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THE ALIGNMENT OF RESEARCH, EDUCATION AND INDUSTRY APPLICATION

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ABSTRACT:

A nexus between teaching and research has long been an aim of universities. This goal has been elusive, and the full potential of such connections has yet to be realized. Opportunities exist to exploit synergies between teaching and research. Melding these activities and subsequently progressing outcomes to a point where research and effective teaching methodologies align is challenging. Examples of successful teaching which harnesses research outcomes are scarce. This paper describes industry funded research into human factors associated with collaborative design activities. Our findings have implications for the teaching of design and we have implemented these in selected courses in our School. In addition, we have developed digital materials (incorporating our research-led teaching and learning strategies) to deliver the research outcomes as professional development modules to practitioners. This paper reports on the processes and the outcomes of our initial research as well as the dissemination strands.

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1. BACKGROUND

Mention is frequently made of the desirability of research outcomes being transferred to undergraduate teaching (Hattie and Marsh 1996, Barnett 1992, Elton 2001). Academics, industry and the general public appreciate the benefits that accrue from students engaging with educators who are working with the latest developments, but there is little evidence of this occurring, as is evidenced in Griffiths' (2004, 709) statement: "There has always been a close, if at times uneasy, relationship between universities and the professions. The roots of this lie in their shared interest in exercising control over the production and application of specialized knowledge…… The university, for its part, has traditionally been the key site for the advancement of both theoretical and applied knowledge."

Various UK government funded initiatives have sought to encourage such transfer (including LINK and TELRI), but the widespread impact of these projects is difficult to ascertain. In his foreword to Jenkins' (2004) recent review, Hammond observes that "it is clear from Alan Jenkins' review that the nature of the relationships between research and teaching, whether direct and indirect, is complex and only partially understood." (p. 2). It is therefore clear that the challenges of promoting this transfer are real and current and warrant further investigation and this paper documents our efforts in this regard. We first of all briefly describe research conducted into virtual teamwork in the construction industry. We then describe how the outcomes from these activities have been incorporated in undergraduate teaching and, finally, how these outcomes have been embedded in the development of an on-line continuing professional development course for industry practitioners. The reflections of these individuals are likely to expose issues for further investigation which may, in turn, be incorporated in future research activities, so generating an iterative cycle of research, implementation and exploitation of research outcomes. This cycle is illustrated in Figure 1.
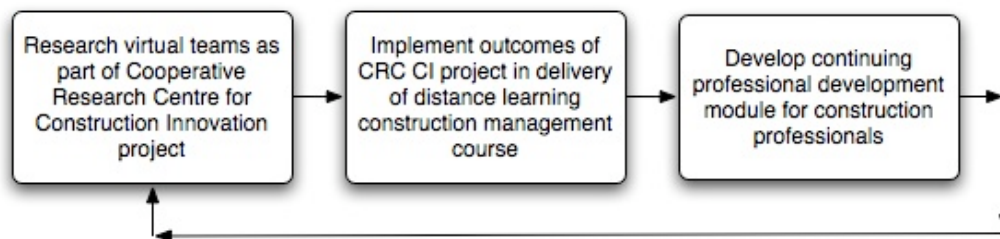

Figure 1: Iterative cycle of research, implementation and exploitation of research outcomes.

2. RESEARCH INTO TEAMWORK

Designing and managing construction projects are tasks that are generally conducted in a teamwork environment. Largely as a result of an ever-increasing trend to globalization of design processes, there is a pervasive move away from traditional co-located teamwork to virtual teamwork. Working virtually appears to address a number of the problematic issues associated when collaborating over geographical distances. Nevertheless, literature indicates that there are some aspects of using information technologies that require a more thorough understanding and application than is currently the case. To function efficiently and effectively as a team, irrespective of whether the team is a traditional or a virtual team, participants require appropriate skills (e.g. awareness, understanding, and abilities to apply). Team members do not necessarily possess the skills necessary for virtual teamwork. Earlier research has highlighted that the introduction of new technologies may impact positively and negatively on team performance. Our contention was that introducing virtual technologies impacts on the generic skills individuals use when working in design teams. We collaborated in an Australian Government funded Cooperative Research Centre for Construction Innovation (CRC CI) grant with other research and industry partners (as reported in Williams, Gameson and Sher, 2007). Our investigations focused on the early stages of construction in which the models for a project are developed and revised. The overall research project investigated three aspects of collaborating in virtual environments:

