Meeting the challenges of engineering education via online roleplay simulations *

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SUMMARY: *Engineering education is undergoing continuous change. Drivers for this change come from a number of sources, such as the K-12 pipeline (eg. school curricula, student attitudes towards science and engineering), the profession (eg. accreditation requirements, increasing globalisation and multidisciplinarity, increased emphasis on sustainability), government (eg. increasing student to staff ratios), internationalisation (eg. greater student diversity, geographically distributed student cohorts) and students (eg. the need to cater for "Net Generation" learners). In order to meet the challenges posed by these changes, creative approaches to teaching that foster partnerships in engineering education are required. In this paper, one such approach is presented: online roleplay simulations. As part of online roleplay simulations, multiple learners adopt the roles of stakeholders with varying points of view and interact online about complex issues that do not have a single "correct" outcome. This enables a number of the challenges faced by engineering educators to be met within a flexible, pedagogically sound framework. For example, use of online roleplay simulations facilitates the development of a range of generic graduate attributes in a manner that actively engages students. In addition, cross-disciplinary and cross-institutional partnerships can be developed to enable students and academic staff from different backgrounds to interact with each other. This not only improves student learning experiences and fosters academic staff development, but also enables vital resources to be shared between institutions. Because interactions occur online, provision can also be made for student cohorts that are becoming increasingly geographically distributed as a result of twinning arrangements and offshore campuses. Finally, online roleplay simulations also cater for the needs and learning styles of Net Generation learners (those born between 1982 and 1991), as they enable students to work on realistic problems in an environment that is rich in imagery, provides flexibility for time poor students and enables students to be socially connected. In this paper, the benefits of online roleplay simulations are illustrated with a case study: the Mekong e-Sim.*

1 INTRODUCTION

Engineering education is undergoing continuous change. Drivers for this change come from a number of sources, as shown in figure 1. Universities act as a pipeline between high school and the profession, and while they can impact on both, they are also influenced by them. For example, the issues with the K-12 (Kindergarten to Year 12) pipeline have been well documented (Olds, 2005; Sorby, 2005). Engineering education is also affected by the accreditation requirements of professional bodies (Bradley, 2005; Felder & Brent, 2005). In addition, the nature of the profession is changing rapidly due to the realisation that many engineering problems have to be "managed", rather than "solved", as a result of their increasing complexity and multifaceted nature (Brown & Rudolph, 2004; Hadgraft & Goricanec, 2004). This requires a different skill set, both for graduates and university teachers (Anderson, 2004; Felder & Brent, 2003; Fink et al, 2005; Shuman et al, 2005). Pressures are also brought to bear on universities by governments, including levels of funding and higher education reforms at both national (eg. Department of Education, Science and Training, 2004, 2005) and international (eg. Department of Education, Science and Training, 2006) levels.

* Reviewed paper originally presented at the AaeE 2006 Conference, Auckland University of Technology, 10-13 December.

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The impact of these drivers on universities is filtered through to individual teachers, and eventually students, through a number of administrative layers, such as faculties, schools, departments and disciplinary groups (figure 1). At the same time, there are fundamental changes in the way students learn. The majority of students at university belong to the Net Generation (those born between 1982 and 1991); students who have grown up with the internet (Oblinger & Oblinger, 2005). These students prefer active, experiential learning activities, to work in groups, to multitask and to work in image-rich, rather than text-rich, environments.

In order to meet the challenges posed by these changes, creative approaches to teaching that foster partnerships in engineering education are required. In this paper, online roleplay simulations are suggested as one such approach, as they are able to help prepare students for meeting the challenges of being a "modern engineer" in a realistic and motivating context, to cater for the development of interdisciplinary and cross-institutional partnerships and to assist with meeting the needs of Net-Gen learners. These aspects of online roleplay simulations are illustrated with a case study example, the Mekong e-Sim, which is centred on environmental decision-making surrounding proposed engineering projects (eg. large-scale hydropower) in the Mekong region of southeast Asia.

