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A research programme into the depth and quality of English and communication skills in first year undergraduate engineering education in India, using Monash University (Australia) as a reference point

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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 research programme being carried out as part of the author's Master's by Research endeavours to address several issues of concern, and investigate those issues through a content analysis of foundation engineering courses of a case study from Asia, namely India. This is compared to Monash University's model in Australia. This should provide researchers with comprehensive information concerning the status and quality of existing English and communication skills courses for engineers within key institutions in India.

SIGNIFICANCE OF THE STUDY

It has become apparent that there is a lack of key skills that is stifling the very discipline that has brought so many advancements to humankind, 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 [1][2], 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* [3]. Furthermore, this lack of communication skills only serves to undermine the whole profile and image of the professional engineer.

Communication skills must 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 [4]. 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 [5]. Indeed, communication skills are considered to be a valuable *career enhancer* [6]. Carlson asserted that *communications is not ancillary to engineering but rather at the heart of engineering* [7].

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

> *Skills such as problem solving, communications, interpersonal skills … 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* [8].

Clearly, 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 undermine their ability to compete in the global marketplace.

However, any standalone subjects that are devised in efforts to address this skills deficit 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. Indeed, it is argued that the skills learnt in a standalone communications subject need to be utilised *across* the degree to demonstrate application and reinforce behaviour.

Courses that train the global engineer must be modified 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.

The study focuses on the model in Maharashtra state in India, compared to Monash University's efforts in Australia. This offers regional comparisons for Australian and Indian tertiary institutions.

LITERATURE REVIEW

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* [9]. 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 [10]. Indeed, its diverse spread has resulted in the slow but definite evolution of different strains, dialects and cultural specifics of English worldwide.

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 building of the Cairo subway [11]. 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 [12].

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 [13].

English has been cited as the … *major language of international business, diplomacy, and science and the professions* [9]. As such, English as a *global* language has distinct business, technological, scientific, social and political implications. Further, Graddol found that English (along with Spanish and Chinese) would continue to rise as one of the world's dominant languages [14]. Additionally, English has become the *second* choice in an increasingly multilingual international community on the Internet [15].

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 need to operate within an expanding globalised framework. In this global environment, graduates should have training in a *business foreign language* [16]. This also reflects on engineering education institutions: to maintain relevance, engineering curricula needs 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.

Communication Skills Acquisition

The current research examines how engineers use language, the nature of communication (eg verbal and visual) and the tools they use to communicate. The research examines 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. [17]). This incorporates interpersonal communication skills, which can aid in general communication, including on an intercultural basis. Also, skills in emotional intelligence (EQ) can help facilitate communication skills [18].

Verbal Communication Skills

The burgeoning importance placed on oral communication skills by employers has been echoed internationally for a decade or more across disciplines. Knowledge and technical know-how are clearly important, but these must be presented with an excellent standard of communication skills, particularly verbal. 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 [5]. Verbal 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 and the use of presentation software/hardware, etc.

Research literature indicates that experiential methods generally yield better results than purely didactic means. Engaging learners helps facilitate and stimulate effective and purposeful learning by students. Involving learners directly, in particular, engenders a stronger sense of responsibility in future graduates that they can take beyond the university and into the work arena.

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 such, 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. Furthermore, competence in intercultural communication needs to encompass a level of understanding in non-verbal communication [19].

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 [20]. 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, intercultural communication, and entail the active involvement of the learner [21].

Visual Communication Skills

Integral to communication is the concept of visual communication, which can often convey information more succinctly and quickly than verbal or oral means. Effective visual communication is cross-cultural and exceeds linguistic boundaries, as well as being multidisciplinary. As such, it is important that engineers of the 21st Century develop visual literacy [22]. Visual literacy can be enhanced through cognitive activities, such as freehand and grid drawing, and is re-emerging as a valuable tool [22]. Visual literacy has been defined by Anderson as involving the 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.

Standardisation facilitates international recognition to exceed language and cultural boundaries. Importantly, standardisation needs to be led by psychological and cognitive research into the best image in terms of instant recognition, rather than bureaucratic consensus or isolated design teams [22].

