

Enhancing Project-Based Learning in Sustainable Building by Incorporating Learning Technology

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Both learning technology and project-based learning have been increasingly used in Higher Education to enhance quality of teaching and effectiveness of learning, while it remains a concern to engage students effectively in authentic practice. This paper aims to address this concern by embedding the use of learning technology in an innovative student project in sustainable building. Within the SharePoint environment of a UK university, a project sub-site has been established which makes use of a number of learning technologies including wikis, discussion boards, intranet and folders. This sub-site provides a platform for students to communicate within their groups and with their lecturers, and to engage with their allocated industry mentors. Furthermore, students can access good practice case studies and categorised information sources. Initial results of evaluating the sub-site indicate that the sharing of documents via the sub-site was perceived useful and efficient, albeit exposed to copyright risks. However, wikis and discussion boards were not regarded to be so useful, mainly due to slow responses. The use of the sub-site also demands a steep learning curve, for all stakeholders. The results contribute to future evaluation of the use of learning technology for student project-based learning.

Key Words: Project-Based Learning, Sustainable Building, Learning Technology, Sub-site

Introduction

Project-based learning (PBL) has been increasingly utilised in Higher Education (HE) (Pan and Allison, 2010; University of Nottingham, 2003), which helps students develop a range of skills, including problem-solving, group working, critical analysis, and communication (Overton, 2003). PBL has also been gradually supported by technology to foster student-directed scientific inquiry of problems in a real-world setting (Barak and Dori, 2005).

Sustainable building has been regarded as strategically important for the future of the UK construction industry (BERR, 2008), given the UK Government's target to reduce carbon emissions by 80% by 2050 (HM Government, 2008). As a consequence of that strategic importance, there have been fast-evolving, increasingly stringent regulations and standards on sustainability and world-wide good practice of sustainable building and construction (see e.g. Atkinson et al., 2009). Therefore, PBL in sustainable building as a discipline will only be effective when the state-of-the-art, fast-evolving knowledge and practice of sustainable building are reflected and engaged in the project learning context.

Despite the previous research into integrating technology to enhance student PBL, e.g. in science (ChanLin, 2008; Barak and Dori, 2005), it remains a concern to engage students effectively in authentic practice, particularly in the comparatively new, fast-evolving discipline of sustainable building. This paper aims to address this concern by embedding the use of learning technology in an innovative student project in sustainable building. Drawing on learning theories, the paper examines a range of learning technologies available at Plymouth University, UK. It then describes the development of a sub-site of the university's SharePoint environment, which aimed to enhance student collaborative learning by effective communicating with external stakeholders as well as with their peers and lecturers. The issues that emerged from the development and use of the sub-site are also explored.

Learning Theories

In the literature of learning theories three main categories or philosophical frameworks appear: namely, behaviourism, cognitivism, and constructivism (e.g. Jonassen, 1991; 2003). Jonassen (2003) commented that these learning theories have guided the field of instructional design in two main periods, with the first lasting most of the 20th century and the other two having dominated the past decade. Behaviourism is focused on the objectively observable aspects of learning. Behaviourists postulate that learning can be caused by external stimuli in the environment and indicated by an observable behaviour (Namhun, 2011). Learning outcomes as a result of behavioural responses to stimuli can be shaped by following reinforcement. Cognitivism looks beyond behaviour to explain brain-based learning. Cognitivists focus on learning as an internal process from the perspective of the information processing. This assumes that there is a sequence of mental activities for learners to understand and store the information given from an external world. Thus, learning can be facilitated and enhanced through the external manipulation of the instruction (Namhun, 2011). Jonassen (1991) posits that both behaviourism and cognitivism are primarily objectivistic, in which learning and knowing are considered as the processes for representing an objective reality. Under such teaching paradigm, learners strive to learn the target objectives by the passive transfer of knowledge and perform the expected outcomes. In comparison, constructivism regards learning as a process in which the learner actively constructs or builds their knowledge through interacting with the outside world and interpreting the experience, and not simply transferring knowledge from the external world.

Together with the shift of learning theory from objectivism toward constructivism there have also been models where the two are combined. For instance, Chen (2007) suggested an objectivist-constructivist blended approach to instructional design for intensive online courses. Namhun (2011) similarly drew on the different learning theories to develop a web-enhanced course in construction engineering and management education. It becomes important that the most appropriate approach is used when designing learning strategies. Jonassen (1991) argued that constructivist-based approach is the most effective for the advanced stage of knowledge acquisition. From the constructivists' viewpoint, learners are expected to manage their own learning, but this may cause introductory level students frustration and discomfort when learning a subject that is better facilitated by an objectivistic approach. The blended approach underpinned the development of the sub-site for enhancing student project-based learning in this present research.

