

Exploring Student Responses to Collaborating and Learning in a Web-Based Environment

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ABSTRACT

This paper describes a study which explored students' responses and reactions to a Web-based environment supporting problem-based learning. The study was undertaken among undergraduate students in an Australian university. The findings revealed that while the majority of the students saw value to be gained from learning in a student-centred and collaborative setting, many expressed a preference for learning in the more conventional teacher-directed forms. The study also sought to explore the potential of the environment to develop problem-solving skills and to determine factors which impeded students' success and achievement. The results did not demonstrate any discernible development of problem-solving skills despite students' extensive experience and participation in problem-solving activities. The findings have suggested a number of important factors missing in the implemented setting including an organising strategy to aid students in the problem-solving process and adequate feedback to ensure reflection among the learners on the quality of the solutions they were developing.

INTRODUCTION

For several years now, many writers have been arguing the need for Web-based learning environments that extend the opportunities they afford the learners (eg. Duschatel, 1997; Collis, 1997). These writers have been guided in their thinking by contemporary learning theories which have demonstrated the need and value of learning environments that provide active and engaging activities for the learners. We now see the literature replete with calls for learning settings that provide a means for learners to construct knowledge rather than being exposed to knowledge presented in transmissive modes.

Many developers of educational Web materials have a tendency to use these powerful new technologies in traditional ways (eg. Dehoney & Reeves, 1999, Kearsley, 1998). The resulting learning environments often appear as electronic forms of traditional courses. There is a growing recognition of the need for teachers to think more laterally and to employ the materials in ways which use their unique opportunities to provide engaging settings for learners, for example, experiential and self-directed tasks involving learner collaboration.

But what of such learning environments? There is always the prospect of a significant gap between what is intended and what is achieved. Are they what learners expect and want from their teachers? How well are they able to provide the levels of motivation and encouragement usually associated with face-to-face teaching? Are they able to provide the feedback teachers need to monitor and support student learning? These are the questions that confronted us when we sought to employ a Web-based learning setting with our students as a means to improve the access and flexibility of a course. This paper describes the study we undertook to gain feedback from our students on their perceptions of the new Web-based environment and our attempts to gauge the level of success we achieved through the various learning strategies to which the learners were exposed.

ADOPTING EDUCATIONAL TECHNOLOGIES

The place and role of new technologies in schools and education after 30 years of development, application and research is often the cause for disappointment among those who have studied education and appreciate the opportunities which technology affords teachers and learners (eg. Kearsley, 1998). Educators have always sought to apply new technologies and have been very creative in their endeavours and activities. From early days, there have been many examples of novel uses for radio, television and video. More recently computer technologies have become popular teaching tools. But many doubt the educational value that much of this use has afforded. Cuban (1986) provides compelling evidence of the continued failure of technology applications to impact on practice and learning in any sustained way and his work continues to hold true as we observe the applications of technologies in the years since he published this landmark viewpoint.

The educational technology literature abounds with arguments supporting and opposing the value afforded by technology. Research into the impact of computers and technology on learning tends to show mixed results. Early meta analyses (eg. Kulik & Kulik, 1986; 1991) reported significant achievement gains among learners using computers compared to others in conventional settings. But more recent writing has questioned the findings of much of this early research in terms of its generalisation to mainstream practice (eg. Stoll, 1996). Research has also demonstrated that the size and nature of the achievement gains derived from technology-supported teaching are no more, and perhaps even less, than those achieved in classrooms where such alternative strategies as teamwork, collaboration, esteem-building and self-directed learning are prominent (eg. Hattie, 1992).

Among all this, people are now beginning to question much of this early research as being inappropriate, inaccurate and misguided in both its aims and method (eg. Reeves, 1993). Emerging from these arguments is the clear indication of the need for research and inquiry to guide the use of new technologies. Too often we see technology being used without the forms of feedback loops needed to inform and guide its success. It is evident that achieving success in the implementation of technologies such as the Web, requires teachers to be sensitive and alert to the various impacts on learners and their learning processes. The research described in this paper was motivated by our desire to observe firsthand the impact of the new environment on learners in order to make the necessary changes to achieve the best possible advantages and learning gains.

