Integrating Experiential Engineering and English Tasks in Second Language Medium Programmes

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Introduction

Joint tertiary-level collaborative programs between international institutes are becoming accepted as globally relevant education experiences. Our institute has been involved in several joint collaborative programs in engineering with likeminded institutes on the Asian continent. This paper reports on the initial stages of a longitudinal case study into the integration of ‘soft’ skills, in particular second language, culture and communication skills into a joint international engineering programme. The focus of the current study involves a collaborative programme between Otago Polytechnic and Dalian Ocean University in which students study the first three years in China before coming to New Zealand for their final year of study. After the completion of their fourth year, students will meet all the requirements for the New Zealand degree qualification. Staff from Otago Polytechnic visit China to deliver twelve courses over the initial three years of the programme. The medium of instruction in China for the engineering courses is English, although local teaching assistants (TAs) are available to help with communication issues. On arrival in New Zealand, students are expected to demonstrate fluency in English language skills and be ready to operate within a project-based engineering environment. This case study is further informed by data from a separate one-year study abroad programme that is offered at our institute in New Zealand in cooperation with a technical institute in Japan.

Research Questions

The case study developed from evidence regarding the difficulty of effectively teaching engineering material through a second language medium, and pertinent questions about whether students were expected to learn English language and intercultural skills from the engineering classes, or whether they were expected to learn these skills separately in language-focused lectures delivered by the partner institute. After several years of classroom experience, we recently carried out a systematic language needs analysis focusing on the following questions:

- What are the current and future engineering English language needs (and expectations) of joint programme students?
- Are the resources and methods being used sufficient and appropriate / effective to meet those needs

Feedback was sought through the use of interviews and focus groups with a range of stakeholders, including managers at both institutes, engineering teaching staff from both institutes, teaching assistants, English language teaching staff and current students from the existing first three years of the programme. This data was collected in 2018 and early 2019.

Based on the findings of this analysis, we then refined a further research question:

- Can we effectively integrate the learning of language and cultural communication skills into the engineering classes delivered offshore in a non-immersion environment?

In this paper, we focus on two of the main findings from the needs analysis – that acquisition of English for use in engineering would benefit significantly from integration of English language skills into engineering classes and activities, and that learners need to be introduced to the cultural expectations of group work, decision-making and learner-centred learning from early stages of the programme, to better prepare them for study abroad.

Needs Analysis

Language needs analysis looks at what is needed to achieve the goals of language acquisition in a specific situation. Such analyses can focus on various aspects of learning, including current needs (and lacks), target needs (what will be needed in the future when learning is "complete"), learner needs (and wants), resource needs and limitations, and stakeholder expectations (Brown, 2016).

In our analysis, we focused only the *current language needs* of the learners in the offshore learning environment, but these obviously reflected the study abroad and future graduate needs as well. We also identified important related sociocultural needs of the learners, discussed further below.

Second Language Acquisition

With globalisation coupled with delivery of engineering products and services becoming more complex, engineers must not only demonstrate technical competency, but also linguistic competency as international connections between organisations grow. This has led to a growth in English medium content-based engineering instruction, as well as English for Specific Purposes courses, and created opportunities for joint international programmes.

However, content-based curriculum planners in our case at least appear to have assumed that, if students are taught technical engineering content in an English language medium, they will naturally develop the necessary English language skills simultaneously, and that there was no need to provide specific opportunities for language learning in the engineering classroom.

There was quite a large spread in English communicative ability even amongst learners in the first year. Some interviewees felt that the level of English was so low that many learners struggled even to understand or respond to basic English. It was also noted that Chinese students generally have had more practice in receptive skills (reading and listening) than productive skills, and are more comfortable with written rather than oral English.

Students in our case study were receiving English language input from three main sources: College English classes, optional IELTS instruction, and the English-medium engineering classes. Although the latter were taught in an English language medium, there was no coherent language strategy or language related learning outcomes, and any learning that was taking place could perhaps best be described as 'incidental'.

