ASSESSING THE USE OF ADVANCED DAYLIGHT SIMULATION MODELLING TOOLS IN ENHANCING THE STUDENT LEARNING EXPERIENCE

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Abstract. In architecture schools, where the 'studio culture' lies at the heart of students' learning, taught courses, particularly technology ones, are often seen as secondary or supplementary units. Successful delivery of such courses, where students can act effectively, be motivated and engaged, is a rather demanding task requiring careful planning and the use of various teaching styles. A recent challenge that faces architecture education today, and subsequently influences the way technology courses are being designed, is the growing trend in practice towards environmentally responsive design and the need for graduates with new skills in sustainable construction and urban ecology (HEFCE's consultation document, 2005). This article presents the role of innovative simulation modelling tools in the enhancement of the student learning experience and professional development. Reference is made to a teaching practice that has recently been applied at Portsmouth School of Architecture in the United Kingdom and piloted at Deakin University in Australia. The work focuses on the structure and delivery of one of the two main technology units in the second year architecture programme that underwent two main phases of revision during the academic years 2009/10 and 2010/11. The article examines the inclusion of advanced daylight simulation modelling tools in the unit programme, and measures the effectiveness of enhancing its delivery as a key component of the curriculum on the student learning experience. A main objective of the work was to explain whether or not the introduction of a simulation modelling component, and the later improvement of its integration with the course programme and assessment, has contributed to a better learning experience and level of engagement. Student feedback and the grade distribution pattern over the last three academic years were collected and analyzed. The analysis of student feedback on the revised modelling component showed a positive influence on the learning experience and level of satisfaction and engagement. An improvement in student performance was also recorded over the last two academic years and following the implementation of new assessment design.

1. Sustainability and Architecture Education: a glimpse at a recent teaching practice at Portsmouth School of Architecture

The subject of environmental sustainability, which has recently become a key theme in architecture education, has influenced the way we teach and design technology courses. The 2005 HEFCE's consultation document presents a vision that highlights one of the key challenges facing architecture education today and the main influences on the design and delivery of technology courses: "within the next ten years, the higher education sector in this country will be recognised as a major contributor to society's efforts to achieve sustainability-through the skills and knowledge that its graduates learn and put into practice, through its own strategies and operations" (HEFCE, 2005, p.4). Technology in architecture education therefore, should be designed not only to help students meet the immediate learning outcomes of their courses, but also to provide students with the skills and knowledge needed for their future professional development.

Over the past few years there has been a growing interest in the subject of environmental sustainability in Portsmouth School of Architecture. This has encouraged several staff members to explore new ways to deliver technology courses. The case reported in this article is one of these emerging practices that are developed in response to the HEFCE's vision. The article focuses on the structure and delivery of 'architectural technology environmental', one of the two main technology units in the second year's unit. A main objective of the work reported in this article was to examine whether or not the introduction of a simulation modelling component and the later improvement of its integration with the course programme and assessment has contributed to a better learning experience and level of engagement.

Unit 211 is structured with the aim of introducing students to the principles of low carbon passive design solutions and encouraging them to assess the influence of some of these principles on the environmental performance of buildings through developing the necessary modelling skills. As illustrated in the unit structure (Figure 1), on successful completion of the programme, students should be able to 1 demonstrate an understanding of some of the key low energy design solutions, 2 understand and integrate low energy environmental design solutions in an architecture project and 3 develop basic environmental modelling skills to assess the effectiveness of proposals. The delivery of the unit, which was previously comprised of a series of lectures, and its associated assessment methods went through two main phases of piloting and revising in the academic years 2009/10 and 2010/11. The first phase of the enhancement implemented in 2009/10 was the introduction of environmental simulation modelling to the curriculum; in which a number of IT sessions were delivered teaching BA2 students basic daylighting and shading modelling techniques. The second main change was made to the assessment strategy where students were asked to submit three assignments in response to the learning outcomes. The first assignment (an essay) focused on understanding the principles (theory), while the other two pieces assessments (environmental site analysis and response and daylight modelling) focus on an application of knowledge.

