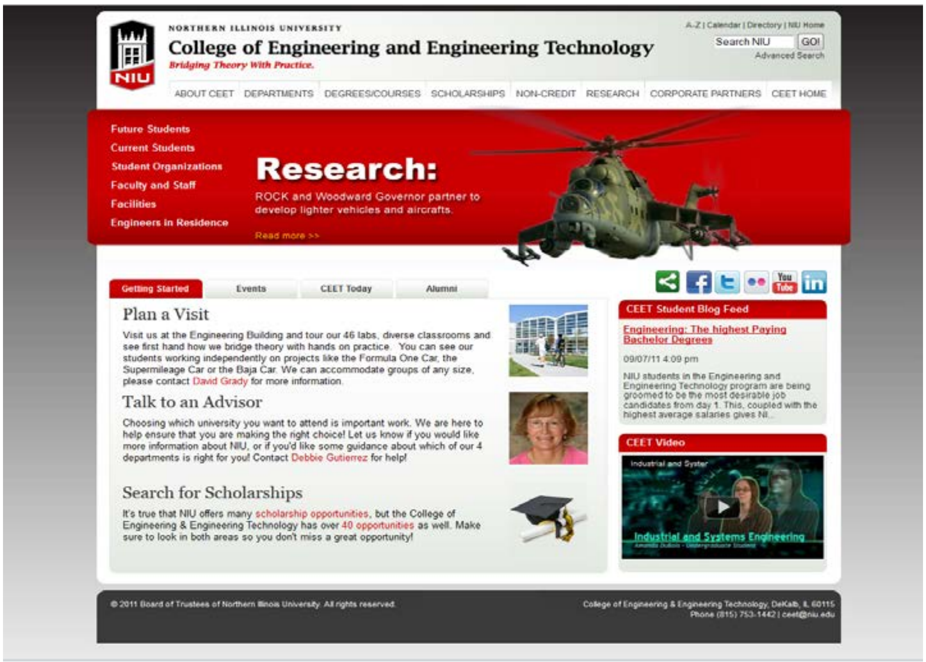

Figure 1: The new Web site.

Once again remembering niche audiences, specific landing pages were created for each of the audiences from the middle school student to the corporate sponsor. Each person can visit these pages and discover a portal into the exact information they need at the moment they needed. These pages will be highlighted at events like open houses or used in direct mail.

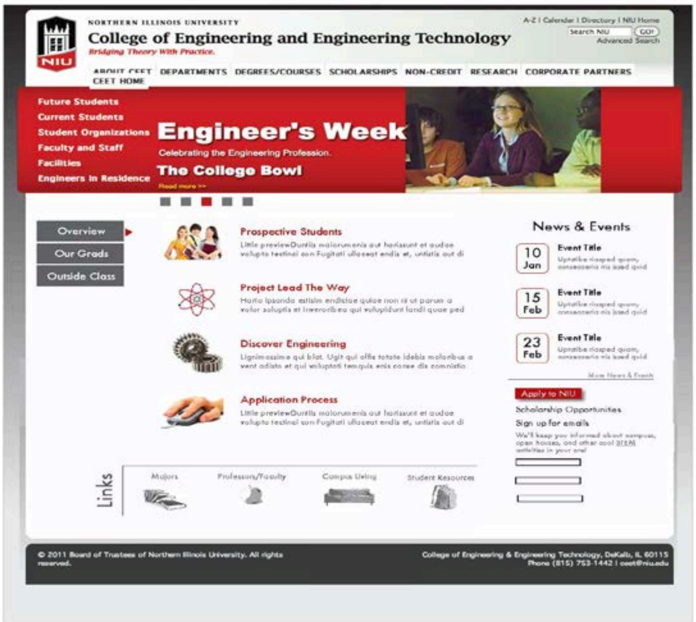

Figure 2: The new Web site.

E-MAIL MARKETING

Each audience is a member of a s pecific e-mail pipeline delivering information to leads who have requested communication. Information is re-packaged from the blogs and social media sites, the Web site, information on NIU's Web pages, and current events into a format specific to the audience. The College can promote events in a cost effective manner, distribute surveys, highlight current achievements and showcase research and student success stories during the year.

SOCIAL MEDIA

Originally thought to be a tactic used to communicate with existing young students, CEET now uses social media for much more. The alumni society (ETAS) promotes job opportunities through Linked In, student organisations showcase activities through photographs and on-line video to potential investors, and middle school students read blogs from the *Engineering Without Borders* students as they travel through Africa. The potential implications of so much content and quick communication strategies are endless, and most importantly - viral.

PRINT

Not all of the marketing efforts generated by CEET are on-line; in fact, the College still produces many print pieces, but uses them as techniques to drive more interested parties to the Web site. Like most universities, CEET creates brochures and flyers, posters and banners, and catalogues and booklets to enhance other pieces of information. In each case, the hope is that the potential lead visits the Web site and signs up for more information.

Figure 3: A typical flier.

MEASURING SUCCESS

No initiative or project is considered to be successful until clear outcomes are declared and measured. Accordingly, the table drawn below identifies outcomes to be measured to determine effectiveness of each initiative.

Table 2: The objectives and measurements.

Objective	Measurement
Promote identity	Gradually move all print materials over to new design and logo. Decorate building accordingly.
Build Web site	Web site goes live in April.
Develop communication pipelines	Create pipelines and track open rates, click throughs, Web site interaction. Quantify inquires as a result of e-mail.
Automate pipelines	Highly engaged pipelines will produce additional information about our leads through forms, dynamic content and Web activity/interaction.
Cross promotion	Quantify number of partnerships, communication and reciprocal Web links.
Host activities	Quantify number of activities and attendance at events. Use surveys and conversations to track what students need and want.
Provide engagement activities	Quantify number of activities and attendance at events. Use surveys and conversations to track what students and partners need and want.

With clear, consistent messaging and a renewed commitment to making engineering and engineering technology approachable and tangible, the College of Engineering and Engineering Technology has no doubt enrolments will continue to rise and its students will become a catalyst to innovation. Communication, via e-mail, print and the Web will be continuous and focused on extending the engineering profession to young people, as well as delivering pertinent information to existing students, and finally, engaging alumni and corporate partners in multiple ways.

CONCLUSIONS

There is no doubt that by engaging young people and helping them make connections to the interesting and important world of engineering that the United States will continue its climb upwards. What is more, these interested young people will become the students of tomorrow, and later engaged and supportive alumni, who become financial partners and offer key internship and co-op opportunities.

The cycle will continue to grow and the fruits of its labour will foster innovation and change in the educational sector, the region and the world. The competition for students will be stiff and the competition for a qualified work force will be stiffer. Therefore, the need to advertise, disseminate and share will increase rapidly and every educational institution will have to employ strategies to market their programmes to build the pipeline and to attract stakeholders.

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Efficiency of a portable electronic vulcaniser

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ABSTRACT: This research was developed and executed for the modernisation of old vulcanising equipment to save time, investment, manpower and the environment through accurate temperature setting and timing of the vulcanising process and by eliminating the problem of gas emissions as produced by conventional (gas fired) vulcanisers. In constructing the product, a letter G body configuration made of GI pipe with a 31.5 cm long log bolt with some special appliances were installed. The level of effectiveness of the equipment was tested using Class A gum. The temperature at which the gum was best bonded to the rubber tyre was 60°C in 1 minute, while Class B gum bonded at 60°C in 2 minutes. The rate of energy consumed by the electronic vulcaniser was much less than for a conventional vulcaniser at a greater level of efficiency. Apart from the technical research, implications for engineering and technology education regarding this technology are also outlined and discussed briefly in this paper.

