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Investigation into the development of English and communication skills for the modern engineer within a cultural context: a research scheme

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ABSTRACT: Communication skills are essential for an engineer who aspires to carry out his/her professional practice on the global scene. Engineering communication skills basically constitute several core elements such as fluency in the English language and the fundamentals of visual communication. The process of the formation of a professional engineer may vary depending on the context that the educational process takes place in, ie whether English is learnt as the first language or a second/foreign language. Further, the cultural context will influence how this is processed and the extent to which it succeeds. However, apart from the English fluency component, the basic elements of communication skills may be the same. The proposal endeavours to address several issues of concern, and propose a research programme to investigate those issues. This should provide researchers with comprehensive information concerning the status and quality of existing English and communication skills courses for engineers within a cultural context. A comparative study of courses available internationally in English and communications for engineering students will also be carried out under the project.

INTRODUCTION

Evidence indicates that communication skills are what helped *Homo sapiens* evolve beyond our related ancestors, and that these skills have helped humankind develop into the advanced societies on Earth today [1]. However, these skills have become stifled in the very discipline that has brought so many advancements, namely engineering.

There is ample evidence that graduate engineers lack the required standard of communication skills, particularly when compared to the needs of industry internationally [2][3], and compared to related disciplines offered at universities (eg business). This is so much so that the Dean of Engineering at Duke University stated that … *engineers who are adept at communications have a considerable advantage over those who are not* [4].

Furthermore, this lack of communication skills only serves to undermine the whole profile and image of the professional engineer. Comprehensive research needs to be carried out in order to determine the profile and focus on those communication skills required for general and, more specifically, for professional use, and how these may vary across cultures and are influenced by differing cultures.

Communication skills have to be considered as a vital aspect in the education of engineers. This has been reinforced by such skills being one of 11 key outcomes required in an undergraduate engineering programme in the ABET Engineering Criteria 2000 [5]. Communication skills are a regular feature of an engineer's job in industry; some graduates employed in industry have identified that education in communication skills needs to be improved, given the demands that have been encountered in industry [6]. Indeed, communication skills are considered to be a valuable *career enhancer* [7]. Carlson asserted that *communications is not ancillary to engineering but rather at the heart of engineering* [8].

The relevance of language and communication skill development was emphasised recently with the statement that:

> *Skills such as problem solving, communications, interpersonal skills and critical and independent thinking should be fostered in engineering education, not just because they are qualities that employers look for but because they should be part of any tertiary education* [9].

It has also been commented that it is with the aid of foreign language study … *that students have access to a different culture and new knowledge* [10]**.** Furthermore, language learning should not only be considered as a skill, but also as a *creative medium to inform students' understanding of society* [11].

BACKGROUND

The purpose of such investigation is to look at achieving a sense of *unity* in the education of engineers in English and communication skills, but still recognising the inherent differences that exist between different cultures. Engineers can relate the same theories of mathematics, of mechanics and technology, but have fundamental trouble in communication skills. This indicates a lack of a direct fit between graduate skills and those required by industry.

This investigation will seek to identify core elements required in the education of engineers for graduates to successfully meet the demands of industry.

This will be reinforced in cultures where the prime language is not English, so that secondary language skills are also acquired

in a world where language can form high borders. Ultimately, this adds a second dimension to the study; are two different models of education required in instances where English is the first language, and another in cultures where English is the second language?

ENGLISH: *LINGUA FRANCA*

As the world develops into regional networks, multilingualism has become vitally important. English has been widely accepted as *the most widespread language in the world* [12]. For instance, after the fall of communism it has become the second language in various European countries. The distinction here lies between the most *widespread* versus the most *widely spoken*.

The English language is, in essence, a *pluricentric* language, ie has more than one centre [13]. Indeed, its diverse spread has resulted in the slow but definite evolution of different strains, dialects and cultural specifics of English worldwide. These differences need to be taken into account in the education of English language skills.

English is the prime means for communication, and can often serve as the *global language* between people from different cultures, wherein English is not the native tongue. For example, French engineers communicated with Egyptian engineers in English during the recent building of the Cairo subway [14]. Another example can be found in the collaboration at Airbus industries between English, French, German and Spanish companies, which utilised English as the communication medium between workers [15].