Student's responses to the first delivery of the redesigned learning programme in 2009/2010 were not particularly positive (Figure 5). While over 74% of the students found the unit interesting and the content appropriate to its aims, only 44.6% of them expressed high level of satisfaction with the overall quality of the unit. The introduction of new modes of assessment also received a mixed reaction, with 63.9% of the students considering the type and load of assessment appropriate but less than half of them satisfied with the information provided on the assessment requirements. In a study of students' perception of the learning environment, Nijhuis et al (2005) found that "those students who showed a higher level of surface learning perceived the redesigned learning environment as less positive in terms of clarity of goals, the usefulness of the literature resources and the work load" (cited in Dochy et al, 2007, p. 94). Similar findings are also reported in a study by Struyven et al (2006). In marking the course assessment, it was noticed that the majority of students submitted and successfully completed the first assignment (the essay) but around one in ten students did not submit one of the two other assignments where a higher level of thinking is required to complete the given tasks.

Given the student feedback, and in a discussion with the external examiner and some colleagues from the second year team, it was felt that the unit would benefit from a review of its assessment strategy. Therefore, a further phase of enhancement was applied in the following academic year (2010/11) in which the unit assessment was revised to one comprehensive assignment of four sub components. This includes re-designing two of the previous year's assessment components: the modelling and written components. While the written assignment is replaced by a case study analysis, the (IES Virtual Environment) modelling task is changed to an assignment completed by a team of four. Many educators believe that using different modes of assessment can be an opportunity to support the individuality of students and their diverse learning styles. For example, Nicholls argues (2002, p. 109) that "no one type of assessment can assess all course aims and learning outcomes effectively, and accepting this is key to successful assessment of any given programme". Similarly, the HEFCE document "Successful Student Diversity" states that as students learn in different ways "adjusting teaching methods and assessment to meet the needs of a very wide range of students, in practice, benefits all students" (2002, p.5).

In this article, the effectiveness of the enhancement phase, in general, and the improvement of the modelling component in particular is later examined in reference to the student learning experience. Specifically assessing the influence of using a role play theme in the modelling exercise, introducing a teamwork scenario and discussion element on student learning and level of engagement.

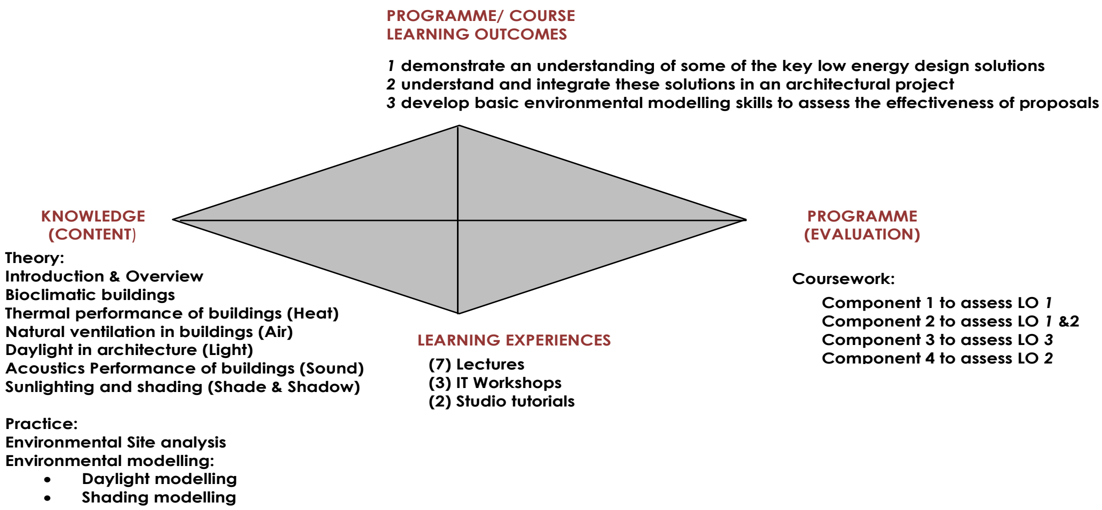

Figure 1.Unit Structure – the diagram is developed based on a model suggested by Nichole (2002)

2. Role playing in simulation modelling

One teaching method appearing in the literature (e.g. Jaques, 2000) that can be useful in designing a curriculum which supports the integration of environmental modelling, such as daylight modelling, is role play. As a teaching method, it can be implemented in a number of ways depending on the nature and aims of the activity. It can involve face –to - face instructions as well as online elements, creating the capacity for online discussion and e-learning interaction. It also offers opportunities for experiential learning and a base for pedagogic exploration which can play a vital role in the learning process. Kolb (quoted in Manorom and Pollock, 2006, p. 1) defined learning as “the process whereby knowledge is created through the transformation of experience”. As students are directly active during a role play activity, Manoron and Pollock (2006) believe that this learning approach is more effective than some other forms of learning, such as essay writing, in transferring concepts into their long term memory. Although environmental modelling skills can be learned by following a set of general instructions, students need to explore the characteristics and limitations of the package themselves and develop their own practical skills for their professional practice.