2 ONLINE ROLEPLAY SIMULATIONS

2.1 Background

Online roleplay simulations are characterised by the interaction of multiple learners, who represent stakeholders with varying points of view, about an issue or problem that does not have a "correct" outcome and contains sufficient conflict to spark debate. They generally consist of a number of stages, as shown in figure 2. In the briefing stage, students become familiar with the requirements and setting of the roleplay simulation, as well as the online learning environment. Next, they adopt their particular role, which requires a good understanding of the responsibilities and views of their role, and how their role would act in a variety of situations. The interaction stage commences with a "trigger event" (ie. the occurrence of an issue or problem), which requires the various roles to interact with each other in order to solve the problem or explore the issue that forms the basis of the enacted scenario. Other triggers, such as the release of "news articles", can be used throughout the interaction phase.

In many instances, the expected learning outcomes of online roleplay simulations go beyond the specific issues that are a feature of the particular scenario being considered. Consequently, a scenario can generally be considered as an instance of a larger

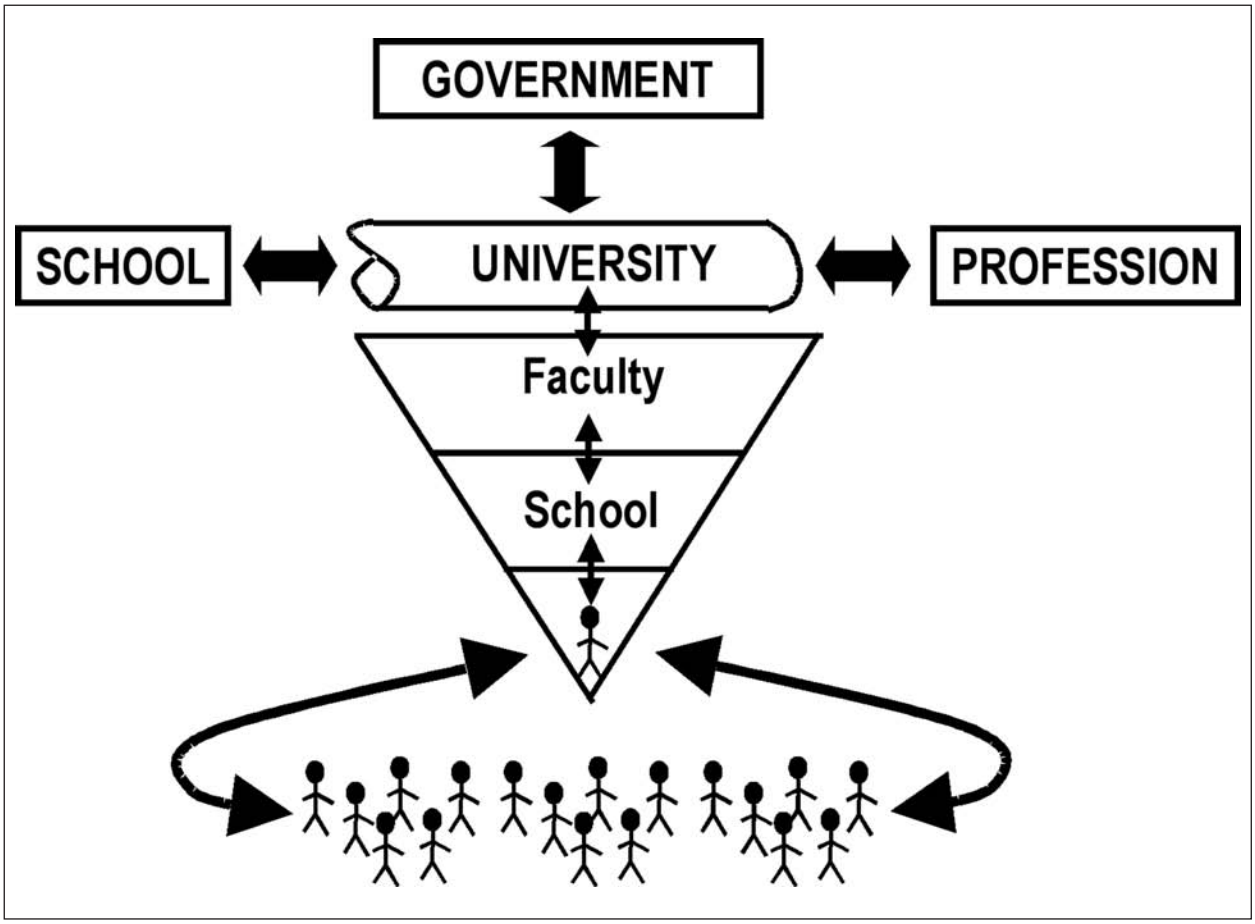

Figure 1: Environment within which universities and academics operate.

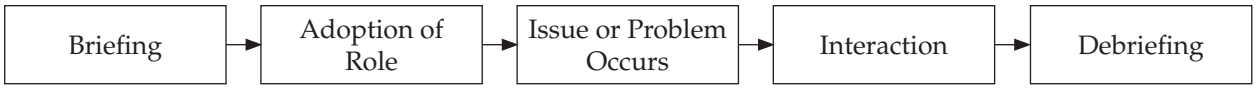

Figure 2: Typical stages of online roleplay simulations.

