Changing practice: An exercise in curriculum development of innovative teaching in construction technology

James Henri
Faculty of Education
University of Hong Kong, Hong Kong
Richard Frewer, Alex Amato, Ruffina Thilakaratne
Department of Architecture
University of Hong Kong, Hong Kong
Sue Trinidad
Faculty of Education
Curtin University of Technology

Evaluations suggest that, within construction related professional courses, technical aspects are the most difficult to teach. This is particularly evident in the teaching of architectural students as many fail to make the link between Construction Technology and the main thrust of architectural education: the Design Studio. The teaching of Construction Technology has, until now, been very much an instructor centred, didactic exercise with little interaction among students or between students. In sharp contrast, Design Studio is dependent on the visual and graphical processes and occurs in settings where students interact informally with their peers and design tutors. If Design Studio can be managed in a student centred and hands on environment, why can't courses in Construction Technology / Tectonics be delivered in a similar atmosphere? This was the challenge faced by the project team as they undertook a project in changing practice through innovative teaching in Construction Technology at The University of Hong Kong. This paper reports on the process and progress of this project where there has been an attempt to shift the pedagogical practices in Tectonics. Changes in students' learning of Tectonics, the issues associated with collaboration between instructors and students, between instructors & instructors and across departments are discussed.

Keywords: Architecture design studio, tectonics, Learner Management System, pedagogical change.

Technology or tectonics?

Traditionally, architecture course curricula have been divided into Design Studio and coursework. As the visual image has become more accessible and immediate through the virtual world, the imagery of the architecture student's work has become increasingly central to their perception of the meaning of architecture. In consequence, technological aspects have been shunned. The elegance and economy of means achieved in a piece of architecture is very dependent upon the way a building is made and sensitivity with which the elements are brought together. To place this notion into the centre of the design philosophy of the school, the term 'Technology' has been replaced by the generic term 'Tectonics' which, within the Century Dictionary Volume 8, is defined as '*Building or any assembling of materials in construction considered as an art'*. By teaching 'Tectonics', it is hoped that the art of architecture and the art of making will become one in the students' mind.

An introduction to the study

This project was a teaching development project funded by the Hong Kong University Grants Commission (UGC) during 2003-2005. A project team comprising of academics from the Departments of Architecture and Faculty of Education was established to provide the expertise required for this project. Academics from the Department of Architecture provided core knowledge and content relating to construction or Tectonics. While two academics from the Faculty of Education provided expertise in curriculum design, possible innovative uses of the Learner Management System and pedagogical

practices. Through an analysis of the pros and cons of traditional 'teacher centred' and 'student centred' pedagogies, the aim of the project was to shift the focus of instruction from the instructor to the student by embedding new methods and interactive techniques such as problem based learning (PBL), online quizzes, online forums, and the use of virtual construction sites. With a high visual emphasis these methods were supported by computer mediated communication (CMC), collaborative group work within the module and integrated with Design Studio exercises. Problem based learning and project based learning (PBL) methods have been long practiced in Design Studio in architecture schools. As student centred methodologies these underpin active learning and are well known by academics in the fields of education, architecture and engineering. Tectonics, offered in all three years of the Bachelor of Arts in Architectural Studies or the BA(AS) programme as a 3 credit core module, was chosen as a suitable pilot course to promote enquiry and innovation. Tectonics combines environmental science, building services, and building structures and construction technology, and the way these are synthesised to improve the overall quality of a design. As global environmental sustainability is so dependent upon improvements in construction, sustainability informs all these areas. At the University of Hong Kong a team of three instructors has offered this course in Year 2. The intention was to radically revise and update content, teaching methods and delivery by producing an integrated curriculum linked and informed by Design Studio. This curriculum was to be delivered via a Learner Management System that would support a community of learners and provide a platform for the extensive use of digital resources, data sharing, social interaction and information exchange in a socially interactive learning environment. Finally through this project it was intended that an inter-university institution for teaching Tectonics should be established.

