

Effective Teaching and Learning: Integrating Problem-based Learning in the Teaching of Sustainable Design

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Abstract

The need for integration of the sustainability agenda in education has led to the development of several new courses and revision of existing curriculum. Research has also been initiated in an attempt to provide answers to the question of what constitutes a sustainable design education. Most academics will agree that education is not just about acquisition of knowledge, but the ability to apply that knowledge in the work place and ideally throughout all aspects of life. The teaching of sustainability involves discussing the serious environmental issues facing the world today, but also the practical solutions that we could apply by integrating real-world situations into our teaching and learning (e.g. through problem-solving exercises).

This small-scale research investigates the effectiveness of integrating problem-based learning as a teaching tool for a string of units focusing on design for the BSc (Hons) course of “Sustainable Design and Environmental Management” in the Department of Environmental Design and Management in the University of Portsmouth and it draws some valuable conclusions based on students’ unit evaluation and peer observation.

Keywords: Sustainable Design, Problem-based Learning, Collaborative Learning

Good Practice Points

- Integrating problem-based learning is a new approach that has enriched the teaching curriculum and contributes to best practice exchange from two different disciplines.
- Problem-based learning has proven to enhance students' critical thinking and independent learning. This points to a need for students to learn by working on cases in multidisciplinary teams. Such multidisciplinary groups provide opportunities for collaboration and reflection that have the potential to greatly enhance student learning. Learning in such an environment can provide students with cases that they can recall and adapt later in their careers.
- The teaching of sustainability involves discussing the serious environmental issues facing the world today, but also the practical solutions that we could apply by integrating real-world situations into our teaching and learning. The presence of the real client contributes to a case study and a problem scenario close to the students' future professional reality.
- The presence of the client provides a source of continuous feedback as well as assessment, and gave motivation to the students to reach a satisfactory target with their work. Combined with the contribution from the experts, students accumulate knowledge from practical work (learning-by-doing).
- Working in groups enhances team collaboration, increases the sense of individual responsibility and although not always successful, contributes significantly to knowledge exchange and skills to cover all aspects of the project.
- The assessment methods (oral presentations) enhance students' presentation and communication skills.
- Students feel motivated and enthusiastic to be able to express their ideas. This contributed to greater participation by the students in order to achieve better results in their assessment.
- Students participate in peer assessment and in the future can even contribute to the formulation of their own assessment criteria.
- Knowledge and experiences from the current projects could be shared and applied to other disciplines, such as architecture and engineering and even form the basis for a multi-disciplinary collaboration in future projects.

Introduction

Sustainability and the environmental debate are at the heart of contemporary culture. A new course was designed and launched at the University of Portsmouth for a degree in “Sustainable Design and Environmental Management” looking at how we can develop a strategic approach to design which is both environmentally responsible and independent of traditional professional boundaries. Such an approach points to a need for students to learn by working on cases in multidisciplinary teams which provide opportunities for collaboration and reflection that have the potential to greatly enhance student learning. Learning in such an environment can provide students with cases that they can recall and adapt later in their careers.

There was an identified need for the development of design-focused units, which the course lacked. It was decided to develop two new core units for the 2nd and 3rd Level respectively, with focus on design elements in the area of sustainability. “Materials and Resources” and “Design for Sustainable Cities and Urban Regeneration” were designed as a string of two units, which address the issues of sustainability and design, related to a single building and the urban context respectively. It was decided to apply my knowledge and experience as an architecture studio tutor in the development of the two new units, and design the units partly to assimilate the format of the architecture studio. Architectural projects are often thought to epitomise Problem-Based Learning (PBL) techniques, which are widely promoted as a method of achieving deep learning and simultaneous mature participation within the educational process (Roberts, 2004).

It was a challenge to discover that the implementation of such teaching was not an easy task, particularly as the students had no design experience and a priority was to explore how successful it had been as a student learning experience.

This small-scale research provides a description of the development of the two units, together with the challenge of integrating and teaching design by problem-based learning, traditionally implemented in the architecture studio, but a novelty in the discipline of Environmental Design and Management. This is prefaced by a short overview of problem-based learning.

Problem-Based Learning in Higher Education

Problem-based learning (PBL) is a style of learning in which the problems act as the context and driving force for learning in a student-centered, contextualized approach to teaching and learning (Barrows, 1985). PBL was originally developed to help medical students learn the basic biomedical sciences. Since its origin in medical education, PBL has been used in other settings such as engineering and architecture (Boud and Feletti, 1991). PBL includes among its goals:

- developing scientific understanding through real-world cases,

- developing reasoning strategies, and
- developing self-directed learning strategies.