Another important aspect in considering this teaching method is the opportunity for teamwork scenarios. In today’s multi-disciplinary architectural practice, learning to participate and to be a team player is an important skill for architecture students to acquire. According to Manoron and Pollock (2006,p.1) “the role play technique develops a greater understanding of the complexity of professional practice and enables students to develop skills to engage in multi-stakeholder negotiations within the controlled environment of the classroom”. In line with this and at the time of revising the use of the modelling component, it was decided that any role play scenario should be designed not only to create a healthy learning environment where students can act effectively, but also to facilitate experimental learning and self-assessments skills.

In the modelling exercise, the students were asked to assess daylight performance of a notional teaching space, similar in size to the one they were required to design for their design studio project and complete what was termed a “daylight matrix template”. As shown in Figure 2 the given template or exercise, is presented as a sort of colourful game board. The board is divided into a series of rows and columns and a palette of vibrant colours is used in presenting the matrix in a way that captures the students’ attention and encourages them to engage with the given activity. The students were arranged in teams of four and each student or team player was asked to complete one row on the matrix (the board), replacing the question mark symbol shown on the row they were given with an illustration (daylight contour map) generated by the IES Radiance simulation package. They were given four teaching spaces with different geometries and fenestration systems and each student was given a specific location to finish his row/model. Four cities were chosen for the daylight simulation including London, Portsmouth, Edinburgh and Belfast covering a wide range of climatic zones within the UK. Students were also provided with a relevant set of step-by-step written instructions depending on the geometry of the scheme and were advised to work closely with their teammates in collectively building one digital model to complete the task within the structured workshops hours. Furthermore, students were confronted with the challenge of assessing their simulation work against their tutor’s results by ticking the proper box (√) (Green for the right answer and Red for the wrong results). This additional assessment element was introduced with the aim of enhancing the students’ participation, observation, self-assessment skills, and hence their overall leaning experience, which is perceived as helping them to engage well with the given task. Race (2001, p.6) argues that one of the main reasons for involving students in their own assessment is to “deepen their learning experience”. He explained that “students can learn a great deal about their own attempt at a task by assessing two or three other students’ attempts at the same task. Students can learn a lot about a task by applying assessment criteria themselves on their own evidence. Students can learn even more about a task by comparing their own judgments about it with those of fellow-students”. In planning this exercise, it was envisaged that students could learn a lot about their modelling skills and judge the precision of their models simply by comparing their results with their tutor’s, and thus this self-assessment element was introduced. The other element of improvement was the introduction of a discussion element or a concluding statement to prompt thinking and a deeper learning. As clearly stated in the briefing document, students were also asked to write as a team one concluding statement based on their analysis of the daylight levels in the four examined locations and in relation to the national visual comfort criteria for teaching spaces. Since valuable learning outcomes can be achieved through peer interaction and discussion (Biggs, 1999) this additional concluding statement was introduced with the aim of encouraging students to communicate with each other by explaining their ideas and trying to understand the thinking of others (Nicholls, 2002). As explained by Exley and Dennick (2004, p. 99-100) through discussion “students may clarify their thinking because they have to organise their thoughts to put them into words. This clearly has the potential to increase the quality of learning experience”.