INTRODUCTION

This study is about modernising the vulcanisation process for automotive, motorcycle, bicycle and other inflatable tyre tubes. An electronically-operated vulcaniser is an environmentally friendly piece of equipment. Modernisation creates new machines that are more accurate, easier to operate, more comfortable and capable of fulfilling their purposes. Examples include a fan turned into an air-conditioner, an abacus into a computer and so many things that have been improved with the advancement of technology. In the industry and economy, worn out tyres are recycled instead of being disposed of into the surroundings and the environment. The production of rubber, specifically in tyre making, may be reduced and manpower will increase and the industry will earn more income.

The portable electronic vulcaniser (PEV) uses heat energy to vulcanise the rubber but it does not exude any harmful substances that could affect the environment in the vulcanisation process. Therefore, it is an environmentally friendly product.

Electricity is a form of energy. It is associated with an electric charge, a property of certain elementary particles, such as electrons and protons, two of the basic particles that make up the atoms of all ordinary matter. An electric charge is an electric current. Electricity can be utilised in many ways, including this electric vulcanising equipment [1]. It can be converted efficiently into other forms of energy and it can be stored. Because of its versatility, electricity plays a part in nearly every aspect of modern technology.

The conditions in a vulcanising shop can be improved by modernising the vulcanising equipment. Adding features, such as a buzzer, timer and temperature gauge may greatly increase the efficiency and accuracy of the vulcanising equipment. This study determined the accurate temperature and duration of the vulcanising process using an electric vulcaniser, which eliminates the problem of carbon dioxide emissions produced by conventional, gas fired vulcanisers. These produce about 2.772 kg of carbon dioxide for 1 litre of diesel fuel and/or 2.331 kg of carbon dioxide for 1 litre of petrol [2].

Global warming is the rise in the average temperature of the earth's oceans and atmosphere and it is projected to continue. The scientific consensus is that global warming is occurring and was initiated by human activities, especially by those that increase concentrations of greenhouse gases in the atmosphere. These include a) carbon dioxide (CO_2), from deforestation and burning of fossil fuels; b) methane (CH_4) emissions from livestock and other agricultural practices and by the decay of organic waste in municipal solid waste landfills; c) nitrous oxide (N_2O), emitted during agricultural and industrial activities, as well as during combustion of fossil fuels and solid waste; and d) fluorinated gases, such as hydro-fluorocarbons, per-fluorocarbons and sulphur hexafluoride, which are synthetic, powerful greenhouse gases that are emitted from a variety of industrial processes [3].

This experimental research was conceived to contribute to the mitigation of global warming, and to provide empirical evidence and knowledge so that investors in this small scale business industry can establish the business outright.

OBJECTIVES

The efficiency of the portable electronic vulcaniser (PEV) was tested to help improve the handling convenience of the electric power device, which is beneficial to the community, the environment and the industry. Specifically, this study was conducted to:

1. identify the design of a portable electronic vulcaniser;
2. determine the material component of the portable electronic vulcaniser;
3. determine the appropriateness of the heating element use in electronic vulcaniser;
4. determine the desirable temperature to exactly bond the Class A & B vulcanising gum to the rubber tyre in one and two minutes respective; and
5. find out the efficiency and cost-analysis of the portable electric vulcaniser.

RATIONALE

The underlying principle of this study is to determine the efficiency of the portable electronic vulcaniser in order to upgrade the living conditions of the stakeholders in vulcanising shops in the Philippines.

STATE OF THE ART

The modernisation of the conventional vulcaniser (gas emitting apparatus) required the researcher to add a new process that incorporated a unique idea into this field of technology. The experimental set-up required different temperatures to be tested for a constant time in vulcanisation. Five trials were conducted to find the perfect temperature at which the gum would bond perfectly to the rubber after one minute for Class A vulcanising gum and two minutes for Class B vulcanising gum.

ANALYSIS OF THE PROBLEM

The electronic vulcaniser and the conventional vulcaniser have a common problem. The electric vulcaniser, if not watched properly during the vulcanisation process, can damage the rubber tyre. In the conventional vulcaniser, if the gas is not properly measured or controlled, the rubber tyre will burn. To solve the aforementioned problem and the environmental concerns, this innovative technology which is expected to be applied over time as technology changes, has been studied.

Flowchart of the Study

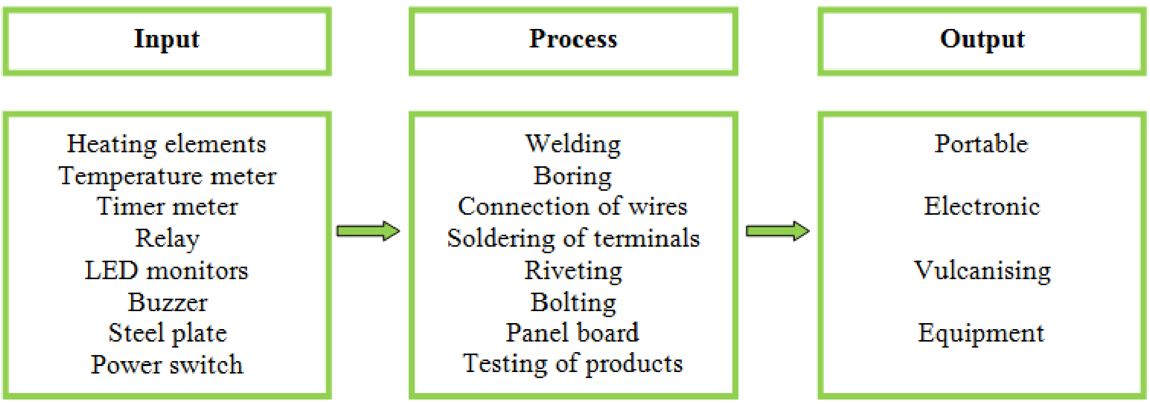

Figure 1: Flowchart of the study.

REVIEW OF THE LITERATURE

The work environment refers to the aggregate of surroundings and conditions that affect the quality of work, life and the individual whether as an employee or an entrepreneur.

Former President Fidel V. Ramos stressed that the living conditions of the people in every sector of society can be improved by initiating a family investment or other group. He wanted the Philippines to be a New Industrialised Country (NIC) in Asia and the Pacific by 2000. Thus, Executive Order No. 318, s.1991, was passed to reinforce a functional programme in the implementation toward industrial reform and development [4].

The Technical Education Skills Development Authority (TESDA) reported the government's quest to realign technician education programme to be of paramount importance. On the other hand, the Presidential Commission on Educational Development (EDCOM), based on the result of its survey, recommended the conduct of feasibility studies and projected modern educational design to revitalise the c hanging demand of the nation's youth for effective manpower development. Mismatch problems between the education sector and industry are vital issues as regards the graduates of colleges and universities, wherein most of them cannot find jobs because they lack the skills needed by industry. Hence, graduates of technical courses have a wider range of employment compared with those graduates of white-collar professions [5].

