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EDUCATING THE WORLD'S RAILWAY ENGINEERS

INTRODUCTION

Railway organisations and state-owned railway authorities have been through continuous change for the past 20 years, through privatisation, downsizing, loss of engineers through retirement and migration to the attractive private sector, and a burgeoning workload as railways have gone through a rapid period of growth all over the world.

The result is that public and private rail companies everywhere have found themselves collectively with diminishing expertise amongst their ranks just when they need it most to accommodate rapid expansion in the sector.

Consequently, professional development and training of the rail workforce is rapidly emerging as a crucial problem for the 21st century requiring solutions across national boundaries, which enable the development of engineers to progress within their workplace, wherever that is, but with the quality assurance processes and educational expertise and facilities able to be provided by the university sector.

GENESIS OF A SOLUTION

In 2001 the Australian government, railway companies and Australian universities together funded a national Cooperative Research Centre (CRC) in Railway Engineering and Technologies, partly with a view to addressing the loss of expertise identified above. Senior experienced engineers from across Australia were commissioned to prepare 19 comprehensive content papers detailing what civil engineers should know in order to design and maintain all matters pertaining to railway infrastructure. The project took five years to complete, generating approximately 1000 pages of vital infrastructure knowledge. This created our first learning community, where a team of experts with an opportunity to describe critical learning, became part of a team with the agreed aim of finding common curricula ground (Stephenson 2001).

The next problem to be addressed was the manner of dissemination of that knowledge to civil engineers entering the railway industry. The time-honoured master-apprentice learning relationship between senior practitioner and new recruit was no longer sustainable. Three alternatives were explored:

- Publish the voluminous material in a commercial book. However, the few books likely to be sold would probably sit on the shelves of busy engineers rather than effect systematic learning of their contents.
- Give the material to railway organisations which funded the project. However, busy engineers would not be able to be released to prepare and run extensive training

sessions in-house at a time of intense expansion within the industry.
- Hand the material to a CRC partner university to be developed into an accredited postgraduate award program for railway engineers.

The latter was the most favoured, building on the network of trust between university experts and industry professionals. The identified learning outcomes for railway infrastructure engineers would be advanced technical skills through a learning community model; collaborative knowledge construction (building on the work experience the learner brings to the group), through shared discussion and critical analysis of case studies. Learners are engaged in solving real world problems) with the integration of learning activities focusing on relevant workplace tasks (Collis 2005).

GENERATING THE LEARNING

Civil engineers working in the railway industry around the world can be solely responsible for monitoring and maintaining track throughout a district from 100km2 to 100,000km2 in area, and be located in cities and regional areas hundreds of kilometres apart. An online learning environment steered by corporate and academic expertise as learning partners (Collis 2005) was the exciting option to capture and share the knowledge of experienced seniors to enhance these engineers' railway skills.

Queensland University of Technology (QUT) in Australia was chosen by the industry as their preferred partner to offer the CRC project materials as a postgraduate degree - QUT academics have developed close partnerships with the railway industry internationally over 20 years. QUT had also developed and implemented continuing professional education modules in railway related topics since 2001 via distance education using printed study materials.
The industry demonstrated its strong commitment to a university postgraduate course by providing significant start-up funding to QUT for development of the Master degree. The degree was successfully launched in July 2008, and in 2009 has students located in Australia, New Zealand, Malaysia, Taiwan and Canada.

Based on the social constructivist approach to learning (and aligning with Merrill's (2002) second principle: Existing knowledge is activated as a foundation for new knowledge), online units of study were designed using emerging technologies where life long learners would interact both synchronously and asynchronously with the set tasks and each other as they progressed through the course (McLoughlin and Oliver, 1995). Integration of communication and collaborative thinking with peers and lecturers through discussion forums, web-based conferencing and blogging provided threads for self directed learning (Merrill's fourth principle: New knowledge is applied by the learner), access to vast amounts of information, and the capacity for increasing experiential learning (Merrill's fifth principle: New knowledge is integrated into the learner's world). This open-ended strategic learning environment has enabled self – management of learning with valued access to the tacit knowledge of experienced industry mentors.