class of problem, and the lessons learnt from the scenario being played out have wider applicability. In order for students to be able to generalise beyond their experience of a particular scenario, it is vital for them to have the opportunity to step back and look at general processes that occurred as part of the interaction phase of the roleplay simulation. This is achieved during the debriefing stage.

2.2 Example: Mekong e-Sim

The Mekong e-Sim (Maier et al, in press; Maier & Baron, 2005) is an example of an online roleplay simulation used for engineering education. The Mekong e-Sim involves between 60-140 students who adopt the roles of stakeholders and respond to proposed development issues in the Mekong River basin of southeast Asia. Through research and interaction with other roles, participants build a case as to whether the proposed development should proceed or not, which they present and defend during an online public inquiry.

Details of the most recent version of the Mekong e-Sim (2006) are given in figure 3. It can be seen that the duration of the e-Sim is six weeks, with two weeks for briefing (including familiarisation and role adoption), two weeks for interaction (interaction and public inquiry stages) and two weeks for debriefing. The Briefing stage of the e-Sim involves participants becoming familiar with the e-Sim structure, geographical context, requirements and technology. It also involves them obtaining information from a range of different sources to develop an understanding about the responsibilities, views and strategies of their adopted role.

The Interaction stage comprises interactions between different roles in response to events that have occurred and the actions of other roles. The events are modelled on news events, such as the