With these plans and standards, a n ational employment plan, as the basis for technical education and a skills development plan, was recommended and provided for improvement for the following problems: enrolment, workload distribution, poor quality of teaching skills of teachers, lack of fitness between programmes and graduates, and limited time for the on-the-job training.

Vulcanisation is the chemical process by which the physical properties of natural or synthetic rubber are improved; the finished rubber is stronger and is resistant to swelling and abrasion, and elastic over a greater range of temperatures. In its simplest form, heating rubber with sulphur brings about vulcanisation.

In modern practice, a temperature of 140°C - 180°C is deployed and in addition to sulphur and accelerations, carbon black oxide is usually added, not merely as an extender but to improve further the qualities of the rubber. Vulcanising gum, which is a classified *ready to heat* rubber, is now utilised to repair worn out interior/exterior rubber tyres with the help of vulcanising equipment. Certain problems, such as inaccuracy of the product, are evident throughout third-world countries as the first-world countries never used them [6].

The Discovery of Vulcanisation

Goodyear thought that rubber could be improved by processing it with other substances. As Goodyear was displaying a mixture of rubber and sulphur, the piece slipped from his hand into the fire. When he removed it, he found to his amazement that the mass had charred without melting. Goodyear named this process of combining rubber with sulphur by heat *vulcanisation*. Later he discovered that the addition of lime, magnesium and lead compounds sped up the vulcanisation process. Elastic substances are obtained from the exudations of certain tropical plants (natural rubber) or are derived from petroleum and alcohol (synthetic rubber) [7].

Newly discovered rubber classes such as vulcanising gum are now utilised for repairing worn-out rubber, such as an automobile tyre. Vulcanising gum is classified according to its texture, bonding temperature and the content of accelerators. The three classes of the gum were as follows [8].

- Class A – usually bonds on the rubber 30°C-70°C and is smooth;
- Class B – usually bonds on the rubber 35°C-80°C and is moderately rough;
- Class C – usually bonds on the rubber 45°C-90°C and is very rough.

RELATED STUDIES

Technological development starts with basic research when a scientist discovers some new phenomenon or advances a new theory. Others then examine the breakthrough for its potential utility. If further development leads to a prototype and engineering refinement makes commercial exploitation practical, then, the technology that is finally put to use could be widely adopted [9].

Technological changes take place in many directions at once; that is, it is multi-lineal. Bar codes, for example, are used to track items not only in grocery stores but also in warehouses, assembly lines, shipping docks, libraries, even in the Department of Defence. Technological changes are also nonlinear; developments take irregular directions. There are many dead ends and each highly visible advance may depend on a host of small developments (including failures) [10].

Actually, electrically-operated vulcanising equipment already exists, but do not have any electronic control devices. If not properly used, the vulcanising gum may be burned, just as with manually operated vulcanising equipment. It also wastes more time, labour, money and manpower in the vulcanising shop operation.

MATERIALS AND METHODS

The materials and methods used in the construction and experimentation of this study were:

- a heating element, a 3 00 W heating device that heats the vulcanising gum and rubber or interior tyre for the vulcanising process;
- an analogue temperature gauge used to a set specific temperature in centigrade for the duration of the vulcanisation process;

- a digital timer device used to set a s pecified time in seconds/minutes/hours for the burning operation of the vulcanising equipment;
- a PC printed circuit board on which all of the electronic parts were installed;
- an LED, a light emitting diode that serves as a light monitoring device;
- boring tools used for drilling holes in the PCB for placement of the electronic parts;
- a relay to conduct power to the timer, temperature gauges once the vulcanisation process takes place;
- a buzzer that sounds when the heating activity is finished;
- nuts and bolts used to tighten some electronic parts to the PCB and as holder of the PCB circuit;
- a circuit made in a PCB so that current will flow;
- a hacksaw that is used for cutting metals as parts of the machine;
- a welding machine is used to join metals for assembling the vulcaniser;
- aluminium sheeting that is used as a shield or protector of the rubber tyre during the vulcanising process;
- a control panel that houses the component parts of the electronic vulcaniser;
- power switches for power connection to the circuit or vulcanisation process;
- the main source provides a prescribe current to any circuit connected to it; and
- the body of vulcaniser that is the holder of all the component parts used in this vulcaniser.

The wiring for the machine to function was assessed by the researcher with the assistance of an electronics expert. For mass production, this machine will cost only Php 5,700.00 (approximately US130).

RESEARCH DESIGN

The study utilised an experimental research method that included the new design, selection and identification of materials, assembly or fabrication, and a testing process:

1. *New design.* The design of the vulcanising equipment was based on its portability and its weight of only 6.30 kilograms and environment-friendly machine. Its body configuration is a letter G in appearance that is made of GI pipe of schedule 40; the base was made of 0.3 cm flat bar that served as the foundation of the equipment; a flat type 300 W heating element and a box type panel board.
2. *Selection and identification of materials.* Selection and identification of materials were considered for this study. The timer that controls the duration of the vulcanising process; a temperature gauge that controls the temperature in the process; a power switch that is used to cut the power supply to the machine; LED as light monitoring device and the buzzer that sounds when the vulcanising process is completed; a stainless circular handle with 315 mm by 12mm lag bolt, used for pressing the heating element and the rubber tyre, and a flat type 300 W heating element was connected to the circuit, which is enclosed by a panel board made of galvalum sheet to complete the portable electronic vulcaniser.
3. *Fabrication*. Based on the plans and design, the body was moulded in a pipe bender to form a letter G configuration, the flat bar was cut to its desired length then welded to form the base and welded it a gain to the body of the vulcaniser. Fabrication of the panel board was undertaken to house the circuit board of this machine.
4. *Testing process.* Testing of the machine was undertaken to determine the workability of the machine.

Figure 2 shows the schematic diagram of the electronic vulcanising equipment.

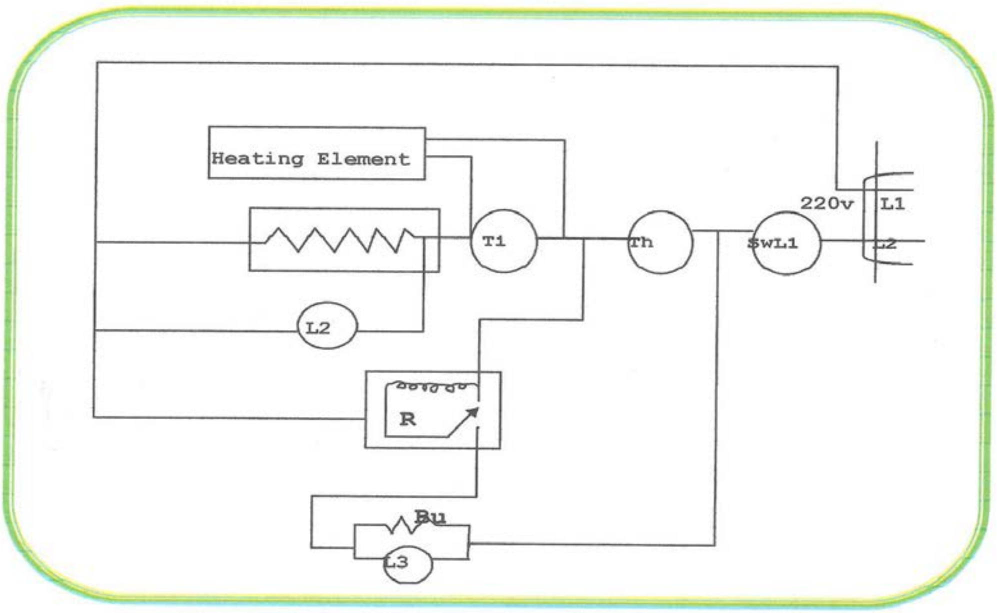

Figure 2: The schematic diagram of the electronic vulcaniser.