A Web-base Solution to A Need for Access and Flexibility in Course Delivery

The motivation for the design and development of our Web-based course was derived from the desire to create a more accessible course of study for off-campus learners and a quest to create an engaging and student-centred learning setting. The context for the study was an introductory unit in the undergraduate multimedia degree in our university in Western Australia. The design was based on strong theoretical grounds and with the benefit of our previous experience and knowledge with Web-based learning. We intended that the learning environment also would foster the development of generic skills to enable the students to continue their learning in this field beyond the life of this course. We wished for the development of such skills as information literacy, metacognition (eg. Blumhof et. al., 1996); problem solving, critical thinking (eg. Ramsden, 1992); personal and interpersonal skills needed for communication, cooperative and collaborative teamwork, and leadership (eg. Ashcroft & Foreman-Peck, 1994)

At all stages in the process it was realised that technology would be a key component of the solution. Our research with technology-supported learning environments had left us fully

convinced that the forms of access and flexibility we sought could be achieved through purposeful design and implementation of an environment in which contemporary multimedia and communications technologies were employed (eg. Herrington & Oliver, 1997). The use of the communications technologies could provide the necessary linking between the teachers and students in the form of distributed environment that we sought to achieve.

Problem-based learning

Our previous research suggested a framework to guide the design of the flexible learning environment (eg. Oliver, Omari & Herrington, 1998a; Oliver, Omari & Herrington, 1998b; Herrington & Oliver, 1999). The design was heavily influenced by the principle of situated learning, a concept that recognises the value to be gained from contextualising learning within settings which reflect the purpose of learning and how learners might ultimately apply this learning beyond the classroom (eg. Brown, Collins & Duguid, 1989). Situated learning is based heavily on constructivist learning principles which encourage learners to construct their own meaning for knowledge and information. Furthermore situated learning recognises the importance of interaction and socialisation among learners as a critical element in the learning process.

We selected problem-based learning as the means to implement the situated learning setting. Problem-based learning is a curriculum approach which helps the learner frame experience through a series of problem solving activities and where the process of learning unfolds through the application of knowledge and skills to the solution of real world problems, often in the contexts of real practice (Bligh, 1995). Problem-based learning uses problems to move students to acquire knowledge rather than through the exposition of discipline knowledge (Boud & Felletti, 1991). It is a form of situated learning, learning through goal-directed activity situated in circumstances that are authentic in terms of the intended application of the learnt knowledge. A common problem with much of the instructional design associated with traditional university teaching has been the decontextualising of knowledge and learning. Jonassen (1991) argues that “the most effective learning contexts are those which are problem- or case-based and activity oriented, that immerse the learner in the situation requiring him or her to acquire skills or knowledge in order to solve the problem or manipulate the solution” (p. 36).

Problem-based learning and the use of authentic tasks have become an alternative to more content-oriented approaches to education. Problem-based learning builds on experiences and empirical findings that have shown that students learn more from a problem-oriented task than from a fact-oriented one. At the same time problem-based learning environments

are frequently reported to increase student motivation, to develop their critical thinking skills and deepen their understanding of significant content (eg. Sage & Torp, 1997).

But research has shown that successful learning is not always guaranteed with problem-based learning nor in fact with any new teaching method. For example, students often experience difficulties and discomfort with collaborative and self-directed learning which are essential elements of problem-based learning (eg. Wilhelm, 1997). Success with problem-based learning often varies depending on how the problems are introduced and the solution processes are structured (eg. Nulden & Scheepers, 1999). Inexperienced learners can experience significant difficulties with self-directed learning activities (eg. Pilling-Cormick, 1997). Assessing of problem-based learning needs to include process as well as product elements (eg. Hmelo, Gotterer & Bransford, 1997). Success in student-centred learning depends on students' abilities for self-monitoring and self-regulation (eg. Biggs, 1987; Lan, 1996). Being aware of these difficulties helped to guide our instructional design and also alerted us to the aspects of students' learning that needed to be reviewed and monitored when we implemented the new learning setting.

THE WEB-BASED ENVIRONMENT

We designed and built a customised set of Web-based tools to support the learning environment. The various tools and their functional elements have been described in several recent papers (Oliver & Omari, 1999; Oliver, Omari & McLoughlin, 1999). In summary, the tools support a learning setting of the following form:

- The course content is broken into weekly topics and for each topic students are provided with access to both print and on-line resources. Student activity each week involves reading in the area to develop a general idea of the scope and extent of the topic and a problem solving activity;
- The problem solving task requires students to work in groups to explore the given problem and to develop a 250 word response. Each weekly problem is ill-defined and open-ended and represents an authentic task representative of the way in which learners will use this material in real life settings;
- Each group posts their solution to a public bulletin board for others to read and students are then required to assess the work of their peers;
- Tutors also assess each problem solution and provide feedback on how they made their judgments;
- Assessment for this component of the course is based on the aggregated scores achieved by each group across the problems completed throughout the course, each member in the group receiving the same mark.