> The processes that enabled effective collaboration using high bandwidth information communication technology (ICT);

> The models that allowed multiple disciplines to share their views in synchronous virtual environments;

> The generic skills used by individuals and teams when engaging with high bandwidth information communication technology.

The third aspect was led by the University of Newcastle. It explored the human domain and the extent to which people contribute to the effectiveness of virtual teams, and it is these studies that underpinned the remainder of this paper.

3. GENERIC SKILLS IN VIRTUAL TEAMING

Teamwork is widespread in the construction industry. Teams are described as a cluster of two or more people usually occupying different roles and skill levels that interact, '…adaptively, interdependently, and dynamically towards a common and valued goal' (Salas, Burke, and Cannon-Bowers, 2000). Teams provide a vehicle for collaborative processes (Beyerlein, Freedman, McGee and Moran, 2003). Design teams are frequently comprised of a diverse mix of professionals (e.g. designers, engineers, surveyors and contractors) with a range of backgrounds and experiences. The management of such teams is challenging and has been recognized as requiring effective skills and facilitation to achieve successful outcomes. A range of technical alternatives to support virtual design teams has been developed and these have spawned different forms of teams. McDonough, Bahn and Barczak (2001) provide the following summary of team types:

> Co-located teams, comprising individuals who work together in the same physical location and are culturally similar. As members must be actually interacting when collaborating this refers to a face-to-face situation.

> Virtual teams, comprising individuals who have a moderate level of physical proximity and are culturally similar, e.g. team members who are in the same building but on different floors.

> Global teams, comprising individuals who work and live in different countries and are culturally diverse

The current trend is to deploy virtual and global teams. Clients are increasingly demanding high quality and efficiency from their design and construction service providers, prompting teams to be assembled from diverse geographical locations (Kimble, Hildreth, and Wright, 2000). Our CRC CI project explored the skills of virtual teams involved in the conceptual design of construction projects. We identified the following generic skills which support collaboration:

> Leadership is important because it decides the balance of relevant skills and contributions required of team members (Baird, Moore, and Jagodzinski, 2000). Moreover, team leader(s) need to be able to create teams which identify the important 'social links' between team members (Baird et al, 2000).

> Co-ordination and structuring skills are required for team members to work collaboratively in a virtual medium (Lahti, Seitamaa-Hakkarainen and Hakkarainen, 2004).

Abilities to provide feedback are important skills for team members (Baird et al, 2000) as large amounts of information need to be validated (Baird et al, 2000).

Interpersonal relationships influence the ways in which team members collaborate and can impact on a team's ability to deliver a satisfactory product. In addition, social collaboration appears to play an important part especially when researching and determining limitations.

Trust is not easily created in a computer mediated environment, especially when team members have no prior experience of working with others (Jarvenpaa and Liedner, 1998). The commitment of others fosters trust, but this takes time to develop and may not reach high levels until towards the end of a task (Jarvenpaa and Liedner, 1998).

Virtual communication presents challenges. A number of factors constrain these interactions, for example:

- o lack of visual cues (such as facial expressions) as well as a lack of auditory input (where intonation, e.g. sarcasm, might influence understanding). Even when visual cues are used (e.g. when video conferences or web cameras are used) team members' abilities to communicate using non-verbal interactions (such as body language) can be inhibited (Hoyt 2000). However, technology does present some advantages when communicating over distance as it often allows more focused and concise information exchange between team members (Gabriel and Maher, 1999; Maher, Simoff, and Cicognani, 2000). Furthermore, technologies may assist team members in keeping to their task (Cleland and Ireland, 2002).