To determine the efficiency of the product in vulcanisation, the researcher used some worn out automobile tyres. Several tyres were vulcanised at different temperatures and for different lengths of time with the temperature interval of 10°C ranging from 30°C to 60°C and at a constant time of 1 minute for Class A vulcanising gum and 2 minutes for Class B vulcanising gum. The results were then recorded and determined what temperature and time the vulcanising gum bonded to the tyre best.

RESULTS AND DISCUSSION

The efficiency and rate of energy consumed by the electronic vulcaniser was compared with the manual gas vulcaniser (Table 1).

Table 1: Efficiency and rate of energy consumed of electronic/conventional vulcanising using Class A and Class B vulcanising gum.

Type of Vulca-niser	Time in Minutes		Temperature In °C		Power/Fuel Consumed		Cost in kWh/ Gas-ml		Rate of Energy Consumption		Results		Efficiency (%)	
	Class		Class		Class		Class		Class		Class		Class	
	A	B	A	B	A	B	A	B	A	B	A	B	A	B
Electronic	1	2	60		0.005 kWh	0.10 kWh	Php 15.1441		Php 0.0757	Php 0.15	Good Bonding		85.22%	
Conven-tional	5	10			20 ml	30 ml	Php 0.054		Php 1.08	Php 1.52			43.38 %	78.08 %

Data in Table 1 show that for the electronic vulcaniser, the temperature at which the gum was bonded to the rubber tyre best. It was 60°C for one minute for Class A gum with a power consumption of 0.005 kWh valued at Php 0.0757 and an efficiency of 85.22%, while the Class B gum bonded at two minutes at 60°C, with power consumption of 0.10 kWh valued at Php 0.15 and an efficiency of 85.22%.

For the conventional vulcaniser, the temperature at which the gum was bonded best to the rubber tyre was 60°C in five minutes for Class A gum, with fuel consumption of 20ml valued at Php 1.08 and an efficiency of 43.38%, while the Class B gum bonded at 10 minutes at 60°C, fuel consumption of 30 ml valued at Php 1.52 and with an efficiency of 78.08%.

Figures 3 and 4 compare the result of the vulcanising process using the electronic and the conventional vulcaniser at 60°C temperature.

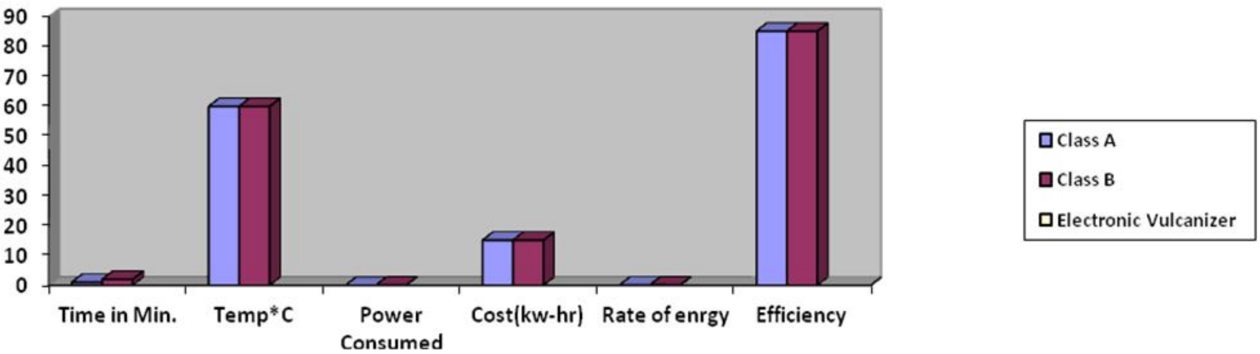

Figure 3: Electronic vulcaniser.

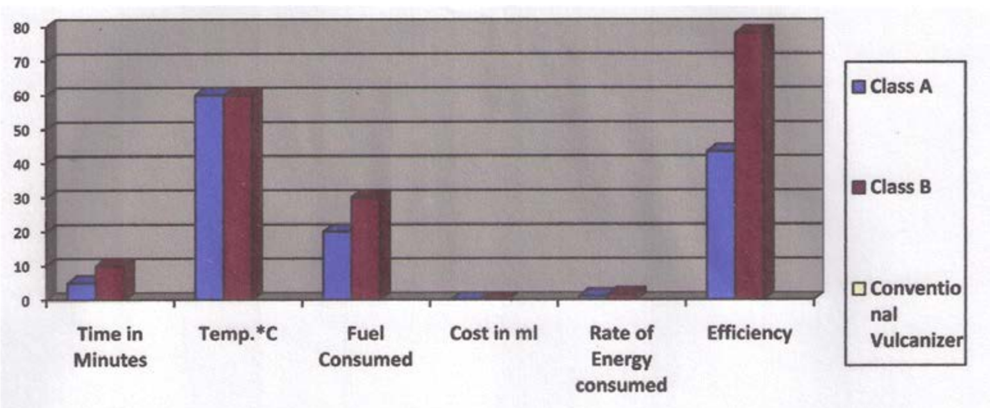

Figure 4: Conventional vulcaniser.

The figures show that the portable electronic vulcaniser is five times more efficient when compared to the conventional vulcaniser for both Class A and B vulcanising gum.

This study determined the accurate temperature and duration of the vulcanising process using the electric vulcaniser, which eliminates the problem of gas emissions produced by the conventional gas fired vulcaniser of about 2.772 kg of carbon dioxide for one litre of diesel fuel and/or 2.331 kg of carbon dioxide for one litre of petrol into the atmosphere.

IMPLICATIONS FOR ENGINEERING AND TECHNOLOGY EDUCATION

Engineering and technology education aims for the advancement of technological capabilities and to nurture and promote the professionalism of those engaged in this field of education. This field of education opens the door to discovery and offers a tremendous variety of careers options. It tends to search for the best and least expensive ways to utilise nature forces/energy to meet the today's challenging world.

Engineering and technology education is the activity of teaching knowledge and principles related to the professional practice of engineering. It includes the initial education for becoming an engineer and any advanced education and specialisation that follows [11]. Technology education often serves as the foundation for engineering education. In the Philippines, the Technical Education and Skills Development Authority (TESDA) is one of the authorised training centres for these careers, with others at some of the state universities and colleges, such as the Technological University of the Philippines (TUP)'s centre for excellence of engineering and technical-vocational education.

The Philippines' Commission on Higher Education (CHED) and TESDA are forging a technology education programme called the Ladderised Education Program (LEP). The changes and developments in the work patterns and skills demanded by various industries, including the emerging ones, necessitate a very strong link between Technical-Vocational Education and Training (TVET) and higher education. The purpose of ladderisation is to open pathways of opportunities for career and educational progression of students and workers. Specifically, it in tends to create a seamless and borderless education and training system that allows mobility in terms of flexible entry and exit into the educational system. In essence, ladderised education is an empowering tool because it provides options or choices to a wider range of clientele on when to enter and to exit in the educational ladder.