A JOURNEY IN DISTANCE EDUCATION

The format of the CRC material supplied to QUT for development varied in style, wording, layout, and structure, having been prepared by many engineers each with their own writing style. Content papers received extensive editing, formatting and desktop publishing to ensure that the key principles for workplace–oriented course design were observed while reflecting the rail context (Collis, 2005). The degree structure comprises eight units (or courses or subjects):

1. Ballast sleepers and fasteners
2. Rail and related track structures

3. Track stability design and formation
4. Geometry and track-train interaction
5. Track construction and civil structures
6. Assets environment and safety
7. Integrated project
8. Elective.

The core curriculum planning team comprised: the Course Coordinator (Civil Engineer) with many years of experience in distance education; an experienced industry project manager, and QUT's Teaching and Learning Support Services who contributed their extensive editing and Learning Design experience to ensure a professional, coherent and consistent structure of content. Distractions of poor navigation and large documents for downloading cause frustrations for the time-poor corporate student. The diverse-skilled team reviewed all materials for quality assurance. Students' appreciation of the quality of the resulting study materials is shown by the following quote:

> "*From a personal perspective, the [materials] are very educational and thorough which provides a great reference guide now and in the future*."

For this distance program to reflect the needs of the corporate context, our design had to capture and share knowledge existent in the industry, and support collaboration and critical thinking and build networks among our geographically dispersed students. Such diversity in our student cohort and teaching team exposes the students to a wealth of different experiences, perspectives, practices, standards and legislative frameworks. One student commented in an anonymous survey

> "*It has been a very motivating and enjoyable studying experience being involved with people who are considered peers in their rail related professions. Their real-life experiences has (sic) provided a great insight into the railway industry*".

The core curriculum planning team met regularly, and included industry consultants as needed, to design relevant learning activities assessed to industry standards. This planning, design and development approach models Collis' (2005) view of instruction.

Merrill's five first principles Merrill (2002), expanded by Collis and Margaryan (2005) for the corporate learning setting, scaffolded the design team's efforts to contextualize the learning.

To reflect Merrill's third principle (New knowledge is demonstrated to the learner), video clips of a respected rail expert talking to each content topics were integrated as weekly activities, supported by tutors from an international pool of engineers expert in rail infrastructure. The tutors include industry guest speakers to scheduled teleconferences for knowledge sharing and authentic critical discussion supporting application, synthesis and reflection of new learning.

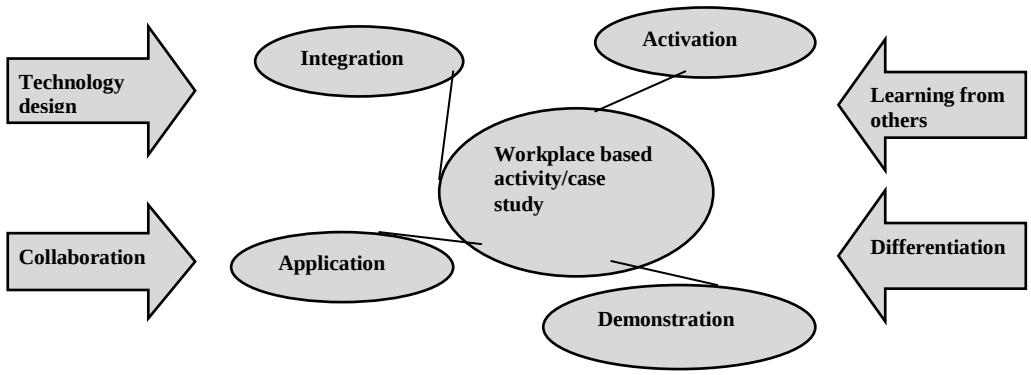


Figure 1: Adapted from Merrill's five principles of instruction expanded for the specific corporate context (Collis and Margaryan (2005)