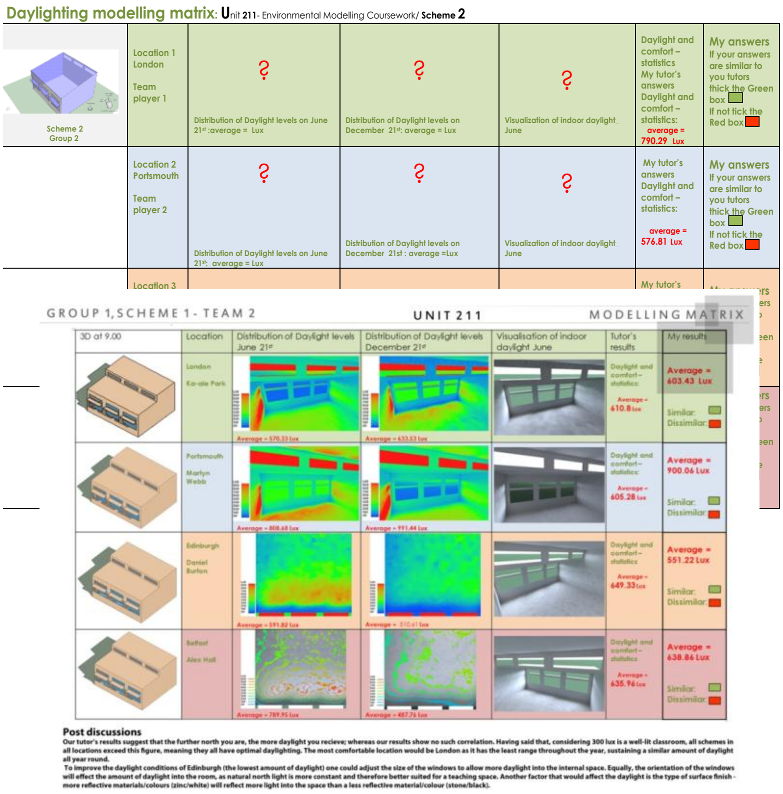

Figure 2. The Daylight matrix template, (bottom) an example of the matrix completed by a team of four players

2.1. A REVIEW OF THE NEW MODELLING SCENARIO

In “Rethinking Assessment in Higher Education” (2007, p. 87-89), Dochy et al identified six characteristics of the assessment practice, or what they called the “assessment culture”, that are likely to enhance the role of assessment as a “stimulus and as a tool for learning”. Their aim was to remind educators of the effects of assessment on students’ learning, the benefits associated with appropriately used educational assessments and the need for strategic thinking if assessment is to 'act as a true tool for learning'. Dochy et al.'s characteristics are illustrated in Figure 3, and although it is not always feasible to include all these measurements in one type of assessment, their model seems to offer an interesting framework to evaluate and critique the new modelling approach. This section uses Dochy et al.'s model as a vehicle for evaluating the new modelling practice and some of the intellectual opportunities given to students through the completion of this component.

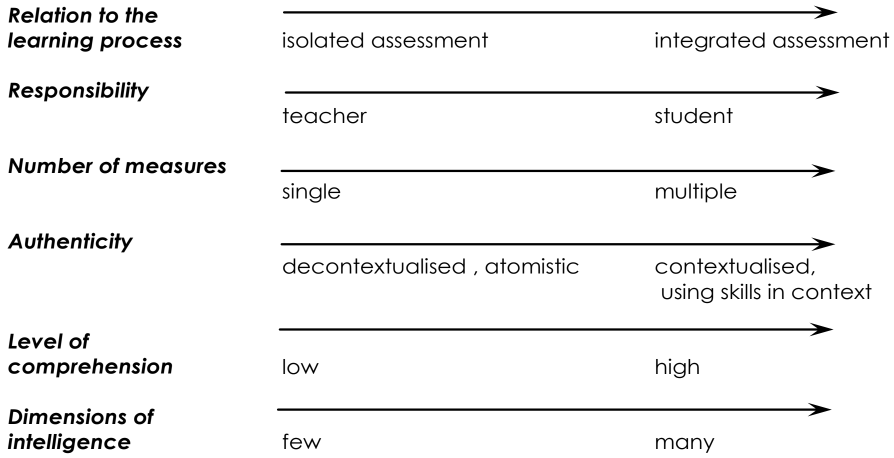

Figure 3. Dochy et al.'s model of the assessment culture (after, Boud and Falchikov, 2007)

First: *Relationship to the learning process*
'There is a strong emphasis on the integration of learning, instruction and assessment. [Also], there is a strong support for representing assessment as a tool for learning, instead of a tool of learning'.

In the new mode of assessment, although the environmental modelling component is mainly used as a 'tool of learning', applying these modelling skills to the design units should help the students to improve some of the environmental characteristics of their architectural schemes. Consequently, completing the modelling exercise cannot be seen anymore as an 'isolated assessment' but an 'integrated assessment' that could contribute to the students' overall learning experience in the course. Indeed, some students have attempted to use this highly specialised package as an experimental tool to explore various design options and improve the environmental performance of their own schemes (see Figure 4).