- o Baird et al (2000) found that virtual environments may not encourage feedback.

- o Williams and Cowdroy (2002) noted that communication is easier if team members have previously worked together.

- o Synchronicity is also an issue as virtual teams can operate in both synchronous and asynchronous environments. For example, virtual team members may interact in real time (e.g. using via video conferencing and / or electronic chat rooms), or through email or electronic bulletin boards (where there are delays between sending and receiving messages) (Maher et al, 2000).

- Social interactions are likely to be inhibited in virtual meetings (Gabriel and Maher 1999). This may be a factor delaying the building of trust noted above.

- Sharing visual information presents difficulties when it is presented through virtual media (Gabriel and Maher 1999; May and Carter 2001; Poltrock and Engelbeck 1999). The significance of this limitation depends on the nature of tasks virtual teams are engaged on.

4. TEACHING VIRTUAL TEAMWORK

The goal of university teaching is to provide students with the most current knowledge and skills. The ability of universities to identify current research outcomes and to apply these to the learning experiences of the students is fundamental. The relationship of teaching to research can be defined in four ways (Griffiths, 2004):

Research-**led** where the curriculum is structured around the research of the teacher

Research-**oriented** where the curriculum includes how the knowledge is produced by research

Research-**based** where the curriculum itself is structured around inquiry-based learning

Research-**informed** where research is used to inquire into the teaching methods themselves

We have utilized all four of the approaches described above. It is our contention that it is imperative that research findings are not confined to academic literature as this restricts outcomes to a discrete audience. It is important for research to be exploited in a variety of ways, one of which is the manner in which subject matter is taught.

The constraints of working in virtual teams, identified in our CRC CI teamwork research, are not confined to the workplace. Recognising that they affect pedagogic teamwork, we have embedded activities which develop students' generic skills in a course delivered to third year Bachelor of Construction Management (Building) students. This course is delivered as an integrated project with students working in teams representing construction companies. Each group aims to win a tender for the completion of a building in competition with other groups. Submitting the lowest bid does not necessarily result in the highest marks being awarded. Other factors are also considered, such as the level of detail which students have worked to, commercial awareness, originality and teamwork. This mirrors recommended industrial practice, which advocates that projects are not awarded on price alone. Rivalry between teams is generally intense.

The students enrolled in our construction management program come from a wide variety of backgrounds. Many are of mature age and already have a construction background. Few are female. Many are highly computer literate and expect to engage with their studies using computer systems. An increasing number of them bring with them financial necessities of having to work to support their tuition. This latter point is emphasized by Mills and Ashford's (2004) in their investigation into part-time employment of construction management students. We have responded to some of the abovementioned challenges by offering our Bachelor of Construction Management program in mixed-mode. This allows our students to study on-campus or as distance-learners, and provides them with the flexibility to decide at what pace to progress their studies. However, arranging for distance-learning students to engage in teamwork activities is challenging for both students and staff.

We have had to devise exercises that allow on-campus and distance-learners to work together discretely or as integrated cohorts. A key strategy has been to facilitate interactions between students, and we have used our Blackboard learning management system extensively for this purpose. The facilities provided by Blackboard include:

- Email, where students can send emails and attachments to each other as well the outside world

- Discussion boards, which allow members of a group communicate asynchronously by posting and responding to messages from other members of their group

- Collaboration tools, which allow group members to communicate synchronously by posting and responding to messages from other members of their group.

- File exchange facilities, which allow students to make electronic documents available to other members of their group.

- Electronic whiteboards, which allow students to communicate synchronously using free-hand sketches and text.

The asynchronous opportunities (email, discussion boards and file exchange facilities) are particularly important for this exercise as they allow students to meet their work commitments and engage in their studies at times that suit them.