The process

Analysis of previous experience is an essential element of any mature innovation. The review of best practice cites an array of student centred learning approaches used within schools of architecture. One of these examples is the use of Integrated Problem Based Learning (IPBL) where all courses are integrated with design projects (University of Newcastle, 2000). Other examples include the use of gaming, online multimedia case studies that simulate construction environments (Ham, 2001; 2002; Batie & Connell, 2000) and hands on approaches (University of Adelaide, 2002; Tan & Elias, 2000). Several research projects related to the development in construction education have been undertaken in Hong Kong at City University, the Chinese University, Polytechnic University and in two departments of the University of Hong Kong. Two projects (Walker, McKinnell & Chau, 1996; Will & Bradford, 1991) had investigated innovative approaches to improve construction education at the University of Hong Kong but these resulted in little change in pedagogical practices. Often these projects happen in isolation within most universities or departments, indicating poor dissemination of information, poor collaboration and poor sharing of outcomes.

A curriculum mapping exercise was employed as the backbone and essential first step to any decision about where to introduce innovative teaching. As documented by Jacobs (2000) a curriculum mapping exercise endeavours to:

- understand what is taught and when;
- create unified interdisciplinary units that foster students' understanding of concepts, ideas, and activities across many subject areas;
- enable the migration of study areas into larger interdisciplinary units (even if they are assessed separately by subject area);
- act as a successful venue for fostering conversation about curriculum and instruction among all faculty members; and
- assist instructors in reflecting and adjusting their own lessons.

This exercise provided hard evidence that a radical attempt to rationalise courses in Tectonics, and in particular, to provide a common core across the university was unlikely to succeed. However, it enabled the project team to identify sustainable construction as a potential area of common ground in which to innovate. Moreover, the exercise indicated that a sustainable construction pilot module would be of use to several university departments. To provide a flexible delivery of the curriculum, it would be mounted within a Learner Management System thereby integrating Information and Communication Technologies

(ICT). Graduate attributes were developed for the modules of the curriculum using a sound pedagogical framework (Trinidad & Albon, 2002; Trinidad 2003) that identified learner attributes, assessment tasks and assessment rubrics. Making use of these ensured that students were being prepared for the future that is largely unknown (Bowden and Marton, 1998), rather than for the present. Based on the current Year 2 BA(AS) 'Tectonics' curriculum, a draft of the proposed new curriculum was developed together with a pilot module.

The transformation: Assessment drives the learning

The focus in this project has been on creating authentic assessment within an environment that encourages a constructive dialogue within the group following a social constructivist philosophy. Social constructivists argue that learning occurs in an environmental and social context. The core of the constructivist instructional principles is integration, authentic tasks, increased students responsibility and ownership and the relationship between process and content learnt (Burns, 1995; Savery & Duffy, 1995; Trinidad, 2003). The '*linking learning with assessment*' cycle (Trinidad & Albon, 2002) was employed to link the curriculum, the tasks, and the assessment. This cycle follows a process in which the assessment drives the teaching and learning interaction; this interaction becomes the vehicle for the construction of knowledge and the knowledge enables the outcome of learning, which is, in turn demonstrated through authentic assessment. The emphasis on assessment was critical since

> Authentic assessment aims to evaluate students' abilities in 'real world' contexts. In other words, students learn how to apply their skills to authentic tasks and projects. Authentic assessment does not encourage rote learning and passive test taking. Instead, it focuses on students' analytical skills; ability to integrate what they learn; creativity; ability to work collaboratively; and written and oral expression skills. It values the learning process as much as the finished product (Pearson Education Development Group, 2000).

This focus has led to a change in the culture of teaching as well as its structure. It has also entailed the introduction of new scaffolding including stratified group work, task check pointing, and the introduction of the Learner Management (LMS) to manage the process. It was decided to undertake a trial project module delivered in a traditional face to face setting but supplemented with the in house developed LMS, Interactive Learner Network (ILN). In this way, ICT was used to support the pedagogical practice, because ILN is a community building environment designed to support virtual education communities of practice where teachers and students work as teams and together engage in reflective, collegial patterns of work. ILN facilitates both cognitive as well as social scaffolding. ILN enables educators and students to become progressively involved in the community and to sustain their commitment and interests (see http://iln.cite.hku.hk/).

Progress and findings

The project during the first 18 months has experienced a series of challenges. As already stated, Construction Technology or Tectonics is considered by many students and many architectural instructors as peripheral to the 'main event' of Design Studio. Students have expected to be spoon fed. Consequently they show deficiency in powers of analysis, evaluation, synthesis and applying the knowledge they had gained. These weaknesses were improved by the adopted pedagogies and the forms of assessment employed within the Tectonics modules. The challenge has been to win the acceptance and adoption of a very different teaching approach. Inevitably, such reforms require the full cooperation of all those involved.