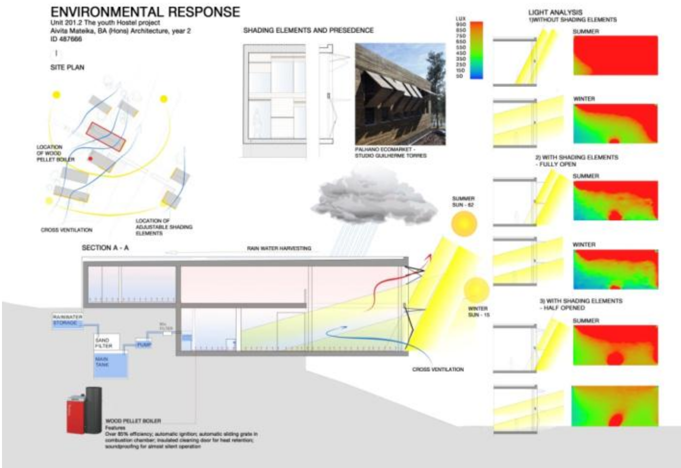

Figure 4. An example of students' work using Radiance Simulation Package as experimental tool (Aivita Mateika, BA2 Architecture)

Second: *Responsibility*

'The position of the student in the learning process is that of an active participant who shares responsibility in the process, practises self-evaluation, reflection, and collaboration, and conducts a continuous dialogue with his or her tutor'

One of the potential issues/benefits with implementing this second phase of enhancement was to encourage students to develop a deep approach to learning through practical application and active engagement. Kember and McNaught (2007, p.45) stated that "learning occurs more through what the students do than through what the teacher says". Similarly Morgan wrote (cited in Kember and McNaught, 2007, p.44) "students only learn by doing-they must be intellectually engaged in the learning process". By introducing practical modelling techniques into the curriculum, students are given the opportunity to put into practice what was covered in the unit's lectures. Also as the students are usually active in practical sessions, one can argue that these IT sessions and relevant modelling exercises are efficient in embedding new vocabulary or concepts into their long term memory.

Third: *Numbers of measures*

'Various [types] and [quantities] of measurements are included in the assessment…this implies that reporting practices shift from a single score to a profile, that is from quantification to a portrayal'.

As explained previously, in the recent mode of assessment students were asked to complete one compressive piece of coursework that is comprised of four different sub-components in response to the Unit learning outcomes. In our view, these 'various types and quantities of measurements' included in the assessment have provided an opportunity to support the individuality of students and their diverse learning needs and preferences. In regards to the modelling component specifically, the brief is carefully designed not only to measure the students modelling skills, their knowledge base and understanding of the examined phenomenon, but also to measure their ability to communicate their thinking in a particular way.

Fourth: *Authenticity*
'With some modes of assessment there is no time pressure and a variety of tools that are used in real life for performing similar tasks are permitted'.
As stated earlier, with the ongoing concern about the impact of buildings on the environment and the global shift towards an environmentally-friendly design, today's architecture practice expects graduates not only to have a specific knowledge base but to be able to apply this knowledge to improve building performance in an efficient way. A key objective of the modelling component is to provide students with one of the necessary skills in today's profession.

Fifth: *Level of comprehension*
'Instead of focusing on tests measuring mainly low level of comprehension (reproduction), with new learning environments, higher-order thinking skills are assessed'
Unlike the first version of the modelling exercise, when the brief was merely designed to develop the students' environmental modelling skills, the recent modelling task includes a conclusion element. In reality, asking the students to contribute to the concluding statement, by summarising the key points resulting from the modelling exercise, means that they have to think carefully about these points, refer to their lecture notes and to the list of further readings. As such, the students have benefited greatly from introducing this discussion element or concluding statement, as it motived them to adapt a deeper approach to learning. This additional activity, as explained earlier, was mainly introduced to encourage them to listen and try to understand the thinking of their peers and thus develop a more active approach to learning.

Sixth: *Dimensions of intelligence*
'Assessment does not intend solely to reflect student's cognitive performance but also metacognitive, social and active learning outcome'.

An important aspect of implementing this second phase of enhancement is to encourage students to be an active team player. Learning to participate and be a team player, as stated above, is an import skill for architecture students to learn in today's multidisciplinary practice. However, achieving such an essential outcome requires an understanding of group dynamics.