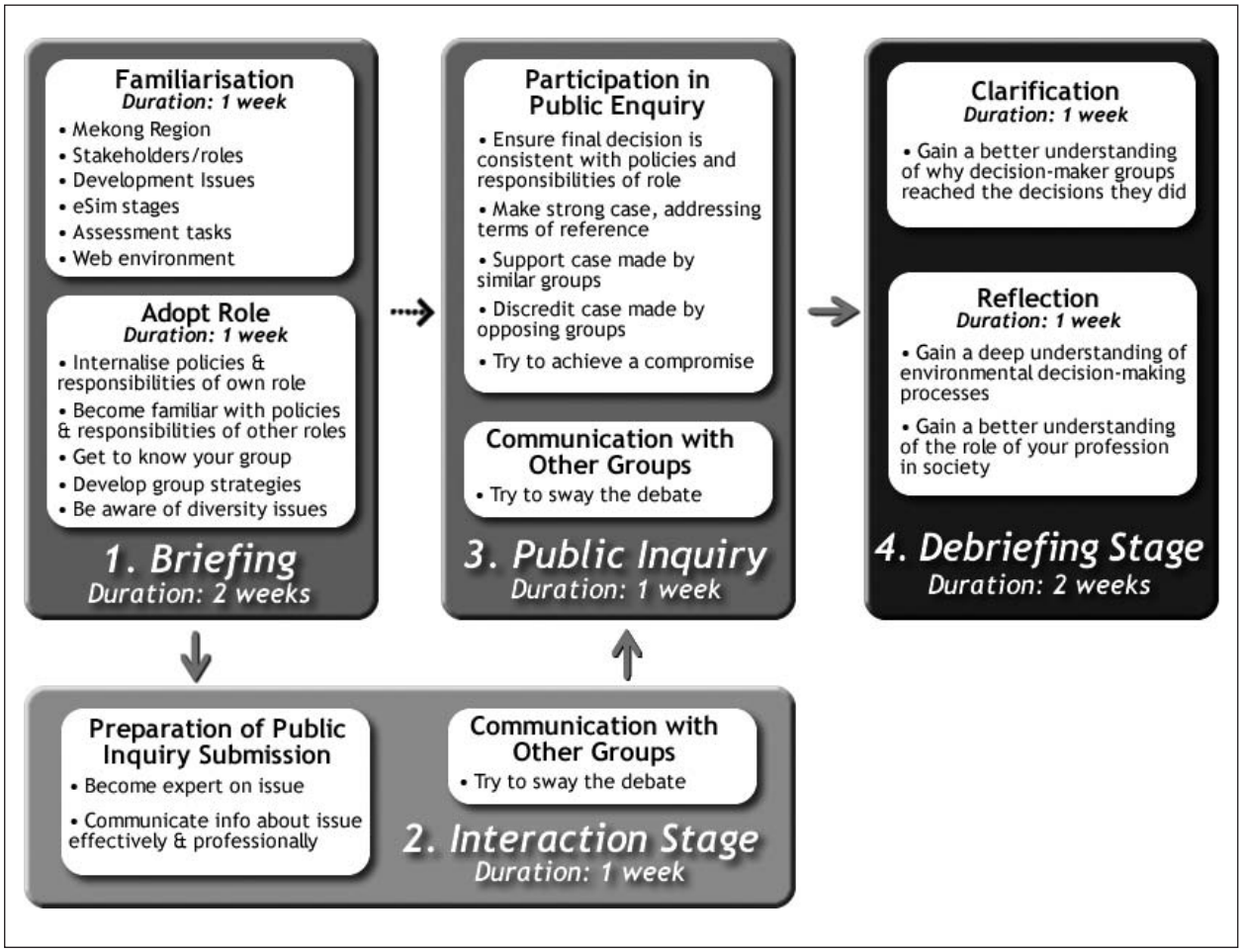

Figure 3: Stages of the Mekong e-Sim.

announcement of a public inquiry on a specific topic. Participants are therefore required to operationalise the understanding of their role and the simulated environment gained during the briefing stage (ie. participants have to act in their role in response to simulated events). This understanding is reshaped as participants experience consequences that follow from their actions. Group development activities also occur during this stage and are aimed at developing the dynamics within the group. During the interaction stage, participants produce their submission to the public inquiry and try to sway the debate about the development issue that is the focus of the public inquiry in line with the policies and responsibilities of their role.

During the Public Inquiry stage, participants make their submissions to the public inquiry, which are debated among the various roles. At the conclusion of the public inquiry, the roles whose responsibility it is to chair the public inquiries announce their decision, including a detailed justification of why this decision was made.

In the first week of the Debriefing stage, participants remain in their roles and have the opportunity to seek clarification from the decision-maker groups about why they arrived at their decision (ie. why certain points were not taken into account or why certain factors were weighted more heavily than others). Participants are required to form alliances (consortia) with other, like-minded groups and each consortium has to develop one or more questions, which they put to the decision-maker groups during face-to-face sessions, followed by a response from the decision-maker groups and general discussion.