Academics are required to meet high performance targets in teaching and research but the research imperative is by far the most pressing. Motivating academics to become involved in a teaching development project is therefore an inherently difficult challenge. In mitigation, colleagues within departments are more likely to offer active support to a project, which has no direct personal benefit, if a 'collegial culture' exists within the department. Such a culture does exist in the Department of Architecture especially amongst those involved in the teaching of Tectonics and those whose interests lie in, or are associated with, the area. This has greatly helped the development of one of the pilot modules. The following findings indicate the successes and some of the challenges of the new strategies adapted in teaching Tectonics.

Instructors as facilitators

Visual materials are essential to communicate the Tectonics course content because in Hong Kong students have little practical, personal experience of construction, even at the DIY [do it yourself] level. Instructors used an array of media: Power Point slides, videos, slide shows, websites, software demonstration, and physical and digital models. It was evident that material with high visual content and interactivity, such as software and games, would enhance students' attentiveness during lessons.

Gaining student interest is an essential first step in the transition from 'sage on the stage' to 'guide on the side'. However such a major change was very difficult for those involved in the project that were employed on the strength of their expertise in Tectonics rather than their teaching experience. Changing to new techniques takes time and guidance. To move directly into a new teaching mode may affect the confidence of the instructors and can lead to partial dismantling of the new scaffolds and innovative assessment methods. This can be damaging to the change and, if not checked, can reinforce the accepted culture. There was a tendency for instructors to continue to practice a heavily instructor centred pedagogy leaving little time for student interaction and discussion. Indeed, instructors continued to describe lessons as 'lectures'. By using ILN to manage the learning materials, the team members were able to learn from each other through discussion and the sharing of teaching materials. Nevertheless, there was a tendency for the instructors to continue to work as individuals rather than as a team.

Feedback from in-class observation suggested that even when the instructors provided the opportunity for greater interaction, the students were reluctant to take a more active role as students initiated few questions. One of the issues in a Confusion Heritage Culture is that students will not ask questions for fear of 'losing face'. This phenomenon of 'losing face' applies both to students and instructors. If the instructor cannot answer a question then the students will perceive this also as 'losing face'. A student who asks a question for which the answer has already been given also 'loses face' therefore asking questions is high risk behaviour in class. However, the adoption of ILN did create a significant change in student activity. In that less threatening environment in ILN students were willing to ask questions and provide critical reflection on the topics. In fact the students were very positive about the early availability of resources. Students began to question the meaning of having resources online if the teacher repeated the same information in the form of a lecture. Dealing with this issue is an ongoing one that has identified the need for systematic, continuous professional development of staff in a range of pedagogical practices. It might be argued that such training should precede a major change but, despite its teething problems, to make a swift change to new methods may have been the only way to innovate while avoiding resistance within the complex dynamics of a teaching department.

The integrated studio

With the restructuring of the BA(AS) curriculum, Tectonics became the major theme of the Year 2 syllabus. The initial agreement between the staff was to integrate Tectonics, Visual Communication (using computers in architecture) with the Design Studio projects and to assess them all through studio. The rationale was to strengthen the link between technical/tectonic understanding and architectural design. This proved beneficial overall but it proved to be over ambitious in the first year of the project because the interconnection of all these elements led to some conflict among the staff, uncertainty in the students and a consequent overloading of their schedules. For decades, assessment in Design Studio has been an interesting subject for debate. There is a difference between the knowledge gained in coursework that can be tested rigorously and performance in studio that, like the performance of music, but be judged with a degree of subjectivity. These like qualities of performance cannot be judged or can be recognised by an experienced designer/critic. The problem arises when project based course work is assessed as design without a rigorous rubric. Rubrics not only provide a way of making assessment objective, they also help to direct student work. It was planned that the assessment in the integrated Design Studio be undertaken by both Design and Tectonics instructors and measured against a sophisticated rubric. Unfamiliarity with assessment rubrics meant the process was not as robust as had been anticipated and will need further adjustment in the coming term. However, despite these logistical problems, positive comments from the students about this initiative indicate a change in student and instructor behaviour and the quality of design work reflected the beneficial input of the Tectonics module in its new form (Figure 1).