2.2. STUDENT FEEDBACK AND STUDENT PERFORMANCE

Whereas in the previous section a personal evaluation is used to critique the new mode of assessment, a more objective approach based on empirical data is used in this section to measure the effectiveness of this second phase of enhancement on the student learning experience.

At the end of each academic semester and in line with the University learning, teaching and assessment strategy, all of the students in the School are given the opportunity to provide feedback and express their views on the standard and operation of the courses by completing a course unit questionnaire. Student responses to the Unit questionnaire received over the last three years (2009/10 to 2011/12) are used to assess the impact of the latest changes of the programme on the learning experience. In total the questionnaire was given to 395 students, 227 responses were received, giving a response rate of 57.5%. The number of students enrolled in the Unit and the absolute number of responses gathered over the last three years are presented in Table 1. However, due to the anonymous nature of the questionnaire it was difficult to show variations in student responses based on some demographic variables such as gender and age.

TABLE 1. Number of students and their responses to the Unit questionnaire

Academic year	Number of students enrolled in the Unit			Number of responses
	Female	Male	Total	
2009/2010	48	93	141	83 (58.9%)
2010/2011	56	79	135	61 (45.2%)
2011/2012	40	79	119	83 (69.8%)

The cumulative responses over the last two academic years and following the introduction of the second phase of the programme enhancement were very positive and suggested that the students were 'satisfied' and 'very satisfied' with the structure and delivery of the new programme and the assessment mechanism (see Figure 6). On average, positive results from the questionnaire include:

Over 84% of students agreed on the clarity of the aims of the unit. 86% expressed positive views about the appropriateness of content in relation to the unit aims. Over 83% found the topics covered interesting and over 76% enjoyed the curriculum. High levels of satisfaction were also recorded for the appropriateness of the unit assessment (78%), the information provided on the assessment (78%) and the type and load of assessment (80%). Interestingly, the improvement of the assessment approach and the modelling component seems to have contributed positively to the overall satisfaction rate on almost all aspects of the learning experience. The comparison of these results with the questionnaire from 2009/10 (see Figure 5) shows that the overall learning satisfaction rate has risen to 78% as opposed to 44.5% in 2009/10. Student satisfaction with the assessment mechanism and type and load of assessment has also risen to 78% and 80% respectively as compared to 57.8% and 63.8% in 2009/10.

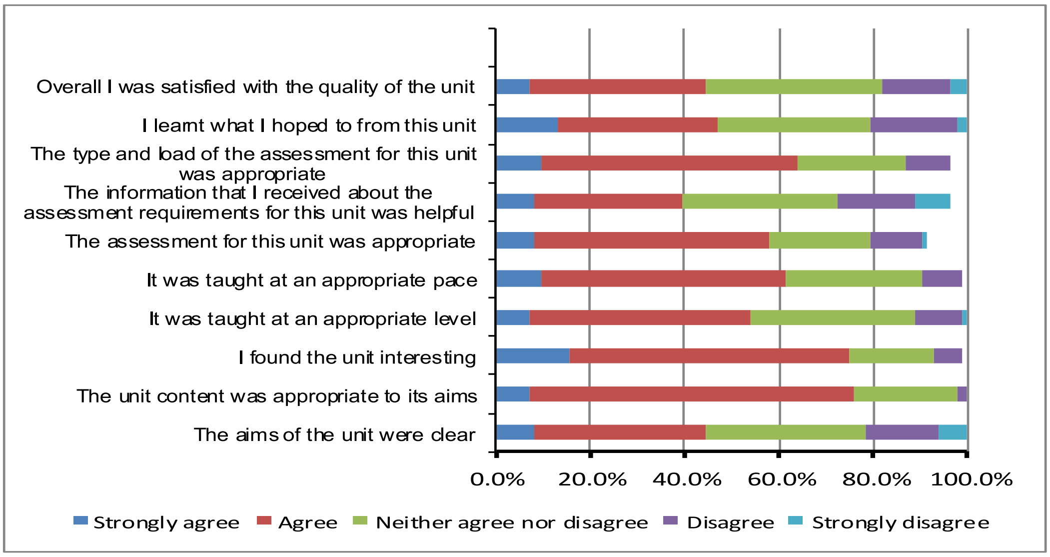

Figure 5. Summary of unit questionnaire responses collected in 2009/10 (before the second phase of the programme enhancement)

