CHAPTER FOUR

USING MOODLE TO SUPPORT A CONSTRUCTIVIST, PROBLEM-BASED APPROACH TO TEACHING AND ASSESSMENT

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Introduction

Professional Issues in Software Engineering (PISE) is a final year computer science module taught as part of the computer science degree at the University of Limerick. PISE focuses on the ethical, legal and social consequences of the design, implementation and use of computer and information systems. The pedagogy used in the module has traditionally been the group-based approach to teaching and assessment. However, the growth in the cohort from around 30 to 180 in the 1990s led to a need to consider using ICT to support this pedagogy as the volume of students and their interactions with the learning process produced unsustainable demands on the lecturer. There were a number of related drivers that also gave impetus to this study. These included:

- Benefits of using collaborative learning pedagogy
- Requirements for authentic learning experience
- Need for virtual team skill development
- Assessing individual contributions to group-based assignments
- Countering plagiarism
- Making learning interesting and enjoyable
- Applying a constructivist pedagogy

These are discussed in the following sections.
Collaborative learning

There are many benefits to using collaborative learning in discursive subject domains such as PISE. The use of a problem-based collaborative teaching/learning strategy has been shown to help develop a deeper understanding of subject domains (Duckerich et al 1990). Research also shows that teamwork encourages social facilitation, better learning and higher cognitive skills (Hiltz 1994). As part of this module students have to work in groups to produce assessed solutions to a legal/moral case study. One reason for assessing this part of the learning experience was to provide motivation to students to work collaboratively. As Faahraeus et al (1999) state, teachers can encourage learners to contribute by giving them credit for their contribution. Thus, students in this study were given 45% of the total marks for individual contribution and 55% for the group work element. Research has also shown that deeper understanding of moral dilemmas can often occur by working collaboratively (Peek et al 1994) and that the collaborative approach to learning, supported by instructional technology, can lead to deeper understanding and new knowledge creation (Harasim et al 1995; Cravener 1999; Mäkitalo et al 2001). There are also practical advantages to using computer mediated communication (CMC), as it is easier to measure individual contributions than in face-to-face situations because an audit trail is created. This in turn makes it easier to deal with situations where some individuals gain more from the process than they input, a term that has been called “free-riding” (Shepperd 1993), as individual contributions can be identified.

Authentic learning

Following early use of a virtual learning management system, feedback indicated that some students expressed a preference for face-to-face communication (Griffin and Grodzinsky 2002). They did not see the point of using a VLE when they often met with their colleagues in face-to-face situations. However face-to-face communication can be unfocused compared to the use of written communication, which is asynchronous by its very nature. Research (Bentley et al 1997) has also indicated the usefulness of asynchronous collaborative communication, because of its reflective nature. It was therefore necessary to find a way to make this an authentic learning situation. I was aware of the increase in the use of geographically distributed groups in multi-national organisations. Some colleagues at UL were involved in research in the area of computer supported collaborative work (CSCW) in geographically distributed
groups. I therefore decided to investigate if this could also work in teaching and learning in PISE.

**Virtual team working skills**

Students in a university learn subject-specific knowledge but also learn a range of secondary skills. These skills include the ability to write reports and essays, presentations, develop logical arguments and debate issues. Working in geographically distributed teams is of increasing importance with the globalisation of software development, and studies have highlighted the importance of being aware of the cultural and ethical norms of remote locations (Prikladnicki et al 2003). Furthermore, contact with employers where students were on Co-Op work-placement (students at UL spend one semester on work-placement) also indicated that there was a need to teach such skills to our students at UL. I therefore decided to explore the possibility of setting up a multi-institutional collaboration to deal with the need for authentic learning situations and to also enable learners to develop these new skills.