A large amount of existing research has looked at the conditions necessary for the acquisition of a second language. Various conditions have been put forward as *necessary, but not sufficient* for a successful second language acquisition environment. They include at least the following:

- **Comprehensible input** (Krashen, 1985)***,*** input at a level that a learner is capable of processing. Generally, this is considered to be at a level just above the current level of the learner.
- **Output** (Swain, 1985) – if a learner outputs (i.e. produces) language, they are more likely to successfully acquire it.
- **Noticing** (Schmidt, 1990), the observation that learners benefit if they are able to cognitively *notice* a new feature or pattern of language.
- **Interaction** (Long, 1996)**,** including the negotiation of meaning and feedback mechanisms, one of the most important aspects of second language acquisition.

Comments from teaching staff, teaching assistants and students clearly indicated that most of the learners in our case study struggled to have any of the above conditions met in engineering lectures in the non-immersive environment, and therefore either had to rely on a translator to aid content learning, or in many cases struggled with both language and content acquisition.

Our data indicates that non-native speakers, particularly those with limited language ability, struggle especially in more lecture-style engineering classes, even with relatively familiar content. Cognitive processing of both engineering and linguistic content more or less simultaneously was often beyond the means of the less advanced language learner, and this lead to disengagement, or over-reliance on interpreters, with the result that neither engineering content nor language acquisition was taking place effectively.

Currently, we could say that the IELTS-targeted curriculum at the institute is focused largely on general academic English, including some English for general social interaction, but nothing specific related to engineering needs. The College English is generic in nature, and focused more on vocabulary and grammar development, although there is scope for topic-based language development to be included as appropriate. There was at the time of the needs analysis at least, no *English language*-focused teaching aimed at engineering English.

Cultural Factors

Our needs analysis also identified a need to carefully consider difference in cultural norms and expectations in planning delivery in joint programmes. In the New Zealand context, project-based or outcome-based learning is a method of learning that stresses the need to develop the soft skills of learners while providing them an opportunity to experience the application of theories learnt in the classroom (Marwan Shamel, 2010). Engineering essentially requires negotiating and working in teams, time and project management skills and communicating through technical reports and presentations, which involve the use of both language and interpersonal skills, visual and numerical evidence. Project-based learning in engineering courses provides the graduates with the required competency to deal with previously unencountered problems and the ability to handle the demands and challenges of a dynamic world (Armstrong, 2008)

Our current joint programmes are primarily designed for students from the Asian continent where the style of learning and team management practises vary in considerable ways from their counterparts in New Zealand. These students are used to solving fixed, well-defined problems with closed-book exam assessments. Assessments are invariably individual and focused on testing technical knowledge rather than fostering group work, interpersonal relationships and communication skills. Further, the education system encourages rote learning and memorization, and is very teacher-centred. Interactive learning and student-initiated learning are not common features at these institutions. This means that many of the students initially have difficulty taking an active part in learner-centred group activities, and this can limit the creation of a cooperative atmosphere that is desirable for project work.

In our classroom practice, we often found that students in our first and second year cohorts, faced with an unfamiliar environment, sat waiting to be told what to do. In these cultures, more importance is placed on developing personal relationships and consensus decision-making (Davis, 2001) rather than the goal-focused teams familiar in New Zealand culture. This meant that students initially struggled to work together. This is particularly challenging since, after arrival in New Zealand, these students will be expected to perform at the same level of competency as local students in New Zealand within a project-based English learning environment.

In summary, our needs analysis recommended that to effectively teach specialized content in a second language medium, we need to have close collaboration between content specialists and language and culture teachers. Ideally, this may take the form of team teaching in the classroom, but at least there must be significant collaboration at the curriculum planning and development stages, and ongoing coordination throughout the programme to ensure effective learning can take place. In the case of joint international programmes, the need for cooperation and collaboration is heightened further as the content experts and English language teachers are spread across several different departments and institutions.

Developing an Integrated Model

We now turn to our subsequent research question:

- Can we effectively integrate the learning of language and cultural communication skills into the engineering classes delivered offshore in a non-immersion environment?