We have devised explicit assessment practices so that students are clear what is expected of them. We have also explicitly required students to demonstrate their virtual teamwork skills, and we have incorporated

activities which assess this aspect. Teamwork is an activity where non-performance by a team-member can compromise the efforts of others. We have provided disciplinary procedures modeled on industrial relations practices, whereby students can identify non-performers and require them to work satisfactorily or be penalized.

Students working in virtual teams need to be proactive and take initiative. Although many of them use electronic media on a day-to-day basis, few have worked collaboratively in the way that they are required to. Time management is a key issue. Students need to provide evidence of their teamworking activities and reflect on the skills they have developed. These activities are sometimes neglected by students, who view the preparation of their estimate and tender as the main focus of their work.

Team working skills do not develop simply with the formation of students groups and letting them perform group assignment. Teamwork learning environments need to be well designed, implemented, managed and evaluated. The teamwork assessment methodology described in this paper was piloted in an integrated problem based learning module delivered to first year construction management and quantity surveying students (Williams and Gajendran (2004)). This course allows students to draw on the knowledge, skills and understanding they have accumulated in prior courses, and during their work experience and assesses the students' teamworking skills in two ways:

1. Students assessed themselves and their peers.

2. Groups submitted logs of their activities which were assessed by staff.

Marks for the self / peer assessments and the logs were converted into a multiplier which was used to manipulate the mark obtained for the estimate. Generic skills associated with team participation were assessed using the self / peer assessment instrument shown in Figure 2.

Please fill in the following assessment sheet using the key below: 1 never 2 rarely 3 sometimes 4 most of the time 5 always fulfils task completely

For the person under consideration circle the number that is most appropriate:

	Never				Always
Participation in group meetings/discussion.	1	2	3	4	5
Degree of preparation for group meetings/discussions	1	2	3	4	5
Fulfils responsibilities allocated at group meetings	1	2	3	4	5
Communicates well with the group	1	2	3	4	5
Makes a positive contribution to group dynamics	1	2	3	4	5

1. **Participation in group meetings/discussion:** Ideally a student should participate in and contribute to group discussions. The contributions should reflect a familiarity with the issues at hand and be thoughtful and constructive.

2. **Degree of preparation for group meetings/discussions:** Ideally a student should have prepared for the group discussion by reading around the area for discussion in addition to their allotted task. They should be keeping abreast of where the group is in terms of discussion and direction.

3. **Fulfils responsibilities allocated at group meetings:** Ideally a student should responsibly fulfil any tasks assigned at group meetings and report on this activity at the next group meeting or date assigned by the group.

4. **Communicates well with the group:** Ideally a student should communicate their thoughts and ideas in a clear concise scientific manner. Communication can also take the form of diagrams small presentations handouts use of the white board or other aids.

5. **Makes a positive contribution to the group dynamics:** Ideally a student should contribute to the harmony of the group. They should encourage an atmosphere of intelligent discussion where all points of view are heard. They should not dominate the discussions or be argumentative; nor should they overly sidetrack the group by injecting issues not directly relevant to the task in hand.

Figure 2: Self / peer assessment of teamworking skills

The methodology developed to support students in evaluating themselves and their peers was informed by the methodologies proposed by Habshaw (in Gibbs, 1995) and involved:

providing detailed instructions of the process

providing opportunities for students to question and discuss the process

trialing the assessment instrument before use

The self / peer assessment process involved students ranking evidence of each skill on a Likert scale (see Figure 2). Each student submitted an assessment for his / herself as well as for all other group members. Staff then collated these assessments for all the students in each group, aggregated and averaged their scores and arrived at a score for each student. These individual marks contributed to the teamwork multiplier mentioned above.