Project-Based Learning and Learning Technology

Numerous project-based and/or problem-based learning studies have been conducted in the fields of engineering and construction. Despite the debate on the distinction between project-based and problem-based learning, many such studies were carried out using a project, and as de Graaff and Kolmos (2003) suggested, the very nature of project work often means that it is problem-based. Also, Perrenet et al. (2000) concluded that in isolation problem-based learning has its limitations and risks; and that in order to better reflect some professions, project work is best suited. Therefore, PBL is used in this paper to denote project-based and problem-based learning carried out in a project context as a meaningful way of learning skills and knowledge.

The prevalence of PBL across an increasing range of curricula is understandable given the favourable reports that have been made regarding its enhancement on certain areas of student learning. Research indicates that students become more proficient at problem-solving, group working, critical analysis and communication (Overton, 2003; Mitchell, 2010; Martinez et al., 2010), all of which were expressed by Sendag and Odabasi (2009) as desirable graduate key skills. However, much PBL research has tended to focus on assessing and analysing PBL in specific subject areas, such as medical health (Barrows and Tamblyn, 1980), architecture (Maitland, 1997; Roberts, 2007), and civil engineering (Mgangira, 2003). Unfortunately little of this has been conducted in sustainable building, a comparatively new area but one which involves fast-evolving knowledge and practice.

Laurillard (2010) reported that developments in digital technologies over the last few decades have extended the potential of traditional forms of teaching and learning to contribute to all aspects of higher education. The concept of learning technology seems to be elusive in the literature. A generally recognised description is given by the Association for Learning Technology (ALT, 2011), whereby learning technology is the broad range of

communication, information and related technologies that can be used to support learning, teaching, and assessment. However, precautions need to be taken in linking the use of learning technology with learning and teaching. Previous research (Archer, 1998) shows that students often fail to make these connections, and tutors often fail to design classroom activities to facilitate learning of situated knowledge and a broader understanding of concepts. Pedroni (2004) suggested that teachers need to take part in planning the environment for technology integration and promote inquiry, problem-solving, and critical thinking. When integrating technology into learning, students are more likely to build on what they learn from technological skills and experiences when their existing knowledge is acknowledged and made central to the learning process. From this perspective, linking technology-focused knowledge construction to students' needs and interest rather than simply delivering technical training isolated from the curricular or instructional objectives need to be emphasised (Kanaya, 2005; Tangdhanakanond et al., 2006). ChanLin (2008) contended that integrating technology into PBL requires a strong linkage with real-world scenarios. This paper presents such an attempt, aiming to enhance student PBL in sustainable building by incorporating learning technology.

Research Design and Methods

The study on which this paper reports was carried out as action research with the disciplines of building and construction in Plymouth University, UK. To achieve the aim four objectives guided the research:

1. Identify the most appropriate areas for improvement in student PBL in sustainable building through the use of learning technologies,
2. Determine the most suitable learning technologies to address the previously identified areas for improvement and how such technologies can add value and be most effectively incorporated into the PBL,
3. Develop a sub-site of the university's SharePoint environment, incorporating the use of the identified learning technologies, for optimising student PBL,
4. Evaluate the effectiveness of incorporating learning technology in PBL in sustainable building.

The project used for the PBL was a real-world 'design and build' project for a waterfront development in the city of Plymouth, UK by a regional developer. The project was a 'brown-field' development (i.e. on a pre-developed site; involving demolition), and included a broadcasting studio, offices, commercial and retail areas, as well as up to 10 storeys of residential units targeting the high-end market. The project required the students to work to the environmental design specifications commensurate with the Building Research Establishment Environmental Assessment Method (BREEAM) 'Excellence' and the Plymouth city's planning requirement for 15% on-site renewable energy, which together required the most challenging practice in the UK construction industry at the time of this study. In total, 70 second-year undergraduate students participated in the PBL, and they were from five sustainability-embedded building and construction courses: Building Surveying, Construction Management, Environmental Construction Surveying, Architectural Technology, and Architectural Design and Structure. Three learning modules were involved in the PBL, and they were: Technology of Large and Innovative Building, Building Surveying, and Construction Management. These features ensured that the PBL was multi-disciplinary. The students worked in groups of five in principle, to cover as many roles in real practice as possible, e.g. architect, structural engineer, services engineer, construction manager, and building surveyor. Each group was allocated an industry mentor. The student project started in early-January 2011 and finished in late-May 2011.