The following are some of students' positive comments about the integration:

> BT [Building Technology] projects…encourage us to think more about the technical parts when we draft out our design. This can refine our designs and make our final design more realistic.
> Such knowledge is really useful and important in our future design works as well as in daily life.

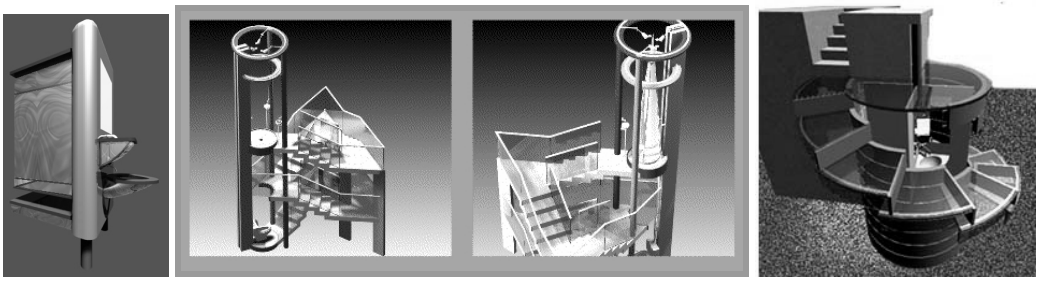

Figure 1: Student work that demonstrates the integration of tectonics knowledge in design

The online learning environment: The ILN

An online learning environment using a Learner Management System like ILN can mean much more than a place for depositing and delivering material via the Internet. It provides the potential to create an interactive learning environment, group work, and robust communication with peers and instructors. This is far more interesting than merely listening to the web based or PowerPoint directed lecture delivered by the instructor. However, the effectiveness of ILN is very much dependent upon the infrastructure in the department. Presently, there is insufficient space and equipment provided, and so the potential of ILN and its ensuing changes in instructors and students' attitude could not be fully explored. Although students realise the importance of this new initiative, it is not easy to demand changes in the infrastructure if there is no collective ownership of it by the wider group of instructors. As well as professional development for staff it is essential for the key administrative staff to facilitate new directions. Findings from the six focus group interviews conducted at the end of the academic year 2003/2004 and comments from the online forum indicate the positive aspects of ILN with some suggestions for further improvement. These suggestions were mainly centred on technical requirements such as the need to add a spell checker for students and staff to check their text before posting, and the addition of graphic enhancers for architectural diagrams to be displayed within ILN. Some comments from students included:

> I believe this system will help us a lot! I am glad to see the change in our way of receiving course information…this change is actually an improvement
> ILN did a great lot in enhancing communication between students and the lecturers
> It encourages us to learn how to learn

The online quizzes

A new initiative to the Tectonics syllabus was an electronically assessed online quiz session at the beginning of the lectures. The online quizzes were formative assessment that provided the instructors with instant feedback about students learning. The objective was to encourage self learning by encouraging more reading and to ensure students' preparation before the lectures. Pairs of students undertook quizzes and this developed students' group working ability and time management skills. The online quizzes contributed to 15% (first term) and 25% (second term) respectively towards the final marks. Students' high performance, high level of participation in online quizzes, and their positive comments provide evidence of the success of this approach. Table 1 and Figure 2 indicate the high rate of attendance in quizzes compared to low rate of attendance in lectures. Levels of attendance were also very low when lessons clashed with other course assignments.

One of the constraints in web delivered programmes is the difficulty to control access, which was insisted by the instructors. The mismatches between students attendance record and quiz participation results

indicate that some students have accessed the quiz remotely. However this is a positive indication about students' interest to participate in online quizzes, regardless of the physical location. Considering these experiences, the instructors now want to implement the online quizzes to be more flexible with more variety such as automated/randomly generated questions. This adjustment had to be incorporated into ILN. In this semester students can access the quizzes at any time from anywhere and complete them with several attempts. This has allowed the instructors to compare paper based vs. online quizzes. They have found several advantages of online quizzes such as easy marking, instant feedback and students' preference for more flexibility.

The online forum in ILN

The online forum in ILN provided an effective mode of communication among students and between students and instructors. Although changes in teaching style with the introduction of an online course room were not evident during teaching, some positive signs emerged through the online forum. As previously stated, Chinese students are seldom willing to engage in debate in front of their teachers but there is emerging evidence that ILN encourages students to be more interactive and communicative through the forum and they begin to exhibit more independent and self–reflective problem solving behaviour. Much greater interaction among students themselves and with their instructors happened in the online forum than in the class indicating more peer learning. The online forum provided opportunities for lengthy and detailed discussion, which was not possible during the two hour lecture session.