**Countering plagiarism**

The increase of internet access and the availability of information there present many benefits to our students. At the same time there are potential problems associated with plagiarism. Some students may submit work that is not entirely their own. With continuous assessment it can be the case that the final product, the report or essay, may contain plagiarised content. One way to counter this is by assessing the process as well as the product. In this study a method was developed which, coincidently it must be noted, countered this problem. Students used the VLE for online discussion and then produced a final report. Marks were awarded for the discussion as well as for the final report. A comparison between the online discussion process, using the audit trail of the discussion created in the VLE, and the final report would alert the lecturer to any significant differences, which might be as a result of a plagiarised section in the report. Further investigation (for example a viva voce) could then take place to ascertain if the work submitted was entirely that of the learner’s.

**Making learning enjoyable**

The feedback collected from students over the eight years in this study has shown that the approach used is generally one that makes the learning
process enjoyable and there is evidence to support the contention that an enjoyable learning environment produces more higher-order critical thinking. A further measure of student enjoyment was that the size of the finished report submitted was often much more that the assessment requirements, i.e. students did more than what was required for an assignment.

**Constructivist learning**

Constructivism is one of many learning philosophies. Constructivism as a theory is credited originally to Jean Piaget (1932) and is summarised as the active construction of knowledge by the learner which is not received passively from the specific environment. Constructivists argue that learners should be active rather than passive. Knowledge is not just absorbed from external sources and artefacts or from someone else. Instead it is the individual learner’s interpretation and processing of what is received through interactions with sources that creates knowledge. The learner is the centre of the learning. The teacher assumes an advising or facilitating role. One particular strand of this learning philosophy is social-constructivism. Social constructivism takes account of all of those people who affect the social world of the learner. This includes teachers, friends, other students, administrators, technicians etc. It takes into account the social nature of learning processes both to the learner in his/her immediate environment and the larger social grouping in any academic discipline. Wood et al (1995) assert that social constructivism includes teaching strategies that are personally meaningful to students. For example, class discussion, small group collaboration and valuing meaningful activities over the production of “correct” answers. Social-constructivist theory, therefore, supports learning through authentic, challenging and collaborative projects. It was the basis for the teaching and learning approach used in this study.

**Using ICT to support constructivist learning**

The increase in cohort size in the PISE module has raised significant management and pedagogical issues. These included:

- How does one lecturer manage such a large cohort?
- How can a meaningful learning experience be had by the students in such large cohorts?
• How can “burn out” be avoided while at the same time considering the needs of such a large body of students?

Being a computer scientist with an interest in the use of computer systems in many areas made it an obvious next step to consider how ICT might support the constructivist pedagogy being used in PISE. Laurillard (1993) in her work on critical dialogue between students identified the potential for two-way communication technologies: computer mediated communications (CMC). She suggested that these technologies can provide opportunities for interaction that can lead to reflection and deeper understanding, in other words, tools that can aid group-based collaboration. Bullen (1998) further identified the type of tools that might be appropriate to this study when he concluded that major consideration should be given to computer conferencing as a means to facilitate interaction and critical thinking. Jonassen and Kwon (2001) compared how groups solve ill-structured problems in face-to-face and in computer-mediated asynchronous groups. In the study, they examined patterns of communication and satisfaction ratings for members of face-to-face and CMC groups. The CMC group conducted their group work using computer-mediated discussion forums and did not meet face-to-face. For the CMC group the primary advantage identified was the flexibility of this approach in terms of time and location on interactivity. A second advantage was the increased time to think and reflect resulting in greater participation of group members in the problem-solving activity when compared to face-to-face groups. Members of CMC groups perceived higher quality and more satisfying experiences than in face-to-face groups. Members who worked collaboratively in CMC groups felt that there was a higher quality problem-solving process and were happier in their group activities than their face-to-face counterparts. The reason given for this was that the flexibility afforded by the CMC approach was conducive to reflective thinking. Finally, there are also practical advantages to using CMC:

• it is easier to measure individual contributions than in face-to-face situations because an audit trail is created
• it is easier to deal with situations where some individuals gain more from the process as individual contributions can be identified.