There is certainly a level of logic in adopting a *lingua franca* that can facilitate wider communication between peoples who may be from different continents that may be as far apart as Brazil and Japan. However, monolingualism is not the goal here; the objective is to promote communication within a multilingual structure. Learning to use another language helps reflect attitudes and conveys tolerance towards others, as well as respect for their identity and culture [16].

English has been cited as the … *major language of international business, diplomacy, and science and the professions* [12]. As such, English as a *global* language has distinct business, technological, scientific, social and political implications.

Part of the English language's survivability can be attributed to its adaptability in embracing words from other languages (including Germanic, Norse, Latin and French), thereby negating any real level of linguistic redundancy. In a study on the future of the English language, Graddol found that English (along with Spanish and Chinese) would continue to rise as one of the world's dominant languages [17].

Multilingualism on the Internet is increasing at a phenomenal rate. The English language once dominated the cyber realm, but this has now been replaced with an increasing emphasis on a more regional cultural identity of the Internet user, including language. Statistics indicate that the prime language of Internet sites is becoming increasingly regionalised, with the local dominant language being the first choice in language options. English is still strong, has become the *second* choice in an increasingly multilingual international community.

This indicates where the English language's strength lies in: as a second language that facilitates communication between different cultures. This has clear implications for engineering education, particularly in the education of engineers who will need to operate within an expanding globalised framework. In this global environment, graduates should have training in a *business foreign language* [18]. This also reflects back onto engineering education institutions: to maintain relevance, engineering curricula will need to incorporate a strong degree of language and communication skills at the fundamental level and should preferably be dispensed in various subjects across the engineering curriculum.

Interestingly, in some cultures, the degree of English fluency can affect, among other things, the status of some individuals, such as the case of Russian scientists entering Israel [19]. While a second language was valued highly in this instance, greater emphasis was placed on English, rather than German or French. This in turn significantly affected the level of job satisfaction and self-actualisation of the scientists.

ENGINEERING FOCUS

The intended research will examine how engineers use the language, the nature of communication, such as verbal and visual, and the tools they use to communicate. The research will examine the two elements on the learning of language and visualisation, which are both critical for the professional performance of tasks.

As it stands, resources are available to be utilised in a communication curriculum, including written and oral communication (eg Ref. [20]). This incorporates interpersonal communication skills, which can aid in general communication, including on an intercultural basis.

Several areas of communication skills required for engineers have been already examined. The first group area of research was English language proficiency and include the following attributes:

- Spoken language fluency;
- Written language fluency;
- Cultural (regional/national) dialects;
- Technical terminology;
- Professional jargon.

English for Specific Purposes

English for Specific Purposes (ESP) will also need to be looked at as it is an important component in the education of engineering students. The concept of English for Specific Purposes achieves more in the education of engineering students by focusing the learner's attention on the particular terminology and communication skills required in the professional field. Various examples in the engineering field can be found, including computer science, maritime engineering's *seaspeak* and so on. To successfully operate on a global academic scene and to develop human resources for industry and academia on a worldwide basis, an engineer, researcher or engineering educator needs to be bilingual at minimum and effectively use a language of international communication with particular knowledge of key words that are fundamental to the discipline.

Visual Communication Skills

The dynamics of visual communication skills have also been analysed and touched upon [21]. The following phenomena, which are related to communication for engineers, require further investigation:

- Perception;
- Cognition;
- Dynamics of visual communication;
- Schematics and diagrams;
- Graphical representations, etc.

Visual literacy can be enhanced through cognitive activities, such as freehand and grid drawing, and is re-emerging as a valuable tool, particularly for fundamentals in industrial design [22]. Visual literacy has been defined by Anderson as involving ability to perceive image-based information, processing and understanding it, and having the skill to communicate to others through drawing and modelling [23]. Interestingly, Anderson also noted that confidence was a major issue for students.

Oral Communication Skills

The burgeoning importance placed on oral communication skills by employers has been echoed internationally for a decade or more and across disciplines. Knowledge and technical know-how are clearly important, but these must be presented with an excellent standard of communication skills, particularly oral. A recent Irish study found that 78% of a sample of practicing engineering graduates stated that were required to give oral presentations as part of their work, quite often on a regular basis [6]. Oral communication skills development, such as interpersonal skills development, has been demonstrated through the use of various methods, including:

- Presentations;
- Group projects;
- Peer review;
- Role-play;
- Video feedback;
- The use of presentation software/hardware, etc.