The research design employed a combination of research methods including: literature review; interviews with students, lecturers, and industry practitioners; meetings with the learning technologist of the faculty with which the building discipline is associated; and questionnaire surveys with students. This paper is focused on the development of the sub-site and initial feedback, while the final evaluation of the use of learning technology will be reported in the future. The details of the research methods are provided below:

- The first objective was achieved by: 1) a desk study of PBL in the building discipline at Plymouth University in the previous two academic years (2008-2009 and 2009-2010); and 2) semi-structured interviews carried out during the period from November to December 2010 (i.e. before the student project reported in this paper) with 11 students (5 final-year students and 6 recent graduates who were involved in previous PBL at the university) and 3 lecturers who taught the three modules involved in the PBL; and 3) discussions with 4 senior construction industry practitioners (who were invited to give a guest lecture to support student project work) during the

period from late 2010 to early 2011. These practitioners included the roles of architect, contractor, engineer and surveyor, addressing the nature of the project work and student roles.

- The second objective was achieved by: 1) an extensive literature review of the learning technologies available at the university; 2) the interviews with the students and lecturers, and discussions with the industry practitioners (as above); 3) a number of meetings between the research team and the learning technologist and two technicians in the university information technology (IT) support department during the period from December 2010 to February 2011.
- The third objective was mainly achieved by the research team, with support from the learning technologist and the university IT personnel.
- The fourth objective was achieved by: 1) structured interviews with all the student groups immediately after their interim project presentations; 2) questionnaire surveys after the students sub-site training and final project presentations; 3) structured interviews with the assessors of student project work (i.e. the lecturers and industry practitioners involved on the final project day); and 4) the researchers' observation of students' learning during the process, and moderation of the use of the sub-site.

The structured interviews took about 10 minutes each. All the interviews were audio recorded where permission was granted by the interviewees. Otherwise, notes were taken, as were during discussions and meetings. The qualitative data (e.g. the notes and transcripts of interviews) was analysed using the 'content analysis' method, i.e. following the logic of identifying the codes, themes and patterns, while the quantitative data (e.g. that from the questionnaire surveys) was analysed using descriptive techniques.

Developing a Project Sub-site Incorporating Learning Technology

Areas for Improvement

PBL in sustainable building has been run at Plymouth University since 1996-97, which embeds good practice such as integrating critical thinking into the learning process and utilising an IT-supported intranet for the first-year eco-house design project. However, the results of this study indicate that the level of utilising learning technologies had been inadequate. The students interviewed commented that they utilised some learning technologies available on the university intranet (e.g. wikis and discussion boards); however, such use was limited, fragmented and more to the individual's interest. Communications within student groups were dominated by more conventional techniques like email, text messaging and telephone calls, while communications between students and lecturers (in addition to face-to-face lectures and project workshops) were mainly via email and individual module sub-sites of the university intranet. A general low awareness of other (arguably more advanced) learning technologies (e.g. podcasting, Live Meeting) was observed of both the students and lecturers. Also, there was limited direct engagement by students with practice/industry for their projects. Further, there was insufficient cross-programme collaboration, i.e. across the five courses involved in the PBL. The results suggest room for improvement in student PBL in sustainable building, for which incorporating learning technology was perceived to be an effective means.

Learning Technology Examination and Selection

In total 12 types of learning technology that were available at Plymouth University were examined within the context of the PBL. These included: blog, discussion board, folders, instant messaging, intranet, iTunes U, Live Meeting, PebblePad, podcasting, RSS ('Rich Site Summary'; more commonly known as RSS), screencasting, and wiki. The examination considered the requirement for new equipment/software, training and moderation, extent of bias, and ability to encourage participation (Table 1). The examination was informed by the desk study of learning technologies available at the university and discussion with the relevant lecturers, the learning technologist and IT support personnel of the university.

The results of the examination suggest a complex profile of the learning technologies. None of the learning technologies satisfied or failed all of the five criteria. Trade-off was needed in the decision of selecting most appropriate learning technologies. Therefore, all the learning technologies were further investigated, one after another, following the logic of rejection or acceptance, on the basis of meeting the criteria for examination (Table 1)

and addressing the aim of the sub-site. Consequently, four learning technologies were selected for use for the sub-site, and they were: folders, discussion board, intranet, and wiki (Table 2).