Problem-based learning is perceived as an instructional method that challenges students to "learn to learn". Maggie Savin-Baden in her book "Facilitating Problem-Based Learning: Illuminating Perspectives" (2003), argues that in problem-based learning the teacher facilitates the project (rather than supervising it) and although the teacher may set the problem scenario, how and what students learn is defined by them.

In PBL, students work in small groups with a facilitator. The students receive an initial scenario /problem and then must question the facilitator to obtain additional case information. At several points in the case, the students pause to reflect on the data they have collected so far, to generate questions about the data, and to hypothesize about possible solutions for the problems. It is also important for the students to be able to identify those issues that they need to learn more about, or do not fully comprehend. The students then independently research the learning issues they have identified and share what they learned. Reflection on the knowledge acquired upon completion of the case study is an integral part of PBL, whereas assessment takes place on both individual and group members' contribution to the group's learning and collaboration.

The review of a problem-based approach to teaching and learning suggests that it is a valuable method, which promotes independent learning via contextualized problem sets and situations and via group work. Because of this, students achieve higher levels of comprehension; develop more learning and knowledge-forming skills and more social skills as well. The current project will reflect upon students' feedback and draw upon best practice examples of the implementation of problem-based learning, in order to achieve effective teaching and improve students' learning outcomes.

The Case Studies

"Materials and Resources"

(http://www.tech.port.ac.uk/tud/db/UnivPort/level_2/MAT&RES.htm) and "Design for Sustainable Cities and Urban Regeneration"

(http://www.tech.port.ac.uk/tud/db/UnivPort/level_3/DESCITIES.htm) were designed as a string of two units, taught in the 2nd and 3rd Level respectively, in the BSc (Hons) course of Sustainable Design and Environmental Management.

The units' aims and learning objectives are introduced to the students during the first week. According to Savin-Baden (2003), there is little evidence on how students' familiarization with PBL affects their ability to adapt to this new learning style. Common practices on preparing students for PBL range from a one-hour introductory lecture to the two-week induction programme which was considered appropriate for the teaching of the current units. Lectures were carried out for the first two weeks of the semester

introducing students to the concepts of sustainable design, eco-friendly materials, renewable and alternative energy sources, urban design, sustainable cities, and regeneration. Students were then asked to form working groups.

The case study for the unit of Materials and Resources was based on a brief produced by a real client who owned a house in a conservation area in Portsmouth. The client was keen to convert the five-storey house into individual flats, using materials with low environmental impact and implement technologies that would contribute to low energy consumption. The students discussed the brief with the client and following a tour of the house they worked in groups in order to prioritise their areas of focus. Each group made an oral presentation with their initial ideas and strategic approaches. Progress with their work was aided by the presence of experts in the field. Representatives from the City Council Planning Office were “interviewed” in order to obtain a better understanding of the limitations imposed by the location of the building in a conservation area.

The final presentation was made by each group in front of the panel of experts and the client, who gave feedback to each team and selected the one team that had achieved most of the client’s wish list within the suggested budget.

The case study for the unit of Design for Sustainable Cities and Urban Regeneration focused on the regeneration of three areas in the city of Portsmouth where the local City Council acts as the client and aims for a sustainable design that implements social, economic and environmental factors.

In order to help students relate their case study with a best practice example, a one-week fieldtrip was taken in the city of Barcelona, where each group collected information on how certain areas of the city have been successfully regenerated during the last decade. After the fieldtrip, students were required to make a group oral presentation of their findings and set a list of objectives as a strategic approach to solving the problem. These were as follows:

- Create a checklist of sustainable indicators.
- Measure the need for urban regeneration in three areas of Portsmouth by applying the scale developed from the fieldwork in Barcelona.
- Measure the presence or absence of these indicators within the designated areas.
- Use these results to ascertain the current environmental, social and economic quality of each area.
- Formulate regeneration proposals for environmental, social and economic enhancement in accordance to the score accredited to each area.

Figure 1 shows the sustainability indicators and regeneration scale development.

Table of Sustainable Indicators (SI)

Environment	Social	Economic
Aesthetics e.g. clean streets	Basic Amenities e.g. general store	Job Prospects e.g. local opportunities
Traffic Volume e.g. pedestrianisation	Safety e.g. street lighting	Income Generation e.g. events
Green Space e.g. public parks	Public Facilities e.g. town hall	Service Exchange e.g. local business
Buildings/Waste e.g. recycling points	Access e.g. public transport	Property Demand e.g. land values
Noise Pollution e.g. main roads	Cultural Heritage e.g. museums	Micro-economy e.g. sustainability?