Research literature has indicated that experiential methods have generally yielded better results than purely didactic means. Engaging learners will help facilitate and stimulate effective and purposeful learning by the students. Involving the learners directly, in particular, will engender a stronger sense of responsibility in the future graduates that they can take beyond the university and into the work arena. This is very important when engaging learners of English as a Second Language (ESL) and English for Specific Purposes (ESP) as it involves a new vocabulary.

Non-verbal Communication Skills

A high percentage of people who engage in intercultural communication are engineers. These engineers, as well as non-engineers, often feel confronted with a task for which they are insufficiently prepared. As a consequence, there is a strong demand for further education and training. The importance of the cultural context in non-verbal intercultural communication is a vital component of international communication. Further, competence in intercultural communication needs to encompass some level of understanding in non-verbal communication [24].

Written Communication Skills

Written communication skills involve a more active, rather than passive, learning method. Writing can enhance critical thinking and problem-solving skills, as well as serve to identify and confront personal misconceptions [25]. Examples that augment written communication skills include engineering reports, technical writing, essays, reflective journals, peer review and *student conference* papers. Other considerations include technology, such as keyboarding skills, group collaborative work, international elements covering intercultural communication, and the active involvement of the learner [26].

Assessment

Communication skills have been identified as multidimensional and it therefore becomes crucial to classify how they will be assessed in students' work. Additionally, the particular communication skills that are required in a profession are usually poorly defined. Individual feedback is important to improve the education of students. However, there needs to be prudent identification and clear operational definitions of the rating dimensions so that the same standards are applied to all students: consistency and accuracy. It is imperative that the student understands what is expected and what will be assessed ahead of time to facilitate education, learning and the generation of desirable characteristics. This will deliver formative (feedback) and summative (evaluation) assessment.

UNDERGRADUATE TEACHING IN COMMUNICATION

Attempts have been made to introduce a complex subject in order to improve the training of engineering students in both verbal and visual communication. As an example, a certain model was proposed by Z.J. Pudlowski over a decade ago for a first-year subject, titled *English and Communication Skills*, within a curriculum of an undergraduate engineering education programme, to develop the use of the English language, as well as certain fundamental communication skills required by the modern engineer [27]. This course was in operation for several years in the International Faculty of Engineering (IFE) at the Technical University of Lodz, Lodz, Poland.

It is envisaged that this will be investigated further in a research scheme that should address these issues and more. However, the initial subject has since been divided into two components: communication skills (oral and verbal) and a separate subject treating visualisation techniques and learning (*Technical Drawing*).

The subject listing developed by Z.J. Pudlowski at the IFE for the initial communication course included the following topics:

- English Fundamentals:
  - Intensive course in spoken and written English.
  - English grammar and style.
  - Introduction to science and technical English.
- Science and Engineering Report Writing:
  - Purpose of writing.
  - Styles of writing, including essays and written reports.
  - Engineering report and its organisation.

- Use of popular computer-based word processors and desktop document preparation systems.

- Presentation Skills:
  - Oral communication and presentation.
  - Structure and organisation of a talk.
  - Oral presentation style.
  - Oral presentation of engineering cases and problems.
  - Use of presentation aids.

- Engineering Communications:
  - Problem solving and generation of a solution.
  - Heuristics and algorithms.
  - Freehand sketching.
  - Introduction to perspective.
  - Orthographic projection.
  - Use of stencils.
  - Basic engineering symbols and diagrams [27].

It would appear that this model covered the prime areas needed to effectively teach English and communication skills to engineering students. This was developed especially for the international arena and was first possible to be realised in Poland. Certain elements of the course have also been utilised in the English Engineering Faculty at the Donetsk State Technical University in Donetsk, Ukraine [18].

However, its position with regard to current engineering practice and the structure of the course need to be investigated, as there has been no feedback with regard to the programme's validity, usability, as well as its cultural, industrial and academic relevance. Another research objective would be to investigate its adaptability for non-European cultures, particularly in key Asian nations, such as India.

This research targets the identification of areas where such a communication course needs to be improved and if different models need to be developed for different global regions. Cultural backgrounds can affect the way people learn and how they communicate, so this model may not necessarily be able to be applied universally. As it stands, the concept of *linguistic determination* suggests that language may determine, or at least influence, the way people think [28][29]. As such, the languages of different cultures will affect thought processes to various degrees.