Table 1

Examination of learning technologies considered for the sub-site

Learning technologies available at the university / Criteria for examination	Blog	Discussion Board	Folders [1]	Instant Messaging	University Intranet	iTunes U	Live Meeting	PebblePad	Podcasting	RSS	Screencasting	Wiki
No new equipment/software needs?	Y	Y	Y	N*	Y	N*	N**	N*	N∞	N#	N∞	Y
No equipment/software training needs?	Y	Y	N	N	Y	Y	N	N	N	Y	N	N
No moderation required?	N	N	N	Y	Y	Y	Y	Y	Y	Y	Y	N
(Relatively) free from bias?	N	N	Y	N	Y	Y	N	N	Y	N	Y	N
Allows active participation? [2]	N	N	N	Y	N	N	Y	N	N	N	N	N

[1] A library of folders on the intranet provided each team with its own shared online file storage area.
[2] Active participation has been defined as synchronous one-to-one or group interaction.
* Headphones
** Headphones, microphone, and Webcam
∞ Specialist production software/hardware
Web application (software download, normally free)
Y – Yes; N – No

Table 2

Selection of learning technologies for the Sub-site

	Description	Rationale for Selection
Discussion Board	Online discussion area where folders (forums) contain series' (threads) of messages (posts) on particular topics (UKCLE, 2010).	The benefit of sharing questions and feedback as a cohort, and the easy traceability of posts, outweighs the moderation [1] requirement.
Folders	Online storage located on the university intranet enables team members and their mentor to share files.	The ability for teams to work online collaboratively outweighs the training and moderation [1] requirements.
Intranet	A computer network that enables a company to exchange or view information internally (Pearson Education Ltd, 2010).	The university intranet (using Microsoft SharePoint 2010) provides an online hub where staff, students, and mentors can easily access and view project information.
Wiki	Online collaboration tool, where edits to a content-specific Web page are instantly displayed (EDUCAUSE, 2005).	The benefit of content-specific sharing as a cohort, and the easy traceability of edits, outweighs the moderation [1] requirement.

[1] Moderation is required, not only to manage any inappropriate language, but also to remove documents that impinge on the copyright permissions of the Plymouth University intranet licence.

The Project Sub-site

The developed sub-site (Figure 1) functioned as a centralised Web-interface to complement the PBL. The functions were designed to cover:

- Facilitating student-staff communication regarding the project and provide a 'platform' for students to engage more effectively with external stakeholders (e.g. their industry mentors and professional bodies) as well as for external stakeholders to interact in students' projects from an early stage. Such design draws on the constructivism learning theory, and improved communications should help students produce more informative and practical project solutions.
- Providing sustainable building case studies and categorised links to a wide range of academic, professional and industry information sources. Such design draws on the objectivism learning theory, and the provided functions should enhance practicality and authenticity of students' project work.
- Students' design solutions were encouraged to be uploaded on to the sub-site to showcase good practice for improving criticality and attracting enterprise/employment opportunities.

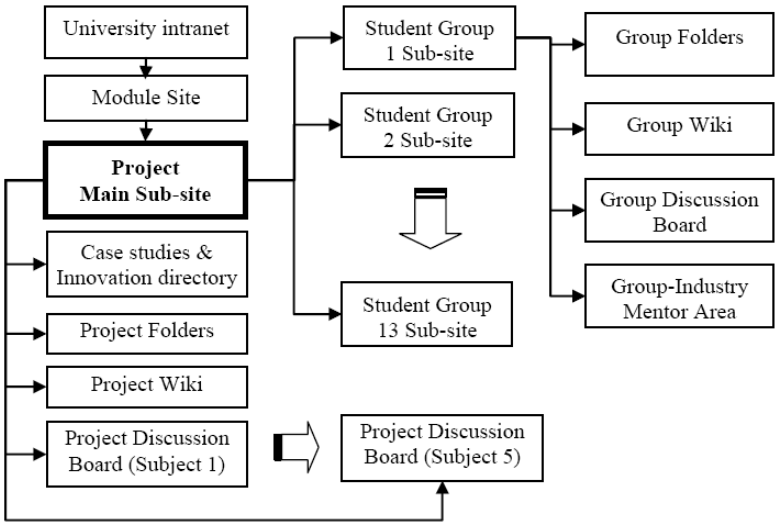

Figure 1: Project sub-site structure

Subjects: building technology; construction management; building surveying; building services; and critical thinking.