More importantly, it creates job platforms at every exit and provides students with an opportunity to get a job and earn income. While there will be no structural and systems changes, the ladderised system provides for portability across levels for harmonisation of qualifications. Through active advocacy, it is expected that more State Universities and Colleges (SUCs) will be encouraged to ladderise their programmes. At present, the programme has been rolled out by TESDA and CHED for the Academic Year 2006-2007 covering eight priority disciplines such as agriculture and fisheries; health and medical services; information and communication technology; maritime; tourism/hotel and restaurant management; criminology; education; and engineering [12].

In engineering and technology, education goes hand in hand with the rapid pace of globalisation that pressures nations to be competitive in order to survive. In this field of education, it ushers in the freer mobility of human resources between countries. While it poses a huge challenge to the survival of the Filipino workforce in the global market, it yields various opportunities. This challenge pushes for the continuing development and replenishment of manpower through this field of education in order to ensure that there are workers of the right quality and right quantity for jobs that become available at any given instance. Further, it urges a stronger labour market intelligence and technology development. Lastly, it encourages transformation of the Filipino workforce to be knowledge-based and adaptable to shifting skills or even occupations.

For curriculum development, questions in philosophy of technology and engineering about the control of technology and responsibility for technology are important. For example, the answer to the questions: is technology autonomous or is it *controlled?* have a direct impact on the contents and structure of technical curricula [13].

From time to time, a new direction for engineering education is heralded. Recent examples from the literature include the renaissance engineer for the 21st Century and global engineers and socially responsible engineers, or science, technology and society (STS) engineers. Often engineering education can look at sustainability and issues concerning the considerate and appropriate application and development of technology as something that *is done in other countries that are underdeveloped*. The inclusion of sustainable developments into curricula is just one example of the models to adapt engineering education in our ever-changing environments [14].

SUMMARY

This study was conducted to determine the efficiency of a portable electronic vulcaniser. Testing was undertaken at the Bachelor level of the Technology Department, College of Engineering, University of Eastern Philippines for school year 2005-2006. The experimental method of research was used. The researcher was responsible for the purchase of the materials needed for the study.

This study revealed that the portable electronic vulcaniser was effective in vulcanising interior automobile, motorcycle and bicycle tyres. It further showed that the best temperature for bonding the gum to the rubber tyre was 60°C for 1 minute for Class A gum and 2 minutes for Class B gum.

The rate of energy consumed for the portable electronic vulcaniser was Php 0.0757 for Class A gum and Php 0.15 for Class B gum with an efficiency of 85.22%, while the conventional vulcaniser for Class A gum consumed a fuel equivalent to Php 1.08 with an efficiency of 43.38%, while the Class B gum fuel consumption was equivalent to Php 1.52 with an efficiency of 78.08%.

CONCLUSIONS

Based on the findings of the study, the following conclusions were derived:

1. The design of the portable electronic vulcaniser is made of a letter G body, which is made of gauge 20 GI pipe with a 0.05cm flat bar base. The height of the body is 41 cm; the base is 23.5 cm long and 10 cm wide; and the panel board has dimensions of 27.5 cm for the height, 22 cm for the width; and 8 cm for the thickness.
2. The material components of the electronic vulcaniser are the timer, temperature gauge/thermostat, LED, buzzer, relay and 300 W heating element.
3. The appropriateness of the heating element was demonstrated in the experiments conducted using this portable electronic vulcaniser, which is a unique flat-type heating element material with a 300 W output for a low cost power generation consumption.
4. The portable electronic vulcaniser requires 60^{o}C temperature for one minute to bond the gum to the rubber tyre for Class A vulcanising gum and two minutes at 60°C temperature to bond to the rubber tyre for Class B vulcanising gum. The electronic vulcaniser is, therefore, efficient as it requires only one and two minutes (for Class A and B vulcanising gum, respectively) to vulcanise as compared to the conventional vulcaniser that needs five minutes to finish the task.
5. In terms of energy consumption, the portable electronic vulcaniser is more economical as it consumes energy equivalent to Php 0.0757 (Class A vulcanising gum) and Php 0.15 (Class B vulcanising gum) with an efficiency of 85.22%, as compared to the Php 1.08 (Class A vulcanising gum) with an efficiency of 43.38% and Php 1.52 (Class B vulcanising gum) with an efficiency 78.08% of the conventional vulcaniser. The efficiency of the portable electronic vulcaniser is limited only for the vulcanisation of gum to the rubber tyres or inner tubes of the automobiles, motorcycle and bicycle or any inflatable rubber materials.

The Internal Rate of Return (IRR) of the vulcanising shop with a capitalisation of Php 185,100.00, including this new electronic vulcaniser is only 3.3356 years of operation.

This study determined the accurate temperature and duration of the vulcanising process using the electronic vulcaniser, which eliminates the problem of gas emissions produced by the conventional gas fired vulcaniser of about 2.772 kg of carbon dioxide for 1 litre of diesel fuel and/or 2.331 kg of carbon dioxide for 1 litre of petrol into the atmosphere.

IMPLICATION

The findings of this study have an important implication for future enhancement and improvement of the study. More tyres can be vulcanised in a shorter period of time; therefore, greater income will be produced. It is environment-friendly since it does not emit gas as compared to the conventional vulcanising; and much more is lesser health hazard to the operator.

RECOMMENDATIONS

- It is recommended that this portable electronic vulcaniser should be used in every welding, automotive and machine shop to save time and costs of their operations;
- Small time businesses like vulcanising shops in the Philippines are encouraged to acquire this portable electronic vulcanising machine so that they can save money and labour in their operation;
- It is recommended also that this study could be improved through additional features like automatic power supply shut down or perhaps a remote controlled operation on the power switch.

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What is the impact of teacher self-efficacy on the student learning outcome?

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ABSTRACT: Research that investigated the impact of teacher self-efficacy on student learning outcomes is presented and discussed in this paper. An effective teaching and learning model was devised and constructed through a review of the literature. In addition, in order to achieve its goal, five hypotheses were proposed and tested: 1) teacher self-efficacy has a positive effect on student learning satisfaction; 2) teacher self-efficacy has a positive effect on student learning outcomes; 3) the teaching process has a positive effect on student learning satisfaction; 4) the teaching process has a positive effect on student learning outcomes; and 5) student learning satisfaction has a positive influence on student learning outcomes. Research results and concluding remarks are presented and discussed in this paper.

INTRODUCTION

In recent years, there has been a considerable proliferation of research concerned with student learning outcomes. Accountability and assessment were the most important issues, as quality assurance in education has been an important development trend in Europe and the USA, and among the assessment topics, researchers have focused on student learning outcomes (SLO) [1][2]. Students achieve deep learning when they successfully construct knowledge and, then, retain the constructed knowledge for the purpose of bringing benefits to themselves and society, so learning outcomes were the main target of the European and American educational institutions [3].

Teachers provide school education and teacher efficiency is reflected in the teaching process and practice. Some researchers have revealed that teachers produce different teaching situations through how their differing backgrounds and decisions intersect with the teaching model. Teachers' teaching efficiency is displayed in teaching practice and student learning outcomes. Kelchtermans noted that teaching practice is a learning process resulting from meaningful interaction with the context (both in time and space) and teachers' professional practice (actions) and thinking [4].