Regeneration scale

Regeneration measured through three integrated dimensions: environment, social, economic.

Five core attributes are used to calculate the current sustainability of each dimension, maximum of one point awarded for each attribute:

- 1 = Adequate conditions
- 0.5 = Conflicting conditions
- 0 = Inadequate conditions

Scores awarded for presence/absence of sustainable indicators.

Sources of information used to establish SI levels: personal observation, interviews, tourist information brochures, property values, internet referencing.

Figure 1: Sustainability Indicators and Regeneration Scale

Image 2 shows the map of the three areas of case study with a focus on the Portsea area.

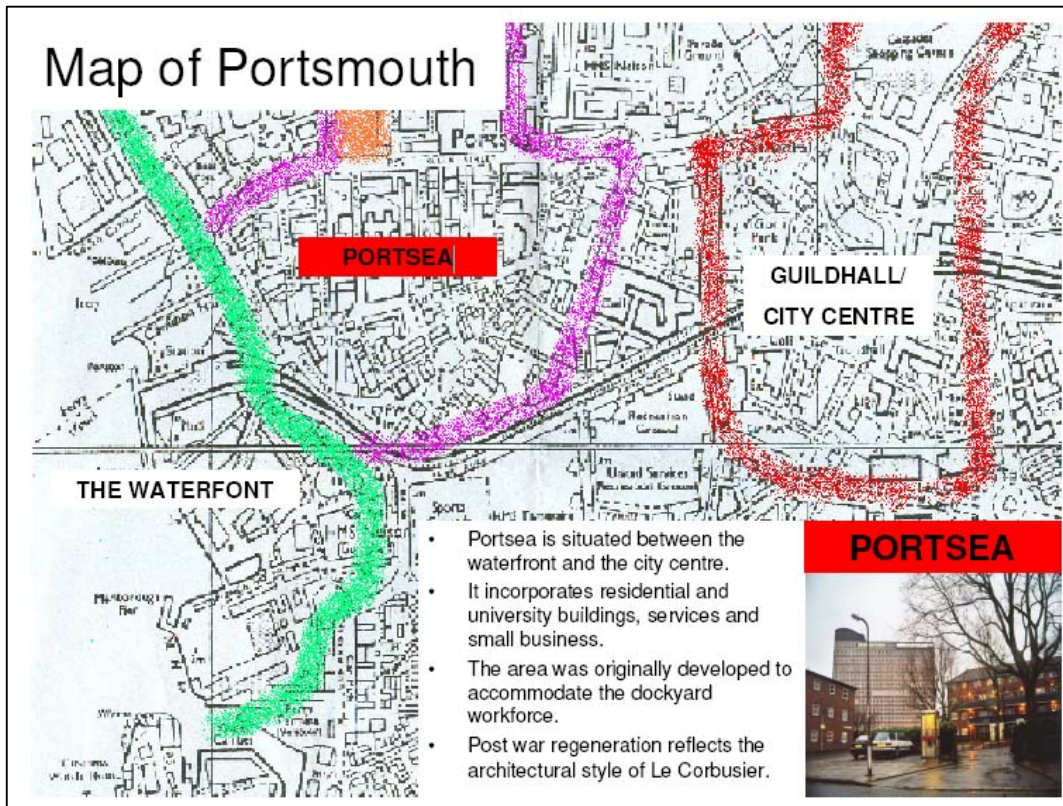


Figure 2: Map of Portsmouth and the three areas of case study

Figures 3 and 4 show the application of sustainability indicators in the Portsea area, the results and the regeneration proposals for the area.