Cross disciplinary corroboration has been suggested as a potential option for integrating language and content (Tatzl, Hassler, & Messnarz, 2012). We believe that carefully designed tasks can enable lecturers to incorporate language and cultural skills into engineering activities and learner-centred laboratories, as well as more open-ended projects. While these tasks focus on reinforcing engineering knowledge, they involve learners in actively producing and negotiating language, including technical vocabulary which is seldom encountered outside the engineering classroom. Cultural expectations can be built into lessons, and interact with cognitive and language skills. Further, aspects of engineering genre can be built in through writing of laboratory (and potentially project) reports.

Given the factors identified above, we were challenged to redesign an earlier model introduced in Weerakoon & Dunbar (2018) to create a framework that could be delivered offshore to enable integration of 'soft' language and cultural skills with technical content to prepare learners to fit as seamlessly as possible into the New Zealand learning environment. The following model (figure 1) shows how we envisage this process occurring:

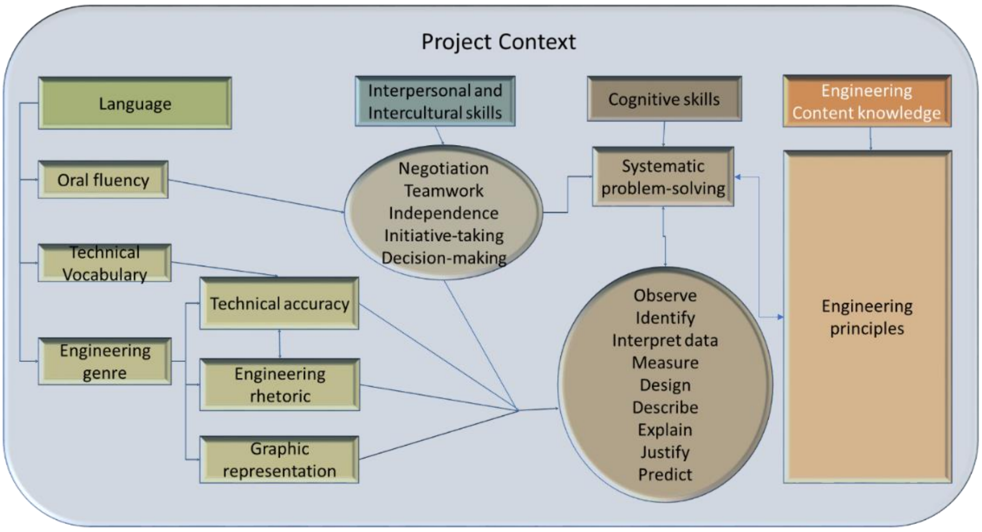

Figure 1: A Framework for Integrating Language, Culture and Technical Content Learning

This model was designed to be used as a framework to prepare integrated projects that create maximum opportunities for learners to develop skills from all domains. We believe use of this model to develop integrated activities can at least enhance the following aspects of soft skill acquisition:

1. Provide context – technical vocabulary can be learned through observation and use, as well as being introduced in both written and verbal form. This means input and output reinforce learning. As one lecturer commented, without this, students may never actually 'pronounce' any technical words themselves in the non-immersion context.
2. Interaction and negotiation of meaning that are vital to language learning can be incorporated in teamwork activities
3. Genre can be introduced and guided through authentic activities such as writing a laboratory report or presenting a brief summary of a project outcome based on a team laboratory

4. Teamwork allows for building in language such as that required for giving and receiving instructions
5. Graphic representation can reinforce communication outcomes.
6. Students are introduced to both language and related cognitive skills simultaneously in an experiential way.

Pilot Activities

Experience has shown us that the limited exposure Japanese and Chinese students have to projects or experiential learning in engineering prior to our joint programmes means that they need to be carefully guided by the facilitators. We initially focused on adapting an activity-focused and project-based model, because this model offered more potential to incorporate both opportunities to *experience* team management and decision-making skills, and to both produce and interact in the English language.

Activity-based Learning

Activity-based teaching (Young 2005) was practiced as a first step to create the learning environment for students to take responsibility and adapt to more learner-centred learning, rather than introducing projects without appropriate preparation.