Educational research has also shown that there is a potential major problem with the use of group-based approaches when it comes to assessment. This is primarily due to the possibility of some individuals
gaining more than they have inputted to the process, a term that has been called "free-riding" (Shepperd 1993). Although research also suggests that groups need to be large to increase the advantages to members, this often increases the occurrence of free-riding due to the difficulty of monitoring large numbers of students (Veerman and Veldhuis-Diermanse 2001).

**Selecting ICT**

As a result of research into CSCW a number of web-based collaborative systems have become available in the education field. Bentley et al (1997) identified a number of advantages of these tools:

- they are platform independent
- access is geographically independent
- web browsers are now commonly available on most computers
- there are generally high levels of literacy when it comes to using this type of tool
- many of these tools allow both synchronous and asynchronous collaboration

There are two broad approaches to computer conferencing, as identified by Bentley et al (1997) in the final point above, the synchronous and asynchronous approaches. Synchronous tools were based on immediate responses, whereas asynchronous tools incorporated a delay between the initial posting and the response. There is also a growing body of research that indicates that asynchronous discussion reflects high level cognitive processing (Järvelä and Häkkinen 2002; Meyer 2003). Veerman and Veldhuis-Diermanse (2001) showed that asynchronous tools compared to synchronous tools can provide learners in online group discussions with more options to think and reflect on information and to organise and keep track of discussions. Learners can also use the time delay to research and find information to support their discussions and then use this information to respond to earlier arguments. This is less likely to happen in synchronous discussions. In one study (Meyer 2003), it was reported that students mentioned specifically how they would take time to read other posts, think about a response, prepare a response and then check later to see other contributions to ongoing discussions.
Moodle and social constructivism

During the initial phases of this research the VLE used was Blackboard (Bb) (www.blackboard.com). This was used with some success for three years but there were a number of disadvantages, not least being the increased cost of licenses and the difficulty in updating and introducing new functionality. The second VLE used was Moodle (moodle.org) and it was with this VLE that the following work discussed was conducted. Moodle had been initially developed by Martin Dougiamas (1998) as part of his own PhD but has now grown far beyond this. The underlying educational philosophy of Moodle was based on social-constructivism so there was an immediate coincidence with the pedagogy used in PISE and this VLE. Dougiamas (1998) had decided that for the learner the three main features of Moodle should be:

- easy navigation facilitated through the use of placement cues, semantic nets and hierarchies, and indices
- clear, simple page design thus improving download speed
- interactivity through a discussion board, journal and quizzes with the possibility of adding further functionality as required

These three features would ensure that students could learn in a socially-constructive manner. From a teacher's point of view the three desirable features of Moodle were:

- the ability for students to learn more about the course content through: course response design; easy modification through a page content editor; the automatic structuring of the content by the system
- student usage patterns and activities would be recorded in logs to help the teacher learn more about student learning behaviour
- the ability to monitor and engage in discussions by using the forums to help the teacher learn more about the class

These features were designed to free up time for teachers for reflection on their teaching. Moodle offered some further positives:

- it was very widely used (over 15,000 sites at the time of investigation)
- it had a large community of developers and users
- it was based on a constructivist teaching philosophy
- it was Open Source (OS)
Using Moodle to Support Teaching and Assessment

The wide use of Moodle indicated that it was a well-tested and stable system. In fact, Moodle came third after Bb and WebCT in terms of number of installations. The wide community of developers and users meant that there was a lot of expertise and support for new users. The philosophy underpinning Moodle, constructivism, was the same as what I was using in my teaching. This meant that a range of tools and functionality had been built in to facilitate this pedagogy. The Open Source nature of Moodle meant that the code was available to anybody who was interested in developing their own amendments and updates. A number of these already existed and were also available to the broader community of users for downloading and integrating into Moodle servers. In other words, if there was any functionality lacking or needing change this could be easily developed and incorporated into the core system, something that was to be of immense benefit later in the research.