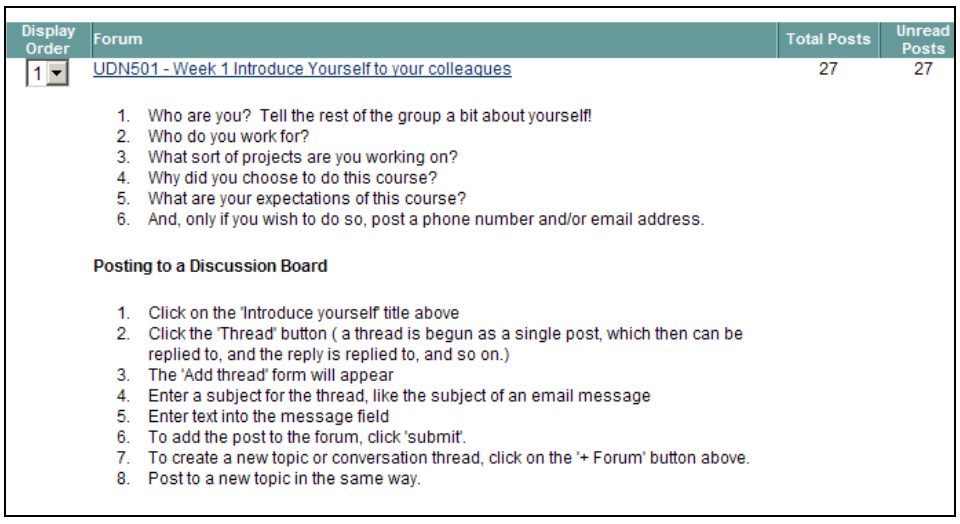
The ovals in Fig.1 represent Merrill's five design principles. The arrows represent the following four of Collis' six expanded design criteria which we used to plan the Rail course contextualisation:

1. collaboration among learners in a course and with colleagues in the workplace;
2. knowledge sharing and learning from others – including student peers, experts and colleagues in the workplace, coaches/mentors, and others elsewhere in the organisation, through integrating in-house knowledge sharing networks in the course;
3. differentiation, by accommodating learners with diverse needs, including professional (experience), regional (workplace situations), and cultural diversity;
4. effective technology design, particularly course environments in Web-based support systems.

LEARNER CENTRED DESIGN FOR LEARNING MANAGED LEARNING

A Masters level course commits to challenging, achievable and authentic assessment tasks which stretch the student to improved workplace practices – consequently, assessment criteria ensured that industry standards were met and institutional learning outcomes were measured. By informing students of the learning outcomes being addressed through instructional text, and consistent reference to the assessment criteria in learning activities, we are presenting a transparent alignment of intended learning outcomes, learning activities and assessment (Biggs 1999).

In recognition of our diverse student cohort, we are engaging with emerging technologies incrementally, with personalised instructional text to overcome any perceived technical fears of using a 'blog' or discussion forum; it is presented so that the student is attracted to the subject matter and learning intent, not the technology itself. Figure 2 shows how discussion forum questions invite participation and aim to create a collegial, collaborative community.



Display Order	Forum	Total Posts	Unread Posts
1	UDN501 - Week 1 Introduce Yourself to your colleagues	27	27

1. Who are you? Tell the rest of the group a bit about yourself!
2. Who do you work for?
3. What sort of projects are you working on?
4. Why did you choose to do this course?
5. What are your expectations of this course?
6. And, only if you wish to do so, post a phone number and/or email address.

Posting to a Discussion Board

1. Click on the 'Introduce yourself' title above
2. Click the 'Thread' button (a thread is begun as a single post, which then can be replied to, and the reply is replied to, and so on.)
3. The 'Add thread' form will appear
4. Enter a subject for the thread, like the subject of an email message
5. Enter text into the message field
6. To add the post to the forum, click 'submit'.
7. To create a new topic or conversation thread, click on the '+ Forum' button above.
8. Post to a new topic in the same way.