Figure 2 shows examples of group interactive activity-based learning in the classroom to facilitate the fundamentals governing the conservation of energy. Figure 2a demonstrates the mixing of hot water with cold water to establish the final equilibrium temperature of the hot-cold fluid mixer. Students were also expected to predict the expected equilibrium temperature using the basic energy balance equations. Figure 2b, shows them conducting an experiment to apply the energy formula to determine the power capacity of a domestic hot water kettle. The measured capacity of the kettle is then compared with that of the manufacturer's technical data. The electrical efficiency of the kettle can then be estimated.

Using the framework in figure 1 above allows us to co-ordinate more easily the four aspects of soft skill acquisition. For example, the conservation of energy activity focuses on the cognitive skills of observation and measurement, so the technical language element could focus on oral expressions for measurement, and in particular mathematical terms and formulae which tend to be weak among non-native learners. The activity-based instructions also helped students to grasp the English terminology used in context, and to improve their confidence in using language and communication skills. Positive feedback suggests that activity-based learning sessions provide the students the foundation they require for a good balance of sound applied knowledge of engineering principles and effective communication skills.

(a) (b)

Figure 2: Activity-based Learning

Project-based Laboratories

Based on these initial pilots, we recently implemented a further step in which learners were presented with two more ‘project-based’ laboratories (see Weerakoon & Dunbar, 2019 for a detailed description). The first laboratory was designed to allow students to conceive, design, construct and test a cantilever beam to measure mechanical displacement due to an applied load, and thus determine both the modulus of elasticity of the cantilever material and the deflection of the beam under various loads. In a second laboratory learners were required conceive, design, construct and test a solar hot water system using materials sourced from the local DIY stores. The aim of the laboratory was to produce 10 litres of warm water raised to a minimum of 45 degrees during a typical winter period in the northern hemisphere (at roughly 40^{o}N) and to determine the heat transfer effectiveness of the solar hot water panel.

These two project-based laboratories were the ideal place to introduce the engineering genre of laboratory report writing, and focus on conventions and expectations of rhetoric.

Feedback and observation from our initial attempts at project-based laboratories have also lead us to identify several other aspects of coordination that are vital to soft skill acquisition. Large classes need project management language – how to hand on information to other team members or other groups. Also, we have identified that there is a need to integrate technical vocabulary both horizontally and vertically – that is, we need our framework model to be a 3D vertical model in which the skills build on each other from course to course and year to year, to ensure reinforcement is maximized.

Next Steps

Based on our needs analysis and pilot activities, we are currently in the process of implementing several steps that we believe will enhance the integration of language and cultural outcomes in the engineering classes:

1. Creation of a series of English language “graduate learning outcomes” that will guide the implementation of language outcomes through the programme
2. Incorporation of a ‘language and culture’ learning outcome into engineering courses delivered offshore to ensure they receive appropriate attention
3. Development of a coherent ‘translation policy’ to reduce the reliance of learners on first language translation in classes
4. Establishment of a corpus of language used in the engineering courses, and identification of vocabulary to be introduced in each course to enable vertical integration
5. Introduction of interactive tasks involving pronunciation of technical vocabulary at the beginning of classes to reinforce the need for students to produce *output* and use words in interaction.
6. Planning for a series of tests to monitor progress in engineering language *use* and retention of terms.

Conclusion

A number of years of teaching experience, backed up by a systematic needs analysis has shown us that relying on the use of English language as a medium of instruction for offshore technical language development has been rather ineffective in enhancing language acquisition, at least for a significant percentage of lower-level learners. In order to better manage these learners’ technical language needs, without compromising the content delivery, there is a need to carefully coordinate language, culture, cognitive and technical content needs. Our framework presents a model that can be used by materials developers, as well as lecturers and teaching assistants, to provide opportunities for more interactive learning that encourages output, reflection, and discovery. Our initial trials of these integrated project-based activities have been well received by both students, staff and institute leaders, and we have recently learned that the Chinese institute has committed to building a dedicated work space for integrated project-based learning following our early progress which they hope will become a model for other similar institutes to follow. We plan further research and monitoring to assess the effectiveness of this integrated approach to technical and soft skill development in an offshore environment.

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