Moodle promotes the idea that learners will reach higher levels of critical thinking by not only constructing knowledge but by creating artefacts. These artefacts can be created collaboratively using many of the tools (called activities) in Moodle. At the heart of Moodle is the activity known as the Forum. This is where online threaded discussions can take place. Moodle also provided a facility to create scales that allow each post to the threaded discussion to be graded according to previously determined criteria. This data is collected and stored by the Moodle system and can be accessed by different users depending on the system permissions. The criteria used to assess posts is discussed in the following section.

Assessing online discussions

Garrison et al (2001) have proposed a model, the Community of Inquiry, as a framework for the analysis of critical thinking in computer conferences. Using this model, deep learning occurs in a community of inquiry comprising learners and instructors who are engaged in the educational process. It is proposed that through the interaction of three specific elements that this learning takes place. These elements are: social presence, teaching presence, and cognitive presence. Teaching presence focuses on the design and management of learning sequences, the provision of subject matter expertise, and the facilitation of active learning. Social presence is defined as the ability of learners to project themselves socially and emotionally in a community of inquiry. Cognitive presence (CP) is defined as the extent to which individuals in a community of inquiry construct meaning through sustained communication. Archer et al (2001) argued that CP provides a framework that can be used to analyse
the effectiveness of online discussion in supporting critical thinking in higher education. There are four categories in the CP element within the model of critical thinking and these are:

- triggering
- exploration
- integration
- resolution

Each category is defined using a set of descriptors (see Appendix A for these). The CP framework was the basis for assessing online communication and providing formative feedback to learners.

**Formative feedback to enhance learning**

Using the CP framework enabled criterion-based feedback to be used for formative assessment. The number and size of posts, and the rate at which students posted to the discussion thread, had been established in earlier research (Griffin 2006). This meant that broadly similar amounts of student work were available for the assessment of each learner. At the conclusion of each week all posts were read and categorised by the lecturer. This information was then available to users and allowed the use of norm-referencing to determine how students were performing in relation to each other. Figure 4-1 below shows a typical output. The following screenshot provides standard Moodle output using the Gradebook function. All activities are shown in the columns following the "Student" column. However, in this study only one activity was being graded, the "Case Study forum - assessed", which can be seen in the fourth column below. The total marks for all assessments are then shown in the next column, but as only one activity was graded these two columns contain the same information. Each student has a separate entry.

The first student data in the following output is now discussed. Because of the way the Gradebook is set up in Moodle an average grade is always shown, with the first entry it is termed "Integration". This was not used in the study and can be ignored. Then the total number of posts for the student are shown in brackets, in this case there were three. The following line of data shows that there were no Triggering posts, one Exploration post, two Integration posts, and no Resolution posts. The entire data from the cohort was visible to the tutor or to anybody with the necessary permissions in Moodle.
Learners were also able to see how they were performing. In this case only the data pertaining to the individual learner was visible to that learner but it did allow the learner to see how they were performing in a single screenshot. The alternative would have been to examine all the posts from the group discussion, and find those posts which a learner had produced and then see the rating that had been applied to the post. A process that was long-winded to say the least. A particular problem with this display was that it only showed criterion-based feedback. However, some students also indicated that reference-based would be helpful (those students who liked to compare their progress with others in their class). It was therefore decided that it would be useful to make this additional data available. This was achieved by the development of a system whereby students could see their reference-based performance by displaying data showing the class average, the highest and the lowest class grade. This is discussed in the following section.