Portsea: Environment 2

Indicator	Comments	Score
Aesthetics	Mix of deteriorating residential/industrial and newer university buildings.	0
Traffic volume	High, Queens street a major transport route through the city. Parking permits.	0
Green space	Communal greens, scale disproportionate to population. Lack of maintenance.	0.5
Buildings/waste	Many original building still used. Portland 'sustainably' designed.	1
Noise pollution	Enclosed residential pockets, noise from traffic and university on busier roads.	0.5

Portsea: Social 1.5

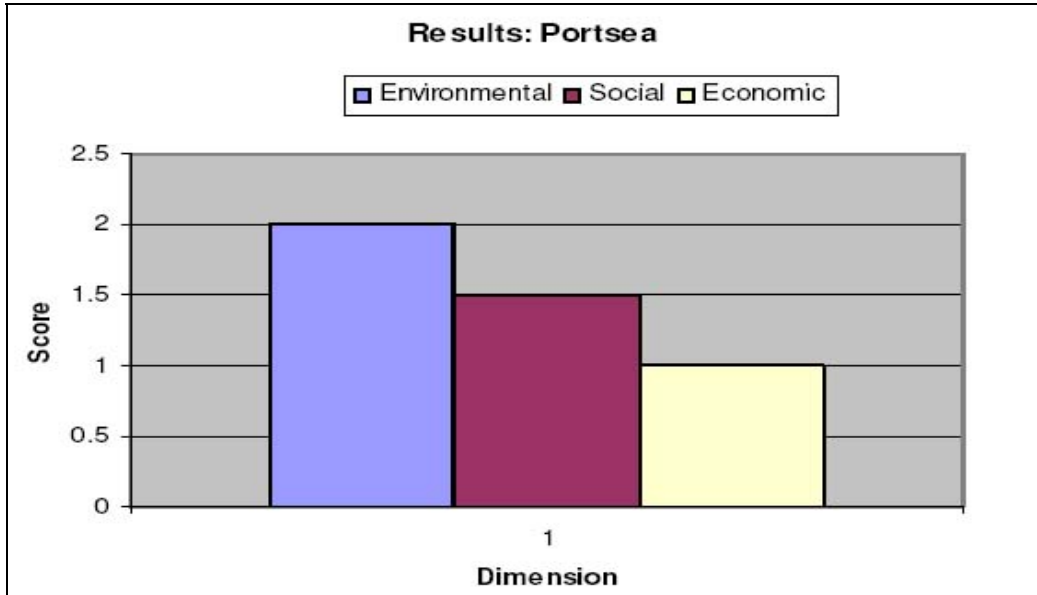
Indicator	Comments	Score
Basic amenities	Adequate facilities for local population, e.g. chemist, hairdressers, supermarket.	1
Safety	Residential streets narrow, unlit alleyways and car parks.	0
Social facilities	John Pounds community centre, but building use mainly residential.	0
Access	Near public transport links but often congested. Cul-De-Sacs, narrow streets.	0
Cultural heritage	Historically important reflected in some monuments but poorly maintained.	0.5

Portsea: Economic 1

Indicator	Comments	Score
Job Prospects	Many disused offices – Brunel House. Navy in decline. University expanding.	0.5
Income generation	Area largely working class, non-professionals. Income low.	0
Service exchange	Residential community use local services, but apparent absence of bakers etc.	0.5
Property demand	High density -flats and terraces, mostly council or ex-council.	0
Micro-economy	Little industry so little prospect of community self-investment.	0

Figure 3: Sustainability Indicators

Problem Identification: Portsea



Environment – Traffic problems inherent due to original narrow streets and location. Poor maintenance of public areas.

Social – Basic amenities only, aging infrastructure presents safety issues.

Economic –

- Diminishing naval presence in area is loss of the core employment base.
- Reduced property demand has decreased land values.
- Subsequent decline in business interests – closure of Brunel House.
- 1960/70s high rise flats built to accommodate low-income occupants.
- High residential: job availability ratio.

Regeneration Proposals: Portsea

- Redevelop Brunel House to capitalise on proximity to Gunwharf Quays – small business and mixed income housing.
- Establish local business co-operative to fund the maintenance of public spaces and building facades.
- Introduce park and ride schemes from outside of the city to ferry terminals and major attractions to reduce congestion along Queens Street and The Hard.
- Improve Pedestrian access and street lighting to increase safety and accessibility within residential areas.
- Provide a social facility to promote community integration.

Figure 4: Results and Regeneration Proposals

Teaching and Assessment Issues

The conflict for many staff is in allowing students to manage knowledge for themselves, when in previous roles and relationships with students they have invariably been the controllers and patrollers of knowledge (Savin-Baden, 2003). I believe that this “fear” is also shared amongst the students and therefore the transition of the role of the teacher from a lecturer, to that of the facilitator, becomes the key issue in the successful implementation of problem-based learning.

One of the main concerns raised by students' experience of facilitation was the difficulty to prioritise their learning needs and generally the nature of self-direction and the role of the facilitator (Savin-Baden, 2003). Other common concerns amongst students, were time and role management and the relationship between teaching and tutoring. The above highlight that the shift for students in understanding the role of the facilitator is not only complex, but often made more difficult by the fact that tutors are themselves in a state of transition.