In the learning process, learning satisfaction is an important factor in student learning outcomes. Many studies have found that learning satisfaction has a positive effect on learning outcomes and similar examples abound in the literature [3][5]. Thus, teaching practice and learning satisfaction are important indicators of teachers' instruction and student learning outcomes. However, no clear direction has emerged about the implications of the impact of teacher self-efficacy on student learning outcomes. This realisation is the motivation for the research outlined in this study. It is hoped that answering these questions will contribute to the understanding of the impact of teacher self-efficacy on student learning outcomes.

LITERATURE REVIEW

Teacher Teaching Self-efficacy

Teacher self-efficacy cannot be easily defined, because teaching is complex and constantly evolving, and self-efficacy involves a great many traits and factors. Ashton argued that the teacher influences students, and that the intensity and ability of teachers represents their self-efficacy [6]. Hoover-Dempsey, Bassler, and Brissie defined teacher self-efficacy as including three aspects: 1) teaching effectively oneself; 2) learning abilities; and 3) professional knowledge [7]. Tschannen-Moran, Woolfolk Hoy and Hoy defined teacher efficacy as a teacher's judgment of his or her capabilities to bring about desired outcomes of student engagement and learning, even among those students who may be difficult or unmotivated [8].

Based on social cognitive theory, teacher self-efficacy may be conceptualised as individual teachers' beliefs in their own ability to plan, organise and carry out activities that are required to attain given educational goals [9]. Attempts have also been made to fashion a model of teacher self-efficacy. Ashton [6] placed the construct of teacher self-efficacy within the framework of Bronfenbrenner’s [10] ecological perspective and identified a complex set of interactions which differentially support or threaten teachers' personal sense of self-efficacy. Their studies demonstrated the contextual dependency and relative instability of efficacy beliefs, but also emphasised the importance of the construct to teaching outcomes.

Ashton concluded that a potentially powerful paradigm for teacher education can be developed on the basis of the construct of teacher efficacy and suggested a number of modifications to teacher education programmes to enhance pre-service teachers' efficacy beliefs [6]. These modifications included many of the approaches recommended for the promotion of deep learning, especially the development of analytical problem-solving approaches from meaningful, context based learning.

Researchers have posited multiple dimensions to self-efficacy. Schunk proposed the three kinds of index: personal self-efficacy, general self-efficacy and professional self-efficacy [11]. Bandura used seven kinds of index to illustrate teacher self-efficacy: 1) influencing the school to make policy; 2) influencing the intersection of schools and resources; 3) the intersection of classes and teaching; 4) regular classroom management; 5) leading parents to participate in the educational process; 6) impelling the community to invest and educate; and 7) build the school interaction atmosphere [12].

Based on the foregoing research, the following components of teacher self-efficacy were identified:

1. Teachers’ personal teaching self-efficacy: the teachers’ belief in the efficiency of their own teaching, understanding of their students and belief that their methods can overcome the harmful effects of the external world on the students and on their own teaching.
2. Teachers’ general teaching self-efficacy: the teachers’ belief in their impact on students’ individual differences, belief in their impact on all students, and belief to overcome the harmful effects of students’ family and society.
3. Teachers’ professional teaching self-efficacy: the professional belief and skill that could train students to have professional skill operational ability and the professional knowledge of professional subjects and practice.

Teachers’ Teaching Process

Teaching practice is an essential component of teacher preparation. It trains teachers to be professional teachers, providing them the opportunity to learn classroom management skills and to match teaching theories with practice during contact sessions and classroom observation. The chance to interact with experienced teachers in schools provides a good opportunity for teachers at the start of their career. Even those who have been through some initial training have much to learn by observing other teachers teaching in an entirely different school [13].

The teaching process is defined as any activity related to teaching carried out by the teacher in the classroom [14]. Joanne argued that effective teaching processes can encourage students to think and make decisions, promote learning motivation and learning of new knowledge and skills [15].

O'Neill identified the 20 most important factors of the three stages in the teaching process: 1) Pre-active stage: teaching plan, teacher's knowledge, teacher organisation and teaching material; 2) Inter-active stage: teacher expectations, teacher's zeal, classroom atmosphere, teacher's management, teaching clearance, advance organisers, teaching model, question level, direct instruction, learning time, changes, flexibility, supervising and teaching progress; and 3) Post-active stage: feedback, teacher criticism and teacher appreciation [16].

In this research, based on the work of O'Neill, Marsh and Baily [16][17], and Douglas and Stacey [18], the teaching process was divided into three stages and eight factors:

1. Teaching preparatory stage: course plan and teaching preparation.
2. Teaching implementation stage: teaching methods, teaching materials and class management.
3. Teaching evaluation stage: teaching assessment, teaching evaluation and evaluation feedback.

Student Learning Satisfaction

Kuo and Ye, and Chang indicated that learning satisfaction can help teachers to understand the course successes and failures in order to improve the course and promote students’ interest and motivation [19][20]. Thus, enhancing learning satisfaction offered the following benefits:

1. Inspiring learning motivation, reducing the dropout rate: As student learning satisfaction rises, learning failure falls. A well-designed course reduces the dropout rate and enhances learning satisfaction and learning outcomes.
2. Ameliorating course shortfalls and promoting learning outcomes: Learning satisfaction is a critical standard in assessing learning outcomes. If learning satisfaction is poor, then, the teacher and the course must be improved.

Moreover, when learning satisfaction is good, learners will recommend that others participate in the course.

3. Enabling the student to learn continuously: When learning satisfaction is good, learners have a higher sense of achievement, improving their learning motivation in order to learning more and continuously.

Student learning satisfaction depends on: 1) level of learning satisfaction demanded; 2) internal factors of learning satisfaction, such as sense of learning achievement, experiences with teachers and classmates; 3) external factors of learning satisfaction including: learning environment, learning software and hardware, interpersonal relationships; and 4) expected and actual learning satisfaction gap, which affects learning satisfaction.

Kaiser, Rosenfield and Gravois divided learning satisfaction into the two dimensions of teacher (teacher teaching capability, course preparation, caring, fairness, ability to inspire student thinking) and course (course organisation, progress, exercise content difficulty and quantity) [21]. Pianta and Hamre identified five dimensions of learning satisfaction: school administration, teacher's teaching, interpersonal relationships, learning achievement and learning environment [22].

Based on the literature reviewed, learning satisfaction was divided into the following five dimensions:

1. Professional teaching;
2. Course arrangement;
3. Learning environment;
4. Teaching equipment;
5. Course content.

RESEARCH HYPOTHESES

A school must understand students' individual differences and learning achievement in order to improve the teaching and learning environment and establish positive interactions between teachers and students. This will help to satisfy students' learning demands, and improve students' learning satisfaction.

Student Learning Outcomes

Student learning outcomes evaluate how the student has learned indicators of achievement. It, thus, indirectly evaluates teaching quality. Student learning outcomes are influenced by the learning model, course design and teaching factors [23]. Numerous scholars have canvassed the personality and learning behaviours that influence student learning outcomes. Bandura investigated the impact of student personality on ability, self-efficacy, personal goals and student learning outcomes [12]. Kaiser et al identified four indexes of student learning outcome: cognitive, skill-based, affective and results [21]. Hutchins found that learner's self-efficacy was one of the most important factors in student learning outcomes [24].