Using data visualisation for formative feedback

Nulden and Hardless (1999) point out that online learning courses are more effective when the learner is provided with formative, effective feedback. Crook (2001) also argues that the purpose of formative feedback
is to enhance learning, because this type of feedback gives the learner the opportunity to see if they are underachieving and to alter their learning behaviour if they wish. It also enables the teacher to detect learning problems. However, providing regular feedback to a large cohort of students can result in overload for the teacher (Otsuka and da Rocha 2002). Bull and Nghiem (2002) also recommend showing the student a model of other student work, including good examples that could be used as an objective, weaker examples to comfort them on their own performance and finally the class average. This is important because often the level of knowledge a student has may make sense only in terms of what their fellow students know. Therefore providing them with a “benchmark” on what their classmates know is necessary to make sense of their own model (Kay 1997). Moodle provided a number of different methods to extract data using the Moodle Gradebook and report functions. However the sheer volume of data that a large cohort creates made it difficult to spot trends or learners who might require assistance.

Data visualisation (DV) is a technique that uses graphical representation to display complex data sets and abstract important information (Tufte 2001). DV is important because graphical representations of data are easier to understand than text or tables of raw data, since it enables the user to take in the data all at once rather than by chunks. This is because image processing and pattern recognition are two strengths of the human mind, whereas processing large tables of data takes more time and increases the likelihood of misinterpretation or missed information (Wright 1999). Graphics should show facts about data, so as to reveal their meaning and offer new insights. Their goal is to help reasoning about the data, by freeing mental resources (such as memory) and bringing out patterns (Mazza 2004). A tool, DVReport, that used DV to display norm- and criterion-based data was developed and incorporated into the Moodle VLE. Students used DVReport for formative feedback. Lecturers used the tool to view up-to-date qualitative and quantitative data on student online behaviour in Moodle. The requirements specification for DVReport had two foci, one for lecturers and one for students. For the lecturers the focus was to evaluate student progress by providing easy access to data on student interaction with Moodle. This was to be achieved by providing visualisation to:

- display all student interactions with the forums on Moodle showing the number of posts, views and discussions started (the quantitative data)
• display the formative assessment for each student gathered from the CP categorisation of posts (the qualitative data)
• show the lecturer how the progress of a student compared with that of other average, worst and best students in the class (both quantitative and qualitative data)

The focus for the student was to improve achievement by providing formative feedback as a means to evaluate their progress. There were two specific aims in achieving this:

• provide students with a visualisation enabling them to compare their own progress with that of other students in the class (average, worst, best) on the number of posts, views and discussions started (the quantitative data)
• provide qualitative feedback by displaying for students their progress compared with that of other students in the class (average, worst, best) gathered from the CP categorisation of posts (the qualitative data)
• offer different types of visualisations so that the student can choose the one that helps them most because people understand graphical data differently

In the early stages of the module students used Moodle for a number of reasons:

• Social stage - where students familiarise themselves with the system and get to know each other online
• Group Formation stage - where students formed groups and managed different organisational issues such as selecting a case study for the assessment

Neither of these were assessable activities but lecturers needed to know that all students were contributing. As was discussed above, Moodle records a large amount of data on user interactions with the system including how often resources are accessed, and whether the user views the resource or adds material. The system also records the time and date of each interaction. All of this is displayed in table form such as in Figure 4-2 below:
As can be seen, the data is displayed as a table and the different types of information can be difficult to extract especially when there is a large number of interactions. The screenshot above is the first of 463 pages of data to be shown. Individual students, specific activities or certain days could also be selected but each of these produced separate sets of data that were not easy to compare.