In the second week of the Debriefing stage, participants step out of their role and identify what they have learned as a consequence of participating in the e-Sim. This is achieved during face-to-face sessions that use a structured process of guided recall, reflection and analysis of the roleplay-simulation based on the experiences of the participants present. It is here that participants have time to reflect on the occurrences of the previous five weeks and to draw their own conclusions.

3 USING ONLINE ROLEPLAY SIMULATIONS TO MEET THE CHALLENGES OF ENGINEERING EDUCATION

3.1 Preparing students for being "modern engineers"

In order to meet the challenges of being "modern engineers", students are required to develop the "ability to function effectively … in multidisciplinary and multicultural teams…", an "understanding of the social, cultural, global and environmental responsibilities of the professional engineer, and the need for sustainable development" and an "understanding of the principles of sustainable design and development" (Engineers Australia, 2005). Online roleplay simulations provide a means of developing the above attributes, which is difficult to achieve in a traditional classroom setting.

As mentioned previously, online roleplay simulations (e-Sims) provide students with the opportunity to interact about an engineering problem/issue/project that does not have a "perfect solution". For example, in the Mekong e-Sim, one of the public inquiries revolves around the proposed development of a large hydropower dam on one of the tributaries of the Mekong river. As these interactions occur between students or groups of students who adopt the roles of stakeholders with different points of view in relation to the proposed problem/issue/project, this:

1. enables students to develop and understand multiple perspectives surrounding the issue, as highlighted by the following written student comments about their experience of the Mekong e-Sim:
   - *"[The e-Sim] helped me develop an awareness of the chain reaction on social, cultural, political and environmental aspects that a major engineering project can have. Social context was brought to light by the need to look after and accommodate the villagers. This also brought the cultural importance into context, as the risk of a loss of culture of the villagers [who] were [to be] relocated was debated. Political and international context of engineering was emphasised by the involvement of government organisations, and groups which were not local to the MB (Mekong Basin). Environmental context was explained in depth in the forum, and from this I learnt the huge effects engineering projects can have."*
   - *"Participation in the e-sim highlighted the complexity of environmental decision-making. It enabled me to identify and relate to the political, economic, social and scientific dimensions to decision making in the context of natural resource management conflicts."*
2. helps students to understand the complexity and impact of engineering projects:
   - *"The simulation showed the complexity of the decision making process, especially when we realised that we were deciding the future of other people's lives."*
   - *"I believe the most valuable lesson that has come from this exercise is the need for compromise to resolve a solution in real life decision making."*
   - *"When I started the e-sim, I pictured it as being like one big group project, with the different groups bouncing ideas off each other until we came up with a satisfactory answer. It wasn't long before I realised that this would not be possible, there was simply no*

solution that could please all stakeholders. As an engineering student, who is used to assignments with clear cut numerical answers, I found this a little disconcerting."

3. prepares students for working in multidisciplinary and international environments:
   - *"I found that the Mekong Esim was an excellent example of working in an international context."*
4. enables students to explore and gain a better understanding of the concept of sustainable development:
   - *"[The Mekong e-Sim] helped [to] show us that there are many different opinions on just what sustainability is. Through experiencing this process the meaning of sustainability became much clearer."*
   - *"[The Mekong e-Sim] increased my awareness for the need for a sustainable environment by highlighting our dependence on natural systems. [It] helped me [to] understand the vast implications that our actions can have on the environment."*
   - *"The need for sustainable development was introduced in lectures, but highlighted in the discussion board. Sustainable systems were explored by providing solutions to environmental and social and economic problems. Sustainability means something different to different people, and this was emphasised by the variety of problems and solutions brought up in the discussion forum. The e-sim materialised the concept of sustainability, so that we could see the process of creating and researching sustainable systems."*

The success of the Mekong e-Sim in achieving the above objectives is evidenced by the following results of student evaluations. The numbers in brackets indicate the percentage of students surveyed who agreed with each of the statements given (responses of 5, 6 or 7 on a 7-point Likert scale).