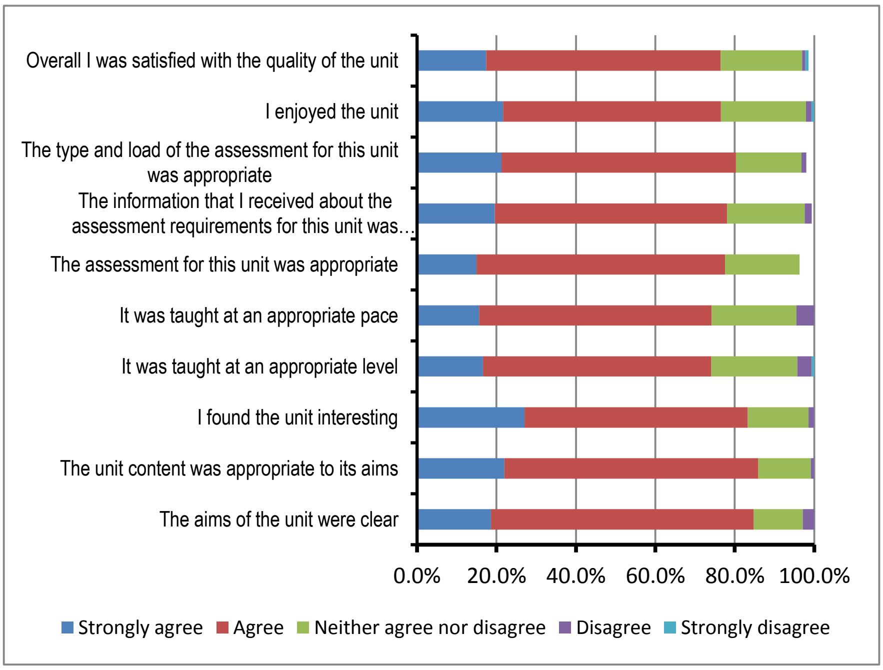

Figure 6. Summary of unit questionnaire responses collected over the last two years (2010/11 and 2011/12)

Whereas the analysis of student feedback, presented above, suggests that the improvement of the modelling component and the overall assessment practice has a positive influence on the learning experience and student satisfaction, measuring whether it has a similar impact on student performance and level of achievement requires a different type of evaluation. Another phase of analysis was then introduced to assess this relationship between satisfaction and performance using students' grades, and the frequency and pattern of their distribution over the last three academic years (Table 2). The review of the grades over the two years showed that there has been an increase in the percentage of students receiving high pass or high achievement. The figure has risen from 9.9% in 2009 /10 to 22.8% in the last two years. The findings also indicate a steady increase in the number of students in the low pass rate. The figure has risen to 40.9% over the last two years as opposed to 29.7% in 2009/10. More importantly, the results also revealed that 88.9% of the students passed the assessment at the first attempt in the last two years as compared to 78.0% in 2009/10. These figures, although limited to students' performance over a two year period, indicate that the amendment of the assessment component of the curriculum has been a success.

TABLE 2. Unit 211–Course assessment results broken down by grades

	High Pass	Pass	Low Pass	Fail	NS	Total number
Distribution of students marks in 2009/10	14 (9. 9%)	54 (38.3%)	42 (29.7%)	29 (20.6%)	2 (1.4%)	141 (100%)
Distribution of students marks in the last two years 2010/11 and 2011/12	58 (22.8%)	64 (25.2%)	104 (40.9%)	22 (8.7%)	6 (2.3%)	254 (100%)

3. Conclusion

Students' expectation has dramatically changed in the last few years. Cloud and located learning are increasingly asked for not only by students but also by learning and teaching institutes in HE institutions. This shift can positively influence the teaching of technical subjects in architecture curriculum. The case reported in this work illustrated some of the difficulties associated with changing the learning environment in technology units in architecture education and the critical role of educator in facilitating the new learning process. The work also highlighted some of the intellectual opportunities associated with making assessment more manageable, providing clear instructions and the possibility of team working, which can be critical, influencing not only student performance but also student's perception of the new learning environment. However, teaching with technology is not cheap. With the current economic situation and the financing constraints facing many educational institutions, establishing, upgrading and maintaining IT facilities including education licenses might be a challenge. Integrating team learning activities into the curriculum as reported in this article, can offer a sensible approach to sustain the delivery of such modelling activities without compromising on the quality of teaching.

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