Each group of students was required to submit a log of their activities on a weekly basis using the template shown in Figure 3. Around ten logs were submitted for this assessment item. Students needed to submit evidence of their 'work in progress' that aligned with the issues / discussions and actions recorded in the logs. The team log thus provided evidence and validation of students' performance of tasks as well as documentary proof of the methodology applied by the group. Furthermore, the assessment of the log also provided a basis for student feedback about the activity

PROJECT MEETING LOG	
Meeting Date: **Time:**	
Team Members Present:	
Report on Actions or Items carried over from previous log	**Member Reporting**
Issue No. 1 Discussed Description of the issue Decisions reached **Issue No. 2 Discussed** Description of the issue Decisions reached **Issue No. 'n' Discussed** Description of the issue Decisions reached	Participating Member
New Actions	Member to Action
Members in Attendance Sign-off	

Figure 3: Groupwork meeting log template

The marks calculated using the Log Assessment Rubric and the Self / Peer Assessment mark were combined into a multiplier which was unique to each student. This was then applied to the mark achieved for the final group report.

5. TEAMWORK AS A CPD ACTIVITY

Continuing professional development (CPD) is an activity that has become mandatory for certain sectors of the Australian construction industry. For example, from 1 September 2007, *licensed builders… will benefit from the introduction of enhancements to CPD* (NSW Office of Fair Trading, 2007). Similarly professions such as Engineers Australia, the Royal Australian Institute of Architects, the Australian Institute of Quantity Surveyors, the Australian Institute of Building Surveyors, the Chartered Institute of Building and the Royal Institute of Chartered Surveyors all require members to engage in CPD activities on a regular basis. The use of on-line environment collaborative environments such as those described earlier in this paper is becoming more widespread, and the research steering committee of CRC CI endorsed the development of a CPD activity on virtual teamwork as an effective way of disseminating the outcomes of our research project. Such a resource was seen as worthwhile as it provides practicing professionals with opportunities to develop skills which many take for granted.

5.1 DEVELOPMENT APPROACH

The delivery of CPD cannot simply be left to reading the work of others. It should involve "learners" in more than passive learning i.e. it should engage them in activities that are meaningful and relevant. According to Dadds (1997), the journey of professional growth must involve practitioners in changing their practices through the understanding of their practices and context in light of their relationship to new research findings. We have endeavored to do exactly this. We have developed a CPD module as a direct outcome of the CRC CI Virtual Teams project which serves to:

inform participants about issues and challenges of working in virtual teams

provides case studies that enable participants to appreciate the nuances and challenges of virtual communication

allows participants to audit their virtual communication skills, and

encourages participants to develop additional skills to complement their strengths and / or to develop additional skills where required.

5.2 CPD MEDIA

The CPD module was developed with transportability in mind. We decided on a digital format with access via an Internet browser. The module can therefore either be hosted on a file server or delivered via stand-alone media (such as a CD or DVD). The delivery of CPD packages in this mode posed an interesting challenge for the developers. As experienced online teachers we fully appreciate that the three roles of online instructors are "cognitive, affective and managerial" (Coppola, Hiltz and Rotter, 2001). To address these roles required a CPD packages which was stand-alone. This format negates any ongoing managerial role for instructors, and thus circumvents what may develop into an onerous task. Furthermore, every aspect of the package needed to be intrinsically valuable to participants, as there was to be no ongoing instructional input. The stand-alone nature of the package required a framework of critical thinking and practical enquiry (Anderson, Rourke, Garrison and Archer, 2001).

In the development of the package the developers drew from established instructional methodologies to ensure that the learning experiences of the participants was both active and "participant centred". To achieve this, the following strategies, as identified by Conceicao (2007) were utilized:

> Application of a variety of strategies

> Case studies

> Problem based scenarios

> Application of theories to real life scenarios

> Application of authentic data gathered from real life situations

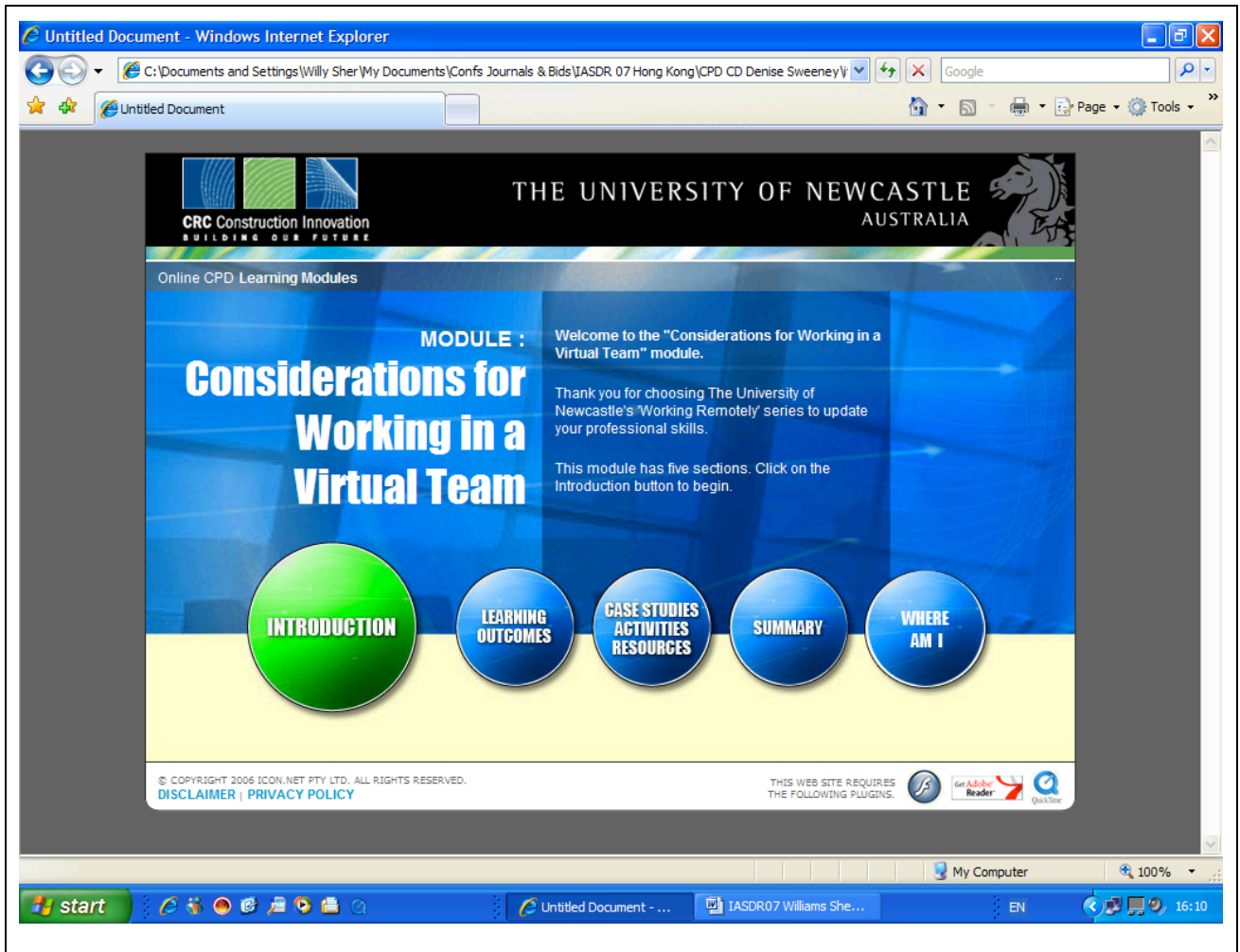Figures 4, 5, 6 and 7 illustrate the application of these strategies:

Figure 4: The entry screen of the CPD module
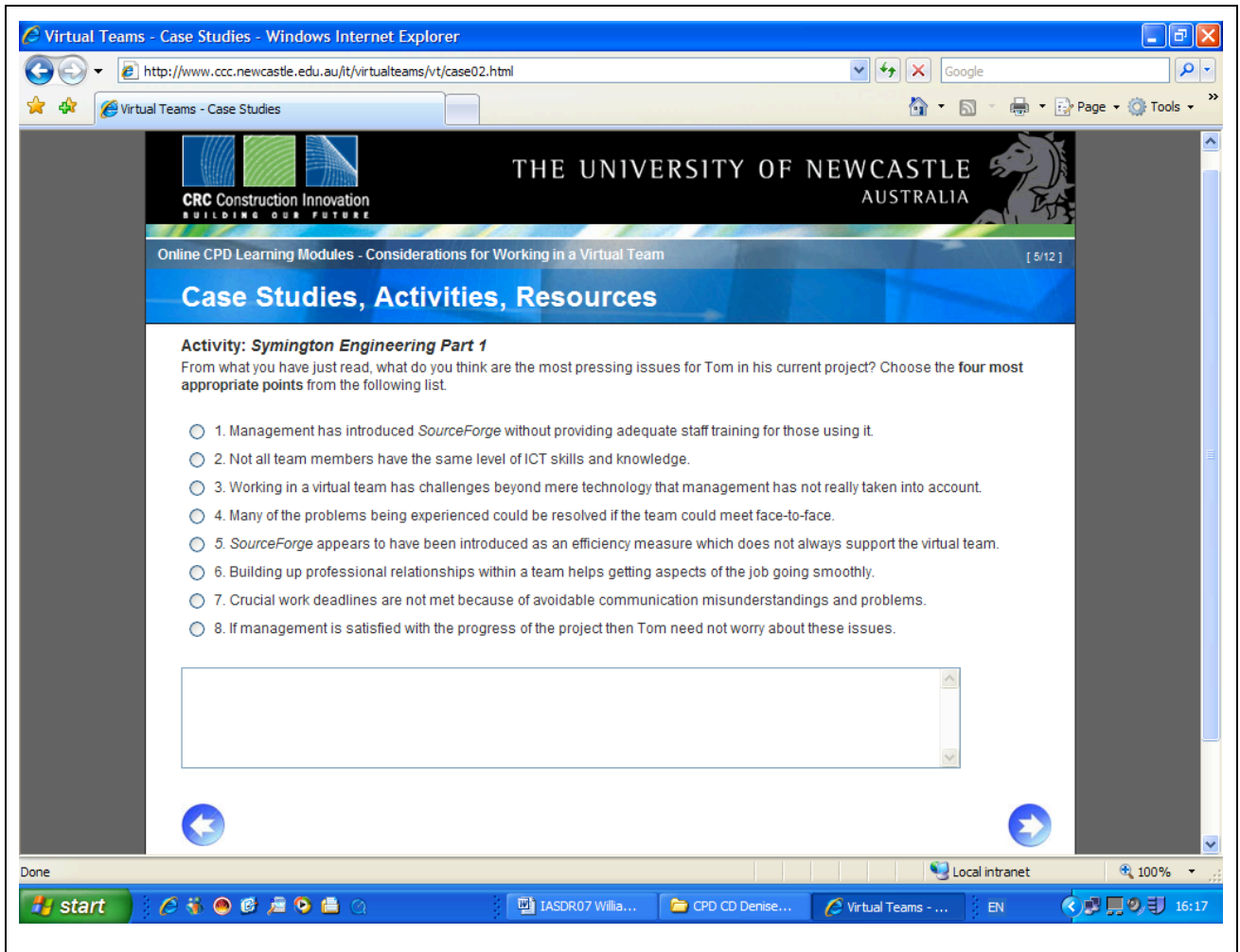
Figure 5: Example of a case study in the CPD module