- The Mekong e-Sim helped to develop my awareness of the requirements of working in an international environment (87.9%).
- The Mekong e-Sim developed my ability to see engineering issues from multiple perspectives (97.1%).
- The Mekong e-Sim developed my awareness of political, social, economic and scientific dimensions of engineering decision-making (93.9%).
- The Mekong e-Sim increased my awareness of the complexity of sustainable development issues (97.1%).

"Modern engineers" are also required to develop a range of generic skills, such as communication, problem solving, critical thinking and teamwork skills (Bullen et al, 2004; Felder & Brent, 2003). As part of the interactions students have with each other during the interaction phase of online roleplay simulations, they model professional practice. They have to communicate with each other, both via email and discussion board postings, in a professional manner, which is something they generally have little experience with during their degree program. The effectiveness of the Mekong e-Sim in developing professional communication skills is highlighted by the following written student comment:

"The e-Sim provided an environment in which to communicate with others in a professional manner, in a simulated environment. This was particularly valuable as these communication skills are difficult to practice in a standard lecture/tute university environment."

As part of preparing and presenting their arguments, students develop their researching, critical thinking and "online debating" skills, as indicated by the following written student comment about the Mekong e-Sim:

"I had no idea before this just how much went on [in] major engineering projects. I learned skills in researching, debating and deal-making which should help me throughout my engineering career."

In addition, depending on the problem/issue/project around which the e-Sim revolves, students can also gain a range of technical engineering knowledge. For example, as part of the Mekong e-Sim, students gain a range of knowledge in relation to river management and rehabilitation. The success of the Mekong e-Sim in developing generic skills and technical knowledge is also evidenced by the following results of student evaluations. The numbers in brackets indicate the percentage of students surveyed who agreed with each of the statements given (responses of 5, 6 or 7 on a 7-point Likert scale):

- The Mekong e-Sim helped me to develop my communication skills (87.9%).
- The Mekong e-Sim helped to develop my teamwork skills (87.9%).
- The Mekong e-Sim increased my knowledge of technical issues surrounding river management and rehabilitation (87.9%).

3.2 Developing interdisciplinary and cross-institutional partnerships

Because e-Sims are conducted online, they provide an excellent opportunity for interdisciplinary and cross-institutional partnerships. In order to participate in an e-Sim, students can be enrolled in different courses and degree programs; all they need to do is share the same online discussion space. Consequently, there are no administrative problems associated with

enrolment and students enrolled in different courses can be assessed separately. In addition, because discussions between students occur asynchronously, there are no issues with timetable alignment or time zone differences.

The Mekong e-Sim is an example of how online roleplay simulations enable students from different disciplinary backgrounds to interact in an online environment. For example, it has included engineering (civil, environmental, mechanical, telecommunications, software development) and geography students. It has also included students from the universities of Adelaide and Sydney, as well as the University of Technology Sydney, and the Sepang Institute of Technology in Malaysia. The only potential problem is that all students participating in the e-Sim have to log into the same course at the e-Sim's host institution. This might pose a problem if e-Sim participants come from different universities. However, this was not found to be an issue at the two institutions at which the Mekong e-Sim has been hosted, including the University of Technology Sydney (2001-2003) and the University of Adelaide (2004-2006). The Mekong e-Sim has also highlighted the benefits teachers can gain from such collaborations in terms of adopting a scholarly team approach to learning and teaching development (eg. Kirkpatrick et al, 2002).

Other features of online roleplay simulations that make them well suited for collaborative teaching approaches include:

- They give students access to a centralised set of information resources.
- Additional students from different disciplines or institutions can be accomodated easily, such as the inclusion of overseas students who are taking courses as part of twinning arrangements.
- They can cater for different numbers of students, which can be controlled by the number of scenarios, the number of stakeholder groups, the number of students per role or even the number of e-Sims that are run concurrently.
- They can be adapted easily to emphasize different learning outcomes by altering the scenario(s) investigated, the stakeholder groups involved and the trigger events (eg. news releases) provided.