It was considered important to assess the students' understanding of the nature of the issues in sustainable design by having them develop and present cases that can be used for future reference. The cases were examined for evidence that the students collected information regarding the pervasive themes of the course: design, social, economic, and environmental factors. Assessment of the students' learning is both formative and summative. Group assessment examines collaboration and consideration of sustainability issues. This is accomplished by analysis of the groups' activities, student logs, and case reports. Summative assessment of the individuals' learning of the course content and transfer of their knowledge on sustainable design issues, was by written and oral presentations by the students. The assessment methods employed aim to examine the ability to respond to a given design brief and integrate principles of sustainable design. This forms a combination of interim seminars/workshops, a final written report and a final group presentation to a panel of experts, including the client.

Assessment is an area that is often problematic on courses that adopt self-direction and learner-centred approaches, because of issues of power and control between tutors and students (Savin-Baden, 2004). When assessment is formally planned, it often does not align well with the objectives of the problem-based learning that preceded it. Therefore students were enabled to assess how they learn, to be equipped so that they know how to provide evidence of this learning, i.e. by developing their own marking criteria.

Teaching effectiveness and students' learning experience were assessed via questionnaires, the results of which are analysed in the following paragraph.

Students' questionnaires results on teaching effectiveness and learning experience

The questionnaires were administered to the students during week 12 of the semester, allowing them 11 weeks to become familiar with the method of teaching and the group work. There were 12 questionnaires received from the unit of Materials and Resources (100%) and 15 from the unit of Design for Sustainable Cities and Urban Regeneration (75%), 27 in total. The questionnaire implemented a set of questions related to the teaching methods experienced by the students in all units so far. Students were asked to indicate those teaching methods they considered more useful or appropriate for their subject and those they would like to form a greater part of their teaching.

From an analysis of the questionnaires, it was evident that students had been exposed to a variety of teaching methods, from traditional lectures to more practical methods such as workshops, tutorials and site-visits. Although most students believe that lectures and site-visits/fieldtrips are most appropriate for their subject area, they show a clear preference for more practical sessions such as tutorials and workshops. Some of the students' comments from the questionnaires are included below:

"In my opinion every teaching method has its advantages and disadvantages. If possible our teaching should start with lectures and seminars, followed by practical fieldtrips and tutorials."

"It is good to have set targets at certain points throughout the semester to work towards, i.e. preliminary presentations."

"...a mid project i.e. seminars/group presentation, is good, in order to give the tutor an idea of where the students are in terms of their progress, presentations in particular were great, the feedback was useful, discussions are good also."

From the above it is apparent that students perceive that a sort of assessment, even formative in type, can provide motivation to complete certain tasks and therefore engage them in the subject. It is also apparent that the majority expressed preference for a continuous type of assessment that will provide them with constant feedback on their progress.

The questionnaire then went on to explore students' attitudes towards the implementation of a problem-based type method, combined with the provision of a certain theoretical background in the form of lectures. On the whole, feedback provided was positive towards this new method of teaching, and students were content in being able to *"express their opinions and thoughts, experiment with ideas and explore things for themselves"*. They also felt that the sessions facilitated student participation and contributed to active learning. However, one student also mentioned *"although seeing and performing examples is interesting and helps inject enthusiasm, exams are also useful"*. It is interesting to note the fact that in my question I have mentioned the term "teaching method" whereas the comment of the particular student was for the method of assessment. I could interpret that as an apprehension for the end result as many

students, at this point, may not have a clear idea of how, or the criteria by which they will be assessed.

Having asked the students to give an overall evaluation of the teaching method implemented, I then invited them to give me specific opinions on what they considered to be the advantages and disadvantages of problem-based learning. Below is a table listing the collated answers:

Advantages of problem-based learning	Disadvantages of problem-based learning
Increase motivation	Time-consuming
Learn through "trial and error"	Working within a group
Investigate further issues of particular interest	Unguided
Develop own ideas	"None"
Practical work	
Helps form your own opinion not just by reading	
Increase interaction between students-tutor	
Information collected-explored is absorbed better	
Simulates real-life experiences	