Figure 6: Example of a self-assessment exercise in the CPD module
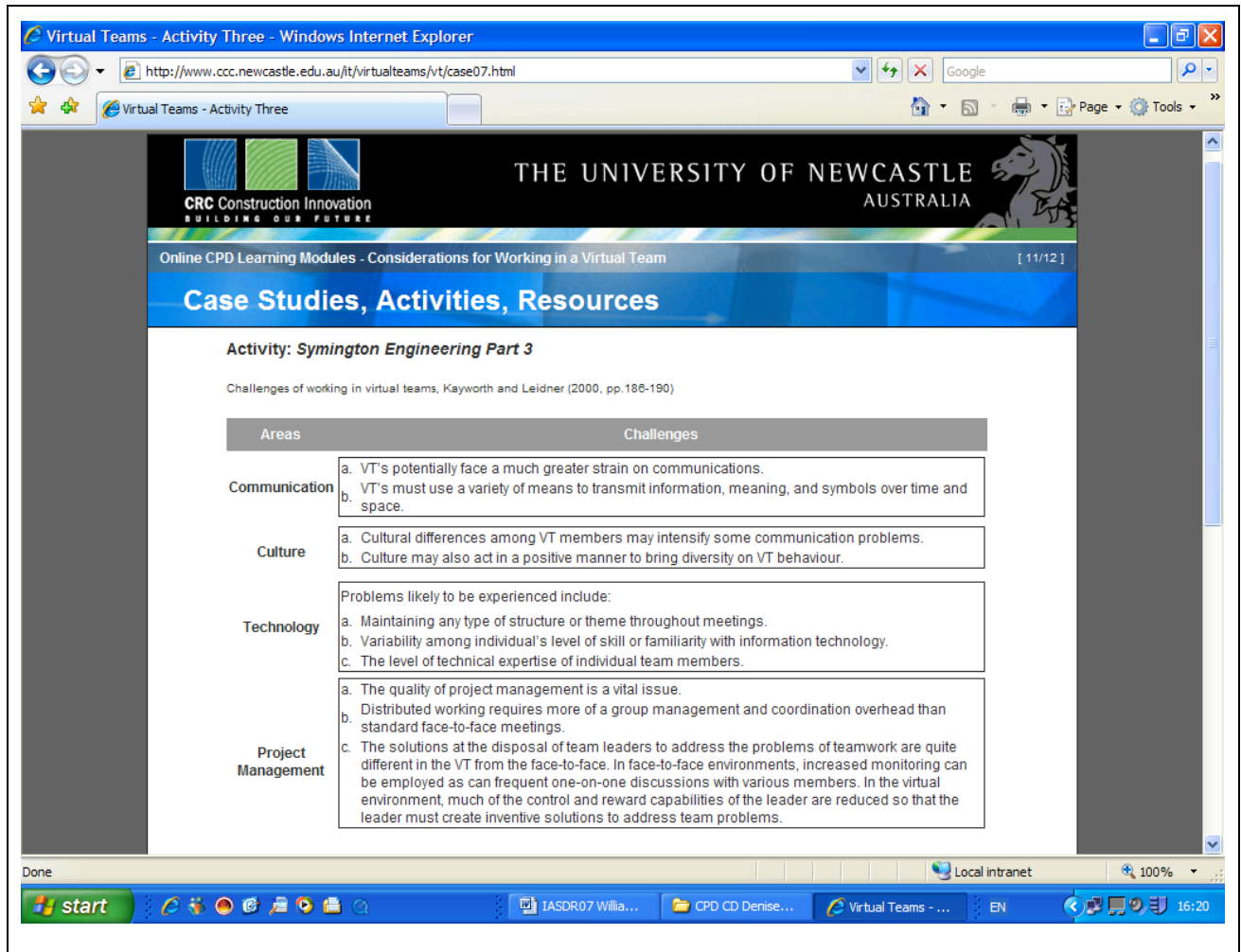
Figure 7: Example of CPD instructional content

6. CONCLUSIONS

The research / teaching / CPD nexus is a novel concept in the relationship between research outcomes, teaching practice and methodologies and professional practice. Dissemination of research findings has often been limited to professional or academic literature but through the application of proven instructional methodologies to research, outcomes are transferable to the domain of practicing professionals through an active mode of learning experience.

The CPD package has been adopted by industry professional bodies and the knowledge, skills and attitudes identified in the research have also enhanced undergraduate student learning experiences. The question must therefore be asked whether this practice should become the norm and the research / teaching / CPD nexus be an acknowledged reality.

ACKNOWLEDGEMENTS

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