In addition, the structure and layout of e-Sims can provide a template from which other e-Sims can be developed with relative ease. For example, because the Mekong e-Sim was developed in a commonly used online learning management system (Blackboard), it was able to be used as a template for the "Disaster Sown Under" e-Sim in Burns Nursing at the University of Adelaide (Kavanagh et al, 2004).

3.3 Catering for the needs of Net Generation learners

As a result of the fact that they have grown up with the internet, Net Geners learn differently from students from previous generations. In particular, they deal with information differently and engage in non-linear, disjointed thought processes. In addition, they are visual, intuitive communicators, can integrate virtual and physical information with ease, learn better by discovery than by being told, like interaction and working in groups, shift attention rapidly from one task to another, and expect fast response times (Oblinger & Oblinger, 2005). Consequently, online roleplay simulations meet the needs of Net Gen learners in a number of ways, including:

- They provide an active learning environment in which students can experience what it is like to act in the role of their persona and to discover knowledge by themselves through research and interaction with other persona.
- They enable students to work in groups and facilitate personal interactions between persona.
- They enable students to learn in an image-rich, multimedia environment.

However, it should be noted that Net Gen learners are not interested in the use of information technology for teaching purposes for its own sake. Instead, they view technology as something that enables them to conduct certain activities. From this perspective, it is the interaction and first-person learning opportunities that e-Sims provide that are important to Net Gen learners, not the use of "technology" itself.

The success of the Mekong e-Sim in meeting the needs of Net Gen learners is evidenced by the following written student comments:

- *"The unique experience provided in the e-Sim is one which transcends the restrictions of a classroom, enabling learning to occur in an exciting and highly motivating context."*
- *"A worthwhile, insightful and different form of learning, which should be further applied in our education. A new way of learning different concepts. Thank you for giving us the opportunity."*
- *"The Mekong e-Sim was a thoroughly enjoyable and a good learning experience – good to do something so different."*
- *"The best part was how strongly the e-Sim puts students in control of how much is learnt. The marks are an incentive, but I found the learning process itself to be most rewarding since it was a modern issue."*

- *"I liked the e-Sim, you were learning a lot of information without realising it – interesting!"*
- *"This simulation has probably been the most beneficial task in teaching me ideas that will be useful to me as a professional engineer for years to come."*
- *"The e-Sim was a tremendous opportunity to be given an insight into 'the real world' of engineering. We do so much theoretical work that it puts light at the end of the tunnel to see a practical sense to it, and know that the class work we do has a strong relevance to actual engineering jobs."*
- *"The e-Sim was an excellent learning tool and experience. It has changed the way I look at engineering and shown that its challenges go far beyond technical issues."*

4 CONCLUSIONS

In this paper, it has been demonstrated that online roleplay simulations, such as the Mekong e-Sim, provide a means for meeting some of the challenges faced by engineering educators. They can be used to develop a range of generic skills requisite of "modern engineers", including preparing students for working in multidisciplinary and international environments, helping students to obtain an understanding of sustainability, assisting students with seeing engineering projects from multiple perspectives, and developing a number of generic skills, such as communication and teamwork skills. In addition, online roleplay simulations provide an environment that fosters and enables multidisciplinary and cross-institutional interactions between students and teachers. Finally, online roleplay simulations can also assist with meeting the learning needs of a new generation of students, those belonging to the so called Net Generation, as they provide an active learning environment and enable students to interact and work in teams on realistic problems.

ACKNOWLEDGEMENT

The author would like to thank Rob McLaughlan, Denise Kirkpatrick, Keith Walker, Phil Hirsch, Judi Baron, Allan Carrington, Dayle Hall, Tim Rowan, Elsie Mann, Eleanor Gee, Phil Staniford and Sarah Jewell for their contributions to developing the Mekong e-Sim.

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