The answers above match the feedback received from the students during the tutorial sessions. They illustrate that students welcome the opportunity to be able to express more of their opinions, develop ideas, interact more with the tutor and their peers and learn for themselves. I was quite happy to see that most of them considered this learning experience a valuable one. However, as discussed earlier, there are certain issues that arise when students feel unguided or unclear about their learning objectives and how they will be assessed. I feel that the points raised and listed in the disadvantages column are related to a certain extent, to the way I have navigated the group and the way I have assisted them towards the completion of the learning objectives. Perhaps it is because I am also in a state of learning, and new experiences have not been yet formulated into a solid teaching philosophy. I was nevertheless keen to explore how and why students can become more independent learners, driven from their own enthusiasm on the subject. This is perhaps one of the reasons that I have opted for the introduction of certain topics through lectures and seminars, so that some of the knowledge and enthusiasm I have acquired on the subject can be transmitted to the students. The second reason was my fear that the transition from a more traditional teaching method model (lectures), to more practical work acquiring critical thinking and self-directed learning, had to be progressive.

The latter part of the questionnaire relates to the oral presentation by the students in the presence of the tutor and the client, the benefits in terms of skills acquired and their opinion of an appropriate method of assessment. Overall, students seemed content with their work and therefore with the opportunity of presenting their work to their client for assessment and feedback. They also stressed that preparing an oral presentation allowed them to develop much needed communication skills in the professional field and build up their confidence. One student stated, "*The oral presentation does not really show what I know on the subject*". Again I believe that this relates to the perception of some students that they learn so that they can "demonstrate" and consequently be awarded for that, rather than develop learning for themselves.

Reflection on the results and thoughts for future changes

The results of the questionnaires advocate that there are clear benefits from implementing a problem-based learning method combined and associated with relevant theory on the subject area of sustainable design. Students relate the theory in an immediate way to the problem they need to solve for the case study; therefore they need to understand it. This was explored and facilitated during the tutorial sessions. It was therefore possible for myself as a tutor to help guide the students towards self-directed learning.

The "client" facilitated an important role for the success of the teaching method as it provided the design brief as well as immediate feedback on how satisfactory or successful the outcome of the student work has been. In other words, the results of the work are clearly evident. The case study with an existing client gave motivation to the students to reach a satisfactory target with their work.

The main barrier has been the introduction to a combination of teaching and assessment methods that could confuse the students, as they are predominantly used to more traditional methods of teaching that is, the delivery of the theory in the forms of lectures. However, the results from the analysis of the questionnaires demonstrated that students appreciate this new learning experience in more than one way. It is evident that students benefit from this new type of increased interaction within the class and with the tutor and are keen to exchange ideas and develop new skills.

Certain concerns were expressed relating to the role of the tutor and the guidance provided towards the completion of the project outcomes. It is also apparent that group work, though with acknowledged benefits, can create misunderstandings, arguments and frustration towards members of the team that do not "pull their weight".

One of the thoughts for the future is for the main "themes" of the syllabus of the units to be introduced by the students, encouraging them to create their own "portfolio" of data on the subject. Then my role as the tutor would be to answer any queries, interrogate the source of their data and the degree of their knowledge on the subject and, provide an overall conclusion stating the important outcomes of each session.

Working towards setting more specific targets for students to achieve through group tutorials apart from the interim and final review, is also considered amongst the future changes. Practical work combined with self-directed learning can be time-consuming if the student is not used to a continuous working and assessment routine.

As with any design project review, the opinions expressed can be considered somewhat subjective; I believe that the feedback and indicative marks from tutors and client should also be integrated with a mark provided to each team by each of the other groups. I am confident that the combination of such assessment will contribute to the production of reliable individual marks rather than group marks.

Conclusions

The current project was based on the evaluation of the effectiveness of teaching and learning methods for two new units in the course of Sustainable Design and Environmental Management. The units were designed to implement a problem-based learning approach in order to assist students to develop critical thinking on issues of sustainable design by applying knowledge into a given scenario (brief) by a real client.

Student feedback from the questionnaires correlated well with that from tutorials; problem-based learning provides an exciting new learning environment, where the tutor becomes the facilitator and the student the independent learner. Concerns related to group work, the role of the tutor and the guidance provided, as well as the assessment of group work, were expressed. These will be explored further and certain alterations will be formulated and implemented in the teaching and assessment of the units from the following academic year.

The project has provided a great understanding on pending issues on students' evaluation of the units and its adopted methods. It has also allowed me to explore the theoretical framework of problem-based learning and relative current research and development in the subject. With continuous review and evaluation of current practices, the teaching within the units will hopefully improve to accommodate contemporary trends and facilitate effective student learning in the area of sustainability.

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