Figure 2. Example of formative open ended questions posed to generate sharing of issues in discussion board:

Vygotsky's (1962) social constructivist theory argued that learning is contextual and a social event. We found that problem-based case study analyses, situated in their real world context, and supported by group teleconferences which reinforced key learning points, enabled us to overcome group work barriers that distance offers to critical debate and collaborative learning. Asynchronous online communications offer the flexibility and self pacing needed to match part-time distance learners' schedules.

Assessment tasks in each unit serve to extend the students' research capabilities by

presenting problem solving activities based on issues often faced by railway infrastructure engineers. For example:

- a new heavy-traffic regional coal-hauling line, drawing on recent announcements of the decision to build such a line by the local state government ;
- an existing busy urban line for which students must investigate, plan and describe their implementation of maintenance works;
- a Pre-mortem approach to a rail disaster case (Klein 2007).

Much of the information they need for these tasks is readily available via the internet and commercial literature databases to which QUT subscribes on behalf of its students. Vital information not available online is either generously provided by industry partners; or can be sourced from a student's workplace. In this way the assessment tasks are relevant and resourced, and informed by the student's local situation. Follow up group consultations, where key learning points from the assessment task are shared, synthesised and reflected upon, provide the necessary feedback loops from lecturer, tutors, peers and the learning materials themselves.

Comments on the assessment tasks from some students in anonymous surveys are:

"*I have found the course material very useful, practical and applicable to my current role as a Track Engineer".*

"*Assignment 3 was a great case study, and very applicable to work."*

"*I just completed assignment 3 and it was very relevant to my work duties here*."

Assessed blogging tasks (see Fig.3) require students to post a short paragraph giving their initial thoughts to a provocative question related to an appropriate infrastructure challenge that faces railway engineers in their work place.

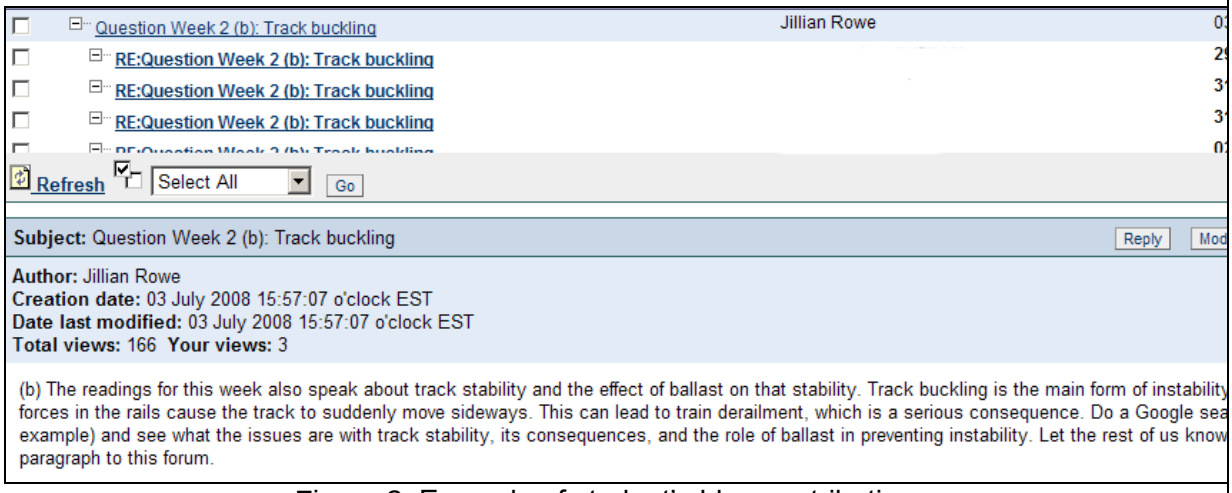


Figure 3. Example of student's blog contribution:

In order to pass the assessment, students must read and post a response to the postings from the other students, which triggers a complex discussion. The more a student responds with considered postings that add to the value of the discussion, the higher their grade. The discussion is moderated by the tutor and meets appropriate criteria.