Based on the literature reviewed, the following hypotheses were proposed:

- H1: Teacher self-efficacy positively affects student learning satisfaction.
- H2: Teacher self-efficacy positively affects student learning outcome.
- H3: The teacher teaching process positively affects student learning satisfaction.
- H4: The teacher teaching process positively affects student learning outcome
- H5: Student learning satisfaction positively affects student learning outcome.

RESEARCH DESIGN

Research Model

The adopted research model is presented in Figure 1.

Participants

Following Krejcie and Morgan, study participants were selected from a convenient sample of vocational high school teachers and students in Taiwan [25]. Each participant was asked to complete a survey with items measuring their beliefs. The questionnaires were administered by the researchers. Follow-up surveys were administered to all participants. A total of 372 surveys were distributed to a vocational high school in Taiwan, and the students' samples were drawn randomly from the teachers' class.

Data Analysis

To address this issue, Structural Equation Modelling (SEM) was conducted to verify the theoretical model. First, the measurement instruments were verified by using tests of reliability and validity and, then, the hypotheses of the structural model were tested. Additionally, a confirmatory factor analysis was performed, and the statistical software packages LISREL 8.70 and SPSS 13.0 were used.

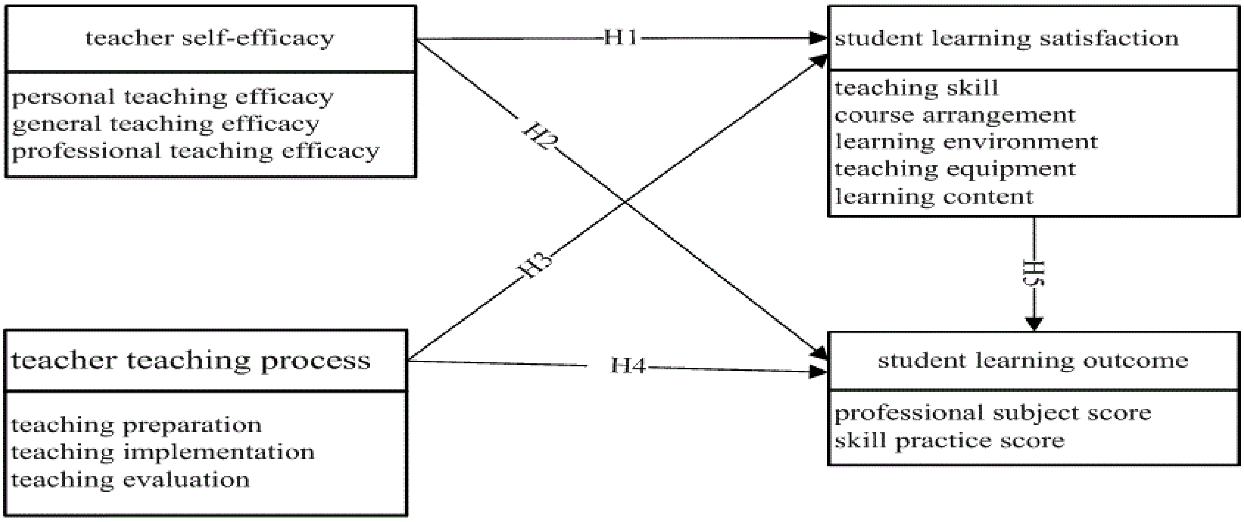

Figure 1: Research model.

Survey Measurement Instruments and Items

Due to the lack of empirical investigation into teaching self-efficacy, teaching process and student learning satisfaction, the measurement instruments of the pertinent constructs were developed from the theoretical statements made in the existing literature. The newly proposed research model in this paper, along with the proposed measurement instruments, reflects the exploratory nature of this study. Seven-point Likert-type scales ranging from 1 (strongly disagree) to 7 (strongly agree) were used throughout the survey.

Confirmatory Factor Analysis (CFA)

The CFA was applied to test the model. The structure of item loadings was consistent with the intended theoretical constructs. Although the chi-square test was significant, other measures, such as the ratio of chi-square and degrees of freedom, the values of Goodness of Fit Index (GFI), Adjusted Goodness of Fit Index (AGFI) Comparative Fit Index (CFI), Normalised Fit Index (NFI) and the Root Means Square Error of Approximation (RMSEA), were used [26].

RESULTS

Measurement Model

A confirmatory factor analysis using LISREL 8.70 was conducted to test the measurement model, and there were three kinds of indexes to evaluate the model fitness, as follows: absolute fit indexes, relative fit indexes, and parsimonious fit indexes.

Three model-fit measures were used to assess the model's overall goodness of fit, the absolute fit indexes including: χ^2, NCP, GFI, AGFI, RMR, RMSEA and ECVI, the ratio of chi-square to degrees of freedom (df), adjusted goodness of fit index (AGFI), incremental fit index (IFI), comparative fit index (CFI), and root mean square error of approximation (RMSEA). The reason for using AGFI instead of GFI was due to the adjustment for degrees of freedom [26]. Further, IFI was used to address the issues of parsimony and sample size [27], while CFI takes into account sample size [28]. The model comprising the measurement items showed adequate fit, the relative fit indexes involved NFI, NNFI, CFI, IFI and RFI; the parsimonious fit indexes had PNFI, PGFI, AIC, CAIC and Normed χ^2.

Next, the psychometric properties of the measurement model in terms of reliability and convergent validity were analysed. The reliability of the scale was estimated through composite reliability [29], and the composite reliability may be calculated as follows: (the square of the summation of the factor loadings)/(the square of the summation of the factor loadings) + (the summation of item measurement error). The composite reliabilities for the three construct scales suggest acceptable reliability of the scales for further analysis (teacher self-efficacy values: 0.840; teacher teaching process: 0.855; student learning satisfaction: 0.889; and student learning outcome: 0.970). Convergent validity was evaluated by examining the factor loadings of the items and their squared multiple correlations.

Following the recommendation of Hair, Anderson, Tatham, and Black, the factor loadings that are greater than 0.50 were considered to be significant, and all the factor loadings are greater than 0.50 [30]. Consequently, squared multiple correlations (SMC) between these individual items and their constructs were also high. Thus, all constructs in the measurement model were judged to have adequate convergent validity.

Structural Model

This model's fit indices showed reasonable fit (chi-square/df = 3.810, AGFI = 0.837, IFI = 0.973, CFI = 0.973, and RMSEA = 0.087). This model helped exploration of the predictive power of teacher self-efficacy, the teacher teaching process and student learning satisfaction on student learning outcomes, as well as it helped to explore the effects of these.

The results suggest that teacher self-efficacy significantly affects learning satisfaction (γ_{11} = 0.28, *t*-value = 5.84, $p < 0.001$), and teacher self-efficacy is closely connected to the learning satisfaction. Thus, Hypothesis 1 was supported. Teacher self-efficacy also significantly affected learning outcome (γ_{21} = 0.25, *t*-value = 7.70, $p < 0.001$), supporting Hypothesis 2. The teacher teaching process was found to affect learning satisfaction significantly (γ_{12} = 0.64, *t*-value = 11.50, $p < 0.001$), supporting Hypothesis 3. Teacher teaching process also significantly affects learning outcome (γ_{22} = 0.16, *t*-value = 3.16, $p < 0.01$), supporting Hypothesis 4. Finally, the results showed that learning satisfaction significantly affects learning outcome (β_{21} = 0.63, *t*-value = 10.43, $p < 0.001$), supporting Hypothesis 5. Therefore, these data lend support to the hypotheses and this study has taken a step in the direction of defining the impact between teacher self-efficacy and student learning outcomes.