The frequency of forum participation ranges over a thirteen week period, from 0-73 visits per week with a peak during the first five weeks of the semester (Figure 2). The following are some of the discussions that occurred in the online forum facilitating peer learning:

Table 1: Students' participation in lectures and online quizzes

Week	Lectures	Class attendance (%)	Quiz attendance	Other work hand-in
Sept. 8	Introduction to the semester	71 (100%)		
Sept. 11	Lecture 1 Lecture 2	71 (100%)	No quiz	
Sept. 15	Lecture 3 Lecture 4	No data	No quiz	 Hand-in
Sept. 18	Lecture 5 Lecture 6	10 (14%)	No quiz	
Sept. 22	Lecture 7 Lecture 8	No data	70 (99%)	 Hand-in
Sept. 25	Lecture 9 Lecture 10	26 (37%)	66 (93%)	
Sept. 29	Drawing sessions	70 (99%)	No quiz	Hand-in
Oct. 2	Lecture 11 Lecture 12	49 (70%)	68 (96%)	
Oct. 6	Drawing sessions	68 (96%)	No quiz	Hand-in
Oct. 9	Lecture 13 Lecture 14	37 (53%)	No quiz	
Oct. 13	Drawing sessions	70 (99%)	No quiz	Hand-in
Oct. 16	Lecture 15 Lecture 16	22 (31%)	64 (90%)	
Oct. 20-24	**Reading week - no lectures**			
Oct. 27	Lecture 17 Lecture 18	35 (49%)	66 (93%)	

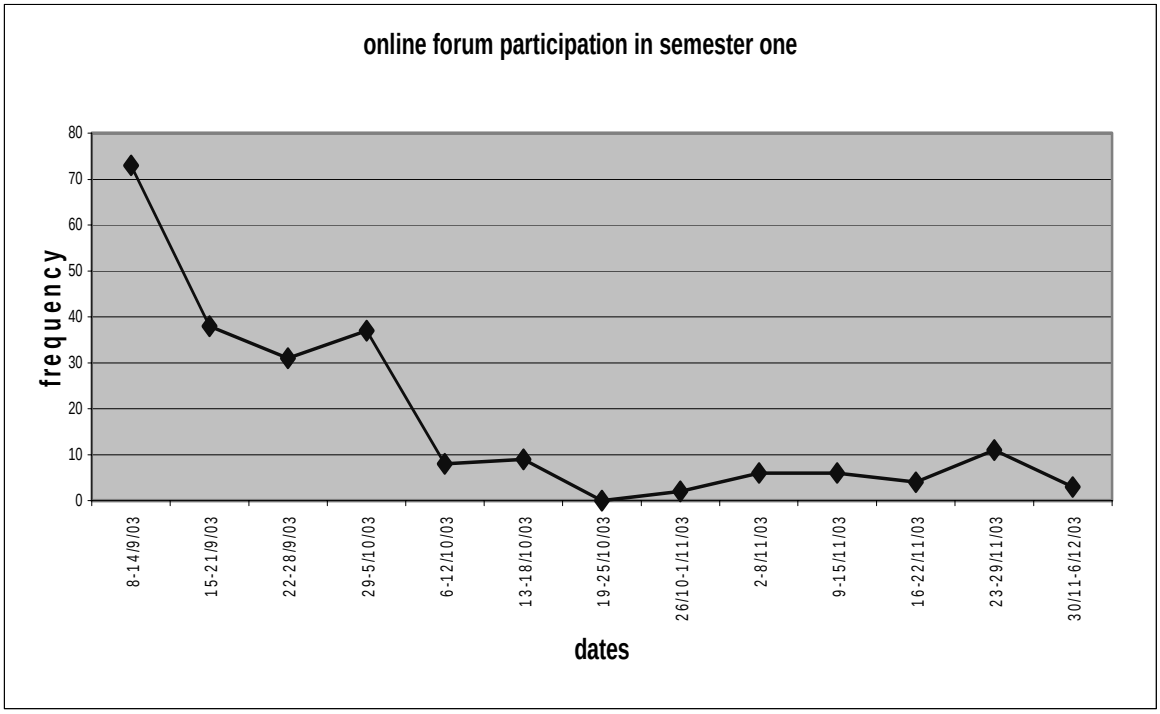

Figure 2: Online forum participation by students, teachers and project staff

> Could anyone help me with the following questions?
> i) What's the structural difference between load bearing and non-load bearing walls, and the floors supporting them?
> ii) What's mineral wool? (Student S).