Skills 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 students' skills. However, there also needs to be consistency and accuracy. It is imperative that students understand what is expected and what will be assessed ahead of time to facilitate education, learning and the generation of desirable characteristics, thus requiring formative (feedback) and summative (evaluation) assessment [24].

Technical University of Lodz Model of Communication Skills

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 English language and fundamental communication skills required by modern engineers [25]. This course was in operation for several years in the International Faculty of Engineering (IFE) at the Technical University of Lodz, Lodz, Poland. 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 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; organisation of engineering reports; 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; 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 [25].

This model appeared to cover the prime areas needed to effectively teach English and communication skills to engineering students, as it includes visualisation, an aspect not always considered in communication instruction. The model was developed especially for the international arena and was first 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 [16].

However, the programme's validity, usability, plus its cultural, industrial and academic relevance, need to be investigated. Another research objective would be to investigate its adaptability for non-European cultures, particularly in key Asian nations, such as India. 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 [26][27]. 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 been identified as a required skill for engineering graduates in industry [5]. Incorporating this necessitates regular updating of coursework in order to keep up with software and hardware advances in communications technology.

Current issues for universities include the following:

- Encouraging communication skills acquisition.
- Eliminating engineering students' attitudes to so-called *soft skills*, which tend to be negative, despite support from industry and professional engineering bodies.
- Integrating communication skills across the curricula.
- Incorporating experiential approaches.

KEY RESEARCH QUESTIONS

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 seeks to identify core elements required in the education of engineers for graduates to successfully meet industry demands. This is 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.

Key research questions to be tackled in this research are:

1. What are the prime elements of the initial Technical University of Lodz model?
2. How relevant is the Technical University of Lodz model in an increasingly globalised and international community of engineering graduates and workers?
3. Should such education in communication skills acquisition be in the form of a standalone subject, or should it be integrated across the curriculum?
4. What are the outstanding characteristics of the Indian undergraduate curriculum?
5. How well does the Indian structure manage communication skills education for engineering students according to established regional and international requirements?
6. What recommendations could be put forward to enhance the current state of play, especially compared to Monash University's structure of the engineering curriculum?

METHODOLOGY

The current research structure of the thesis is as follows:

- Chapter 1: Literature review;
- Chapter 2: Review of the communication component in the undergraduate engineering curricula in Maharashtra state;

- Chapter 3: Review of the communication component in the undergraduate engineering curricula at Monash University (Australia);
- Chapter 4: Results of a content analysis of the Maharashtra model, using Monash University as reference point;
- Chapter 5: Conclusion and recommendations.

The research methodology comprises ongoing literature review; course reviews; Internet searches; surveys and interviews; plus potential fieldwork activities.

The research programme is structured as detailed below.

A literature review covers existing and up-to-date literature. This will include the Internet, journal publications, conference publications, other library sources, report documentation from India, and report documentation from other tertiary institutions.

The research also incorporates various discussion points, such as models of engineering education in communication and the extent to which they have been successfully implemented in various cultures. Research of established European models will serve as additional (but intermittent) comparisons (especially in the literature review), although these will be limited by the different cultural context [28-35]. Language and cultural issues, such as can be found in the Arab world, will also aid in offering a counterbalance [36][37].

The study includes analysing how engineers communicate and their general communication skills within the context of different cultures [38]. 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 [36]. If extrapolated, this suggests that poor written communication skills 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.

Additional Considerations

The theoretical analysis also covers important theoretical frameworks, such as constructivism in the education of students and student-centred learning [39]. Additionally, incorporating elements of emotional intelligence (EQ) in coursework assists in maximising the learning potential of students; EQ also contributes to a level of self-awareness and empathy with other cultures, skills that are so important in today's international dealings between professionals [40].

Verbal and written communication skills can be enhanced by guiding students to become reflective practitioners [7][41]. Further, such skills can focus students' attention on the links between technology and culture [7]. Elements such as Problem-Based Learning (PBL) also need to be considered [42]. Also being investigated is the potential to integrate communication skills across the curricula [43]. While the author is aware of these additional considerations, it seems unlikely that all of these elements can be validly tested in the present Master's project.