CONCLUSION

Teacher self-efficacy and the teacher teaching process show a strong association with learning satisfaction. The proposed model accounts for 47.8% of the variance in learning satisfaction, and teacher self-efficacy, the teacher teaching process and learning satisfaction all showed a strong association with learning outcomes. The proposed model accounted for 72.0% of the variance in learning outcome. Several pedagogical implications can be drawn from this study, and future research will provide more detailed results, which may differentiate these views from one another.

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A new speech-based emotion identification approach for a modern technology education system

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ABSTRACT: Owing to the emotion deficiency problem in many of the conventional technology education systems, examining emotion sensing has become a new research trend that makes it possible to provide useful strategies to enhance the learning effectiveness of a student. Among the various modalities for emotion sensing, this paper addresses speech-based emotion identification technology. In addition, an emotion feature set, comprising mel-frequency cepstral coefficients (MFCCs) and five perceptual features, i.e. spectrum power, sub-band powers, brightness, bandwidth and pitch are presented and discussed in this paper. The proposed feature set was fed into a frame-based multiclass support vector machine (SVM) for emotion identification. The superiority of the proposed system has been demonstrated via a seven-class emotional database with a 78.5% accuracy rate.

INTRODUCTION

In recent years, identifying a student's emotions to facilitate the learning process has become a new trend in technology education learning. Addressing the emotion deficiency problem in many of the conventional technology education approaches, sensing emotion is able to provide useful cues about a student's learning effectiveness. Proper teaching strategy and content should be adopted to enhance the learning.

For example, D'Mello et al developed an agile learning environment that is sensitive to a learner's affective state [1]. This design augmented an existing intelligent tutoring system and promoted learning. Facial expressions, gross body movements, and conversational cues were utilised to sense emotions. Luo and Tan applied facial emotion and speech emotion identification technologies to a distance education system [2]. For a predefined state of emotion, corresponding emotion encouragement and compensation have to be created.

A similar emotion identification technology based on speech has also been developed for a Web-based education system [3]. Recently, Tsai et al brought together speech recognition, emotion inference and virtual agents to implement a system for student interaction in an educational environment [4]. Motivated by these studies, a new speech-based emotion identification approach to be used in the modern technology education systems is presented in this paper.

EMOTION IDENTIFICATION

The proposed emotion identification system is described here. With received speech, non-silent frames of input waveform are identified first and used to form feature vectors. In this paper, a feature set, which includes spectrum power, sub-band powers, brightness, bandwidth, pitch and MFCCs is presented. A frame-based multiclass SVM is then used to perform the emotion identification.

Emotion Feature Set

Total spectrum power. Denote f_0 as the half sampling frequency. The total spectrum power is computed by:

$$P = \log\left(\int_0^{f_0} |F(f)|^2 df\right). \tag{1}$$

Sub-band powers. The sub-band powers are extracted from the following sub-band intervals: $[0, 0.125f_0]$, $[0.125f_0, 0.25f_0]$, $[0.25f_0, 0.5f_0]$ and $[0.5f_0, f_0]$. The *i*-th sub-band power is computed using the following expression:

$$P_i = \log(\int_{L_i(i)}^{H(i)} |F(f)|^2 df), \quad (2)$$

where $H(i)$ and $L(i)$ are the upper and lower bounds of the i-th sub-band.

Brightness. The brightness is the gravity centre of the power spectrum. It describes whether the power spectrum is dominated by low or high frequencies. Denote p_i as the power associated with frequency f_i, the brightness is calculated as:

$$F_C = \int_0^{f_0} f_i \cdot p_i df \Big/ \int_0^{f_0} p_i df \, . \quad (3)$$

Bandwidth. The bandwidth is the second moment of the power spectrum. It describes whether the shape of the power spectrum is concentrated near its centroid or spread out over the spectrum as follows:

$$F_B = \sqrt{\int_0^{f_0} (f_i - F_C)^2 p_i df \Big/ \int_0^{f_0} p_i df} \, . \quad (4)$$

Pitch. A simple pitch detection algorithm, based on detecting the peak of the normalised autocorrelation function, was used. The pitch frequency is returned if the peak value is above a threshold, or the frame is labelled as non-pitched.

Besides the above mentioned perceptual features, mel-frequency cepstral coefficients, which model the human auditory perception system, were used. The derivation of MFCCs is based on the powers of the theses critical-band filters. The MFCCs can be found from logarithm and cosine transforms.

Emotion Classifier

This study proposes an emotion classifier using a frame-based multiclass SVM. The input waveform is segmented into separate frames. Passing through the procedure of feature extraction, each frame will be transformed into a feature vector. Assume a N_F - frame utterance, $\bar{x}^{(j)}$, $j = 1, \ldots, N_F$, is to be classified into emotion class C_m, $m \in \{1,2,\ldots,M\}$. The steps for emotion identification based on frame-based multiclass SVM follows. First, for each emotion class C_m, and for all the classes C_n ($n \neq m$), one can compute:

$$score_H(C_{m,n}|\bar{\mathbf{x}}^{(j)}) = \sum_{j=1}^{N_F} H(\overline{\mathbf{wx}}^{(j)} + b) - \sum_{j=1}^{N_F} H(-(\overline{\mathbf{wx}}^{(j)} + b)), \quad (5)$$

by the C_m-C_n 2-calss SVM. In Equation (5), $H(\cdot)$ is the Heaviside step function.

The accumulated score for each emotion class C_m is then computed using the following formula:

$$score(C_m|\bar{x}^{(j)}) = \sum_n score(C_{m,n}|\bar{x}^{(j)}) \, . \quad (6)$$

Finally, the most possible emotion class C_{m^*} is chosen by:

$$m^* = \arg\max_m score(C_m|\bar{x}^{(j)}) \, . \quad (7)$$

EXPERIMENTAL RESULTS

The German emotion speech database consisting of utterances with seven different emotions (anger, joy, sadness, fear, disgust, boredom and neutral) was used for the experiments. For each emotion class, half of the audio files were utilised for training and the others were used for testing.

The frame size is 512 samples (32 ms), with 50% overlap in each of the two adjacent frames. For assessing emotion identification results, the accuracy rate, which is defined as the ratio between correct-classified utterance number and the total testing utterance number, was used. With the proposed emotion classifier and feature set, the accuracy rate can achieve approximately 78.5%.

CONCLUSIONS

Identifying a student's emotions to facilitate the learning process is a new trend in technology education learning. This paper proposed and outlined an effective emotion feature set, which includes mel-frequency cepstral coefficients

(MFCCs) and five perceptual features. The proposed emotion identification system uses this feature set and a frame-based multiclass support vector machine. The experimental work has proved that the proposed system is able to identify 7-class emotions with about 78.5% accuracy rate.

It is envisaged that future work should endeavour to integrate the proposed emotion identification system into computer-based and Web-based technology education systems. The initial research work has already been undertaken in this respect.

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