A reply from a fellow classmate was:

> I think the major difference between a load bearing wall and a non-load bearing wall is that the former has to support loads other than its own weight and resist loads both vertically and horizontally, but the latter has only to deal with its own weight and resists only to horizontal loads such as wind (Student K).

Following is a discussion between a student and a teacher.

> When I read the WEBSITE on ventilation, I find that roof water pond can be used for cooling. Is it possible? (Student L).
> Water on roofs - usually contained within the asphalt tanking, is a very effective way of keeping the roof structure and finishes at a more constant temperature than without the water pond… (Instructor A).

This public forum not only helped the instructors to interact more with the students but also facilitated a holistic understanding of student views about the new curriculum. The graph (Figure 2) indicates that enthusiasm started to fluctuate due to various factors such as coursework submissions and the focus on studio. This was to be expected, as the main input to teaching was early in the semester. Significantly there was a rise in interest shortly before the final design submission.

Conclusion

With the exception of Design Studio, courses in the Department of Architecture are predominantly instructor centred with students adopting a passive role. Therefore, any shift towards a student centred model poses considerable levels of uncertainty and even resistance from both staff and students. The

major intention of this project has been to radically revise and update content, teaching methods, evidence of learning and delivery by producing an integrated curriculum linked and informed by Design Studio. This curriculum has been delivered via the Learner Management System ILN that has supported a community of learners and provided a platform for the extensive use of digital resources, data sharing, social interaction and information exchange in a socially interactive learning environment. A web based system such as ILN forces instructors to make their teaching resources available to students and they in turn are required to be more responsible and accountable. The online forum and online quizzes have been the most attractive features of the innovation for both students and staff. While this paper describes a change process that may not sound like a radical shift for the students and staff of the Department of Architecture, this has been a giant leap forward in creating a more pedagogically sound learning environment. The biggest step forward has been there is now more explicit communication that has become pivotal to the learning process that is now taking place. While the focus is still on teaching the information in a transmissive manner and having an online quiz to test this information has been learnt, there has been a growing recognition that building a curriculum around learning outcomes is necessary and this has been linked to more group work and authentic activities driven by the studio design process. The mindset needed to shift from 'lectures' provides evidence that old habits will take time to change and evolve. The availability of the forum has enabled a more active participation from some of the students and this has lead to the emergence of some peer learning. As shown in the focus group appraisals covering course and teacher evaluations, students have reacted positively to the use of ILN which has made resources available to download anywhere at any time, and communication with instructors and peers has been accommodated outside regular class hours. The use of ILN has provided a systematic way of managing teaching resources, posting announcements, tracking the use and participation in various functions, hence enabling instant feedback for the development and evaluation of both the teaching and the programme.

Inevitably the implementation of new pedagogical practices suffered from the differences in approach between departments, between different instructors teaching 'Tectonics' and the need for students and instructors to become familiar with the new methods. Predictably, most of these deficiencies are indications of a need for further professional development for the academics in the area of modern teaching techniques (Trinidad, 2005; Newhouse, Clarkson & Trinidad, 2005). There is strong evidence that the following developments need to be made in order to gain more from ILN and curriculum development of innovative teaching in construction technology:

- a reward structure to shift instructors' attitude;
- professional development for instructors and administrative staff;
- reliable instruments to ensure and assess student's learning; and
- infrastructure to support an interactive learning environment within lecture rooms

On the whole these new initiatives have been as successful as can be expected within such a short period and certainly data collected indicates a positive change in the students' learning behaviour with positive steps being made to lead the way for the last phase of the project where a design game and more interactive content will be added to the current materials coupled with on-going professional development of staff.

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James Henri, *Faculty of Education, University of Hong Kong, Hong Kong*
Richard Frewer, Alex Amato, Ruffina Thilakaratne, *Department of Architecture, University of Hong Kong, Hong Kong*, itct@hku.hk
Sue Trinidad, *Faculty of Education, Curtin University of Technology, Perth, Western Australia.* S.Trinidad@curtin.edu.au

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