Case Study of Maharashtra State, India

A comparative study is being undertaken by reviewing the structure of the models within different cultural contexts at institutions like India. 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. The target university is the Maharashtra Academy of Engineering and Educational Research (MAEER), with additional information from the Maharashtra State Board of Technical Education (MSBTE).

Justifications for selecting India include:

- UICEE Partner institutions can aid in the collection of information;
- Burgeoning world economy, especially in technology;
- Strengths in technology education;

Indian engineering undergraduate education in the State of Maharashtra, which has the highest concentration of industrialisation and technical education in India, has the following characteristics:

- The engineering undergraduate courses are of four years' duration after 12 years of formal education.
- Standardised curricula again reduced due to private institutions.
- Remaining institutions have a common syllabus that was formulated, designed and controlled by the Director of Technical Education (DTE) with the approval of the All India Council for Technical Education (AICTE).
- Communications skills subject is 1st year only (as for diploma courses).
- Focus for both is on written and oral communication [44].

This case study will be based on the foundation engineering curriculum taught at the MAEER. Using this document, a content analysis will be undertaken to measure the nature and extent to which different types of communication are being used. This will serve to quantify the level of commitment and assessment the MAEER has to the fostering of communication skills in its engineering students. For example, two types of content analysis will be possible, namely:

1. The case study curricula will be searched to establish the frequency with which key concepts, such as *emotional intelligence*, are used as a percentage of total words;
2. The assessment component of the curricula will be analysed in order to establish the relative weightage given to these different types of communication in the teaching environment. For example, if there is no assessment at all that tests a student's knowledge of *emotional intelligence*, then it is reasonable to assume that neither the teacher nor students paid any attention to this – despite the appearance of the concept in the curriculum document (Note *emotional intelligence* is only used here as an example).

The standard procedures for a content analysis will be applied (eg see ref. [45]). The rationale for what appears to be such a literal interpretation of the engineering curricula in India is the well-known adherence to the approved curricula in classroom situations. This is in contrast to Australian universities, where lecturers have considerable discretion in interpreting and

redesigning curricula and, indeed, setting examinations; certainly in India, such academic freedom does not exist.

Enhancing the level of correlation between what is touted in the engineering course documents and what is actually assessed will be addressed in the *Conclusions and Recommendations* section of the research project.

Potential Recommendations Relevant for this Research

The literature review undertaken so far already indicates important recommendations that may be useful for this study. The best possible model for communication skills acquisition at a university should include elements like peer assessment, particularly in verbal and written presentations [46]. Opportunities for self-reflection help in the development of communication skills, as well as in the personal development of students and ties in with recent discussions about emotional intelligence, which also influences multicultural awareness and communication capabilities. Communication skills education in the engineering field should also include examples of regional engineer's reports plus international case studies [47]. Ultimately, it should also recognise those advances already established internationally, plus relevant key criteria of recognised international engineering bodies. Discriminatory language and motivational issues are also being considered.

The communication course itself should incorporate relevant examples of the cultural history of prime English-speaking nations, as well as the history of major engineering feats. This contributes 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 also serves to reinforce engineering terminology and concepts.

The research project covers several important areas, including:

- The utilisation of examples from various international case studies that can also provide useful comparisons for the advancement of communication skills acquisition [45].
- Discussion of theory like constructivism, student-centred learning and experiential approaches, plus the so-called *fun factor* to enhance students' learning experiences [40][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.
- Recognition of the impact of cultural stereotyping and ethnocentrism [49][50].
- Culture's impact on engineering education is also being considered [51].
- The culture of curriculum design in India is also being examined.
- Consideration of the *more implicit social and cultural values … embedded …* in language [52]; such values include incorporating education in human rights in engineering curricula [53].

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 skills in a cultural context.

TIMELINE AND FUTURE WORK

The first half of the research has focused on research into communication skills and elements that can impact on them. This data is now being brought together in the first chapter, which is a survey of the existing literature. It is envisaged that the second half of the research will target closer investigation into existing Indian curricula, notably Maharashtra State, and the extent of the integration of such skills across the curricula of the institutional case study to reinforce skills acquisition and improve the skills base of future engineers.

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