Already, the increased technological acumen required for computer-generated reports and presentations in industry has recently been identified as a required skill for engineering graduates in industry [6]. Incorporating this will necessitate the regular updating of coursework in order to keep up with software and hardware advances in communications technology.

RESEARCH CHALLENGES

In examining the model, it is necessary to carry out a test of the relevance of the model in Poland and the Ukraine, and its further applicability elsewhere, such as India, and would be the main challenge for this project. Moreover, research needs to be undertaken on whether its curriculum is valid regionally and, indeed, valid for the global scene.

This insight information would provide the researcher with the view as to whether the model is adequate for the international purpose, or improvements need to be carried out, or other models need to be developed for specific cultures. In summary, this targets the identification of:

- A research model.
- The validity and relevance of the course.
- Whether this model is adequate, or if different models need to be developed for different structures.

STRUCTURE OF THE RESEARCH PROGRAMME

The research programme to be carried out would be structured as detailed below.

Literature Review

A review would be undertaken covering existing and up-to-date literature. This would include:

- The Internet;
- Journal publications;
- Conference publications;
- Other library sources;
- Report documentation from tertiary institutions.

Research would also incorporate various discussion points. This will include models of engineering education in communication and the extent to which they have been successfully implemented in various cultures.

Review of Practices and Systems

Analyses would be made on how engineers communicate and their general communication skills within the context of different cultures. A distinction needs to be drawn between verbal, visual, non-verbal and written communication skills. Indeed, different practices and techniques need to be undertaken in order to augment skills in these professional areas. Intriguingly, a recent study found that poor English (as a second language) written communication skills tended to parallel poor written communication skills in the native tongue, in this case Arab [30]. If extrapolated, this suggests that poor written communication skills will hamper attempts to adopt written communication skills in another language, indicating the importance of instilling sound communication skills in students, particularly in the engineering field, as this discipline has a poor reputation with regard to communication skills.

Other Considerations

The theoretical analysis will cover important theoretical frameworks, such as constructivism in the education of students and student-centred learning. Additionally, incorporating elements of emotional intelligence (EQ) in the coursework will assist in maximising the learning potential of the students; EQ will also contribute to a level of self-awareness and empathy with other cultures, skills that are so important in today's international dealings between professionals [31]. Oral and written communication skills can be enhanced by guiding students to become reflective practitioners [8][32]. Further, such skills can focus students' attention on the links between technology and culture [8]. Elements such as Problem-Based Learning (PBL) also need to

be considered [33], as well as the potential for integrating communication skills across the curricula [34].

Review of Courses

A review of engineering courses across various cultures will be undertaken and will cover a broad international search of engineering courses that include English and communication skills in the curricula. More importantly, this review will also make investigations into those regions where English is a second or foreign language. A comparative study will be undertaken by reviewing the structure of the models within different cultural contexts at institutions in places such as:

- Technical University of Lodz, Lodz, Poland.
- Donetsk State Technical University (DonSTU), Donetsk, Ukraine.
- Other European models in such places as Sofia, Bulgaria [35], Aalborg, Denmark [36], Copenhagen, Denmark [37], Helsinki, Finland [38], Wismar, Germany [39], Budapest, Hungary [40], Vilnius, Lithuania [41], Bucharest, Romania [42], Madrid, Spain [43], etc.
- Analysis of non-European cultures to provide a counterbalance, eg India, Taiwan, Monash University Malaysia [44], Thailand, the Arab region [45], etc).

This will utilise, but not be limited to, the expanding network of international institutions from around the world fostered by the UNESCO International Centre for Engineering Education (UICEE), which is based at Monash University, Melbourne, Australia.

Research Methodology

The research methodology will be comprised of:

- Literature review;
- Course reviews;
- Internet searches;
- Surveys and interviews.

Course Structure Formulation and Research on Best Possible Model

The course structure formulation, as well as research into the best possible model, will elaborate on the Pudlowski model as part of an engineering course and its regional and international applicability [23].

The best possible model will include elements such as peer assessment, particularly in oral and written presentations [46]. Opportunities for self-reflection can help in the development of communication skills, as well as in the personal development of the student and ties in with recent discussions about emotional intelligence, which also influences multicultural awareness and communication capabilities. The potential best possible model should also include examples of regional engineer's reports plus international case studies [47]. Ultimately, a best possible model must recognise those advances already established internationally.