DVReport produced the following output of quantitative data for the lecturer view. As with the Moodle Gradebook output, this data set showed the entire cohort and was visible to the lecturer or those with the same level of permissions. Each line shows a graphical representation in the form of a bar graph of a student's interactions with Moodle. In the following figure all interactions with all forums are shown, but this could be changed for more specific analysis. Each bar shows three different types of interaction:

- "Views", where a user has just viewed a post-secondary
- "Posts", where a user has posted a contribution
- "Discussion started", where the user has started a new thread or discussion
In Figure 4-3 above the second student's data would alone have taken many pages of the Moodle log to display, as there were over 2,400 interactions by this student with Moodle forums. However most of these were views and this is much higher than those of others in the cohort. A student would see the view in Figure 4-4 below. The incorporation of norm-referenced data was included in this output. The first line in the output showed the student's own behaviour. The following lines showed the highest, lowest and average in the class levels of online activity, without the identities of those students being revealed.
The second kind of feedback to display was qualitative. This was the aggregation of ratings following the CP categorisation process as described above. This was the Assessment stage where every group member posted their contributions to the case studies. As each post was individually rated on a weekly basis this enabled me to provide formative feedback. Moodle showed this data in a spreadsheet format and as with the quantitative data discussed above it was difficult to decipher with the large data sets. With DVReport this data was displayed graphically and it was easier to abstract meaning. Figure 4-5 below shows the lecturer’s view. In this view all student grades can be seen. For each student there is a separate entry and this shows the number and type of posts using the CP categorisation previously discussed. The first student has two Triggering posts, two Exploration posts, four Integration posts and two Resolution posts. The brackets show the change in relative position to the rest of the cohort since the previous grading. As was mentioned beforehand, grading of posts was carried out at the end of each week of the online discussion period. A plus figure indicates a student had moved up the list relative to others and a negative figure indicates a move down. The numeric indicates the number of positions moved. Thus the lecturer could also see how students were doing relative to others in the class.
The graphs are easily digested and the relative position of each student can also be seen at a glance. With these different outputs it was possible for the lecturer to be fully aware, easily and efficiently, of student interaction with Moodle and their progress at each stage in the ethical dilemma assignment. Intervention could take place if a student was not achieving as much as was expected. Students had a different view to the lecturer of the qualitative data. As with the quantitative data, the student can only identify their own details by name but are also shown the highest, average and lowest score for the entire class. This enabled anonymity to be maintained while at the same time providing students with a reference point to compare their own performance with the others in the class. This is shown in Figure 4-6 below.
Figure 4-6: Student view of qualitative output from DVReport for assessed posts

From the student perspective, with DVReport the learners are able to judge their own performance using both norm- or criterion-referencing.

**Conclusion**

Using ICT to support group-based learning and assessment has provided many tools for lecturers and students. However, there are still potential problems for lecturers in dealing with large cohorts and for students in determining their formative feedback. One method that can provide for a meaningful learning environment is the use of online discussions but these carry their own potential problems. Individual contributions often need to be determined and this can only be achieved using a formal method for assessing individual posts. In this study the method adopted was based on an existing framework but adapted to the specific domain. Because of the size of the cohort and the amount of data generated from the assessment of individual posts, the volume of data produced made the abstraction of meaning difficult. Lecturers were sometimes unable to determine which students were failing and students were often unable to see how they were progressing. A tool, DVReport, was developed to enable data visualisation to be applied to facilitate this. DVReport also incorporated extra data not produced by any of the existing Moodle functions.
With these different outputs it was possible for the lecturer to be fully aware, easily and efficiently, of student interaction with Moodle and their progress at each stage in the ethical dilemma assignment. The lecturer could also intervene if a student was not achieving as much as expected. Student feedback strongly indicated that DVReport was a useful tool and that it contributed to their ability to determine how they were achieving in PISE. It enabled easy abstraction of important data for both norm- and criterion-referenced feedback. DVReport also enabled the lecturer to see more easily how each student was performing and to undertake educational intervention at an early stage. Finally, DVReport, by using data visualisation, enhances formative feedback for students and enables lecturers to see more easily how individual learners are performing. These latter factors further contribute to the enhancement of learning for students working collaboratively in the domain of PISE. The DVReport tool is specific to Moodle but can be adapted to different types of assessment instruments. It shows how DV is a useful method to abstract meaning from large data sets in a learning environment and provides a template for similar tools in other domains and with other VLEs.

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