The blogs have the purposes of evaluating students' critical and analytical thinking, of providing opportunity for workplace issues to be shared, and especially of promoting more familiarity and interactive learning amongst the students. Some students commented in an anonymous survey:

"*The interactive aspect with other participants was great*."

"*I thoroughly enjoyed the blog activity in assignment 2. I was a bit unsure this*

activity leading up to it commencing but learnt a lot from the postings of the other students."

THE LEARNING COMMUNITY

Aside from the vital technical knowledge gained from studying this Master degree, participating in a distance-based postgraduate program is an opportunity to network with peers and experts from around the world. It is therefore critical that every effort is made to promote a sense of community to the learning of the students. Technology design and pedagogical strategies aim to give the learners responsibility for their learning management within the community. Strategies used to engage are:

- personalising the program by introducing students to each other promotes collaborative learning;
- regular informative and instructive emails starting before the semester are sent to all students from the coordinator of the program using a friendly collegial tone, which supports the social constructivist theory of learning from peers;
- students send a small digital photo of themselves which goes onto a world map for the students to see each other's locations;
- students must respond and contribute to assessable blogs, triggering critical discussion;
- students and tutors come together virtually through telephone based teleconferences and computer based synchronous interaction. Students' comfort with this is shown by the following student comment:

"*Overall very good. Initially the fully electronic interaction was daunting. Phone hookups were valuable*".

A final typical comment from a student summarises the overall view of the students of their study of this course:

"*Overall, very enjoyable and I look forward to Semester 1 next year*."

CONCLUSIONS

As Bonk(1999) observed, web-based learning offers a chance for students to enter into dialogues about authentic problems, collaborate with peers, negotiate meaning, become apprenticed into their field of study, enter a community of experts and peers and generally be assisted in the learning process. In this online, internationally subscribed Master degree that is unique to the railway industry globally, the teacher becomes a facilitator of and aid to the learning process, through resources that enable rapid communication and collaborative learning in ways not possible until relatively recent times.

The course is built on a collaborative framework that began with its genesis in experts working with universities to capture their soon-to-be-lost knowledge, progressed through the development of that knowledge into a full postgraduate course, and climaxes with a structure of learning that brings together students, experts and academics internationally in an online, real time format.

Consequently, students as they progress through this professional level course take back to their workplace not only increased and highly relevant technical knowledge, but also a world-wide network of experts and peers, together with experience in sourcing, sorting and processing complex information about typical challenges faced in the railway industry. The students are developing capabilities at collaborative problem solving, critical thinking, communication via various media, and high level research skills. They are greatly improving their skills in managing and progressing their learning in this rapidly changing field.

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Summary of the full paper

An increasing loss of engineering expertise from the railway industry globally coincides with a rapid expansion of the industry. Continuing professional development is critical to this sector, but needs to be distance based to cater for the international demand for such development. A unique Master degree in railway infrastructure was created out of extensive materials prepared by expert engineers, which captured their detailed knowledge. A team at Queensland University of Technology in Australia prepared the detailed and high quality online resources needed for this degree; the team comprised an academic, a project manager, learning designers and a publisher, all with experience in distance education. The degree has been running for 12 months with students from many countries. A key aim of the degree is to create a collaborative community comprising learners, teachers and practicing engineers from around the world. The team has also worked hard to ensure the content of the study materials, the form of the assessment tasks and the interactive learning sessions relate closely to real-world problems and challenges faced by the students in their workplace, wherever that is. Widely differing time zones are a challenge but are usually obviated by the asynchronous nature of the online resources.