The project sub-site was developed at two levels: one project main sub-site and 13 student group sub-sites (Figure 1). All of these sub-sites incorporated the selected learning technologies: folders; discussion board; and wiki, while their facilitation was made possible by use of the university's intranet. The project sub-site also provided case studies of good practice of sustainable building and an innovation directory which included a wide range of links to information sources. The project main sub-site was accessible by the students and their lecturers, while each student group sub-site was also accessible by the students' respective industry mentor. The lecturers were asked to respond within 48 hours to students' inquiries posted on the discussion boards; five discussion boards were set up on the project main sub-site to suit the different expertise of the staff involved, which comprised: building technology; construction management; building surveying; building services; and critical thinking. A wiki was also provided on the project main sub-site to encourage staff and students to share content-specific construction information pertinent to the project. The industry mentors were asked to advise students' work on a basis of 30 minutes to an hour each week during the PBL process. Training on the use of the sub-site and the learning technologies was provided to the students in the form of an intensive computer lab-based tutorial, and briefings during the project advisory workshops.

Discussion and Conclusions

The developed sub-site and its incorporated learning technologies (i.e. folders, discussion board, and wiki; made possible by the use of the university's intranet) reflect a practical approach to their use. Such use does not attempt to refute the usefulness and importance of other, possibly more complicated learning technologies, but is supported by the literature of learning technology, which generally promotes simplicity but effectiveness in relation to the use of learning technology. Traxler (2010, p.150) contended that *"Manifestly it is better to use simple tools expertly than to possess a bewildering assortment of complicated gadgets and either neglect or use them incompetently."*

Despite the relative simplicity of the learning technologies used for the PBL project (compared to the other learning technologies examined), they were still perceived complex and difficult to use by some lecturers as well as by some of the students. Face-to-face training was offered to the students, and for lecturers and industry mentors a step-by-step user guide (with screenshot illustrations of the project sub-site) was provided. Such support was considered as important to the effective use of the sub-site and subsequently to the communications within student groups and between students and their lecturers and mentors. However, a steep learning curve of using the sub-site was observed for all the stakeholders. These results support the claims made in previous research. For example, Laurillard (2010, p.425) reported that *"Designing their teaching with digital tools and resources requires either technical support of the kind that takes away their [the teaching staffs'] control, or a steep learning curve."* Cahill and Turner (2010, p.291) commented that it was recognised that staff need time to develop their skills particularly relating to learning technologies (e.g. Tablet PCs, podcasting). Nevertheless, the researchers acknowledged that the users of the sub-site would not become proficient after just one course of training. Therefore, keeping the use of learning technology as simple but effective as possible was deemed crucial to achieving the research objectives. The use of the sub-site should aid the communications between the users (i.e. the students and their lecturers and industry mentors), rather than becoming an IT barrier to learning. Also, the users should be able to get familiar with the use of the learning technologies and gain confidence and benefit from their use. For all these reasons, a small number of simple learning technologies should be more appropriate than an extensive and complicated array of learning technologies. However, such argument in the context of the developed sub-site could be substantiated from further evaluation of its use.

The results also suggest that the incorporation of the use of learning technology into PBL was useful for the students to enhance communication. However, such benefit mainly existed in communication within student groups, primarily in relation to document sharing and storage. Such sharing of documents via the sub-site was however exposed to copyright risks, which required a significant amount of moderation by the researchers.

The discussion boards and wikis were used to some extent but were perceived not as convenient as conventional ways of communication such as by email, telephone calls or text messaging. The communication between students and their lecturers and mentors was found not to have dramatically benefited from the use of the sub-site, mainly due to slow responses to questions and messages posted on the discussion boards, and perceived difficulty with its use. In this sense, the use of learning technologies should not replace, but complement, the use of existing methods of communication, e.g. by lectures, face-to-face meetings, email, text messaging, and telephone calls. The use of the sub-site demanded a steep learning curve; training is important to ensure effectiveness of the use of learning technology. Further evaluation of the use of the sub-site however will substantiate the argument about the effectiveness of using learning technology to enhancing student PBL, and will be reported in the future. Such evaluation could also expand to cover student PBL in consecutive years, so that longitudinal learning could be enabled.

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