The course itself should include such elements as relevant examples of the cultural history of prime English-speaking nations, as well as the history of major engineering feats. This will contribute to maintaining relevance for engineering students by combining education within a cultural context in the technical language, communication skills, plus additional engineering information that students can refer to. As such, it will also serve to reinforce engineering terminology and concepts.

Furthermore, there should be conscious avoidance of utilising discriminatory language in the education of English and language skills to engineering students; otherwise this may inadvertently alienate them from dealings with native speakers. This also brings in the concept of incorporating elements of emotional intelligence and so-called *soft skills* in the education of engineering students in order to augment communication skills. Motivational issues would also be reviewed.

Discussion

The discussion section will cover several important areas, including:

- The utilisation of examples from various international case studies that can also establish new benchmarks in the advancement of a best possible model.
- Discussion of theory from current engineering education. This includes important elements such as constructivism, student-centred learning and experiential approaches, as well as the use of the so-called *fun factor* to enhance the learning experience of students [48].
- Discussion of pertinent theory from non-engineering fields of communication and cultural studies (eg business communications and sociology). However, relevance must be maintained for current engineering practice. For example, Ahearn has commented on the need to utilise rhetoric theory pragmatically in the training of engineering communication and that rhetoric theory can provide valuable tools in this area to counter ineffective communication in engineering [49].
- Discussion of theory from ESL studies (ie English as a Second Language). Recognition here should exceed European cultural boundaries in order to provide for the potential greater applicability of the model.
- Recognition of the impact of cultural stereotyping and ethnocentrism [50][51].
- Consideration of the cultural features found in speech that influence effective communication and the integration of these in language learning programmes [52][53]. Furthermore, an analysis of culture's impact on engineering education will also be undertaken [54].
- Consideration of the *more implicit social and cultural values … embedded …* in language [11]. Such values include incorporating education in human rights in engineering curricula [55].

This discussion and the comprehensive research gathered should lead to one of the following outcomes:

- Confirmation of the existing model.
- Acceptance of the existing model with some modifications.
- Proposal of a new model.

Conclusions and Recommendations

It appears that the above research plan includes all the necessary steps required to investigate the research hypotheses and to determine the efficiency of the subject.

SUMMARY

The incorporation of language and communication improvement courses and recognition of external cultures are important elements in promoting continuous learning, and will ultimately contribute to the process of life-long learning. This should in turn facilitate advancements in engineering and engineering education through streamlining fundamental communication and skills in a cultural context. Furthermore, this research will seek to establish its own model, if found to be necessary in order to *evolve* and *advance* the Pudlowski model, for such an introductory course by building on past successes.

However, stand-alone subjects need to clearly identify the benefits and relevance of utilising the methods learned so that they can be transferred into the rest of the student's experience. For example, integrating compulsory communications education, whether represented wholly or in part by one or more units, should be part of an engineering degree. The skills learnt in a stand-alone communications subject need to be utilised *across* the degree to demonstrate application and reinforce behaviour.

Finally, it is imperative that engineering undergraduates develop and augment English and communication skills. The English language has become a major medium for communication across borders globally; a deficiency in this area may result in barriers for graduates' personal and professional development and will undermine their ability to compete in the global marketplace.

Courses that train the global engineer must be made ready as soon as possible so as to be responsive to industry demands, particularly in university courses where the next generation of engineers are being educated. Secondary language skills need to be acquired by engineering students in a world where language can form high borders and generate barriers.

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Conference Proceedings of the *7th UICEE Annual Conference on Engineering Education* under the theme: *Educating for the Global Community*

edited by Zenon J. Pudlowski

The *7th UICEE Annual Conference on Engineering Education*, held under the theme of *Educating for the Global Community*, was organised by the UNESCO International Centre for Engineering Education (UICEE) and was staged in Mumbai, Maharashtra State, India, between 9 and 13 February 2004.

This volume of Proceedings includes papers submitted to this Conference and offers a diverse compendium of articles that detail various international approaches to engineering education research and development related to the Conference theme, as well as other specific activities.

The 47 published papers, representing 21 countries, offer an excellent collection of works that tackle fundamental issues, concepts and achievements of individual researchers, as well as the concerns and challenges regarding engineering and technology education in different cultures.

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- International examples of engineering education and training
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