The Web tools provided a means to manage the learning resources, to provide a structured framework for the activity across a large number of students and to provide a sound management and organisational system. The system makes extensive use of the Web and the Internet for information access and the communication and collaboration necessary to complete the various tasks.

To provide some idea of the way in which the new environment differed from the conventional teaching approach we had previously used, it is useful to compare the learning activities within each. The topic for Week 6, for example, Graphics and File Formats, deals with the various formats for storing digital graphics and images for multimedia applications. It covers such areas as representing images and graphics in digital forms, file formats and storage requirements. In our previous implementation of this component of the unit, the lecturer described these various topics using examples and illustrations in a formal presentation and students were assessed on their knowledge acquisition through an examination. In the problem-based learning setting, students were given a problem to explore and provided with only minimal formal exposure to the content and knowledge required. The problem for Week 6 was:

A multimedia student is considering buying a camera to collect images for her multimedia projects and her portfolio. She is not sure whether she should buy a small 35mm camera and scan all her images from photographs or to buy a digital camera instead. Her budget is about \$500. What advice would you give?

The process of solving the problem required students to read the textbook where a large amount of salient information was contained. It then required students to explore the Web for current information on digital cameras and to explore the issues associated with image creation and storage through this means. The expectation was that the learners would attend to the relevant information in thoughtful and meaningful ways in their quest to create a solution. The involvement of other learners was intended to cause them to reflect on the knowledge being acquired and to articulate their understanding. Assessment of students' learning was based on the quality of the response to the problem, reflecting the process of learning as well as the product

But many questions surrounded the implementation of this new learning setting. Together with the known difficulties associated with problem-based learning described earlier we were also concerned with such questions as: How well would the collaborative environment appeal to the students? How much would they learn through the problem solving activities? What strategies would the students employ to manage their learning? Will the collaboration assist students' learning? And many other questions existed concerning the ways in which the students would organise themselves and take responsibility for the

learning tasks. Answers to these questions could really only be gained through an exploration of student activities and behaviours as they participated in the learning process and an action research study was undertaken to achieve this.

THE RESEARCH PROCESS

This Web-based learning environment was implemented with the full cohort of students studying the first year core unit, Introduction to Multimedia. The cohort comprised 240 students with 220 studying the course on-campus and 20 studying in an off-campus mode. The cohort was organised into smaller groups, Workshops, under the guidance of a tutor. The students were given guidance in the problem-solving process in the early lectures in the form of suggested strategies and learning activities. Students were allocated to their various Workshops on the basis of choice. The students in each Workshop were formed into random groups of 4 or 5 by their tutors in the second week of the course and had 2 weeks to plan the problem-solving processes they would use. The students all had some experience in using the Internet and email and used the first few weeks of the course to further their skills in these areas through coursework activities. The problem solving activities commenced in the 4th week of the course. In the 5th and subsequent weeks of the 13 weeks course, the students worked in their groups with little intervention from their tutors. Feedback on the success of their weekly activities was based on the scores achieved and personal communications with tutors. An action research study was implemented to gather data to determine the quality of the learners' experiences and factors which influenced the outcomes. In particular the study sought to explore:

- the various ways in which the learners undertook the group-based problem solving activities;
- learners' responses to this alternative form of learning environment; and
- the extent to which the process developed students' skills and abilities to solve the forms of problems to which they were exposed in the course.

Data was gathered from the learners in several ways. Interviews were conducted with 20 individual learners from various Workshops throughout the course to determine the ways in which they were working within their groups. An on-line questionnaire was given to all students towards the end of the course which asked them to provide feedback on their feelings and impressions. Questionnaire responses were gained from 160 learners. Although there were both on and off-campus learners in the setting, the small number of off-campus students in the cohort did not make it possible to explore differences between these two types of learners in relation to the learning environment.

1. Learning Strategies

The interviews with the individual learners were conducted in an informal manner to gather information from the learners about the processes they employed to solve the weekly problem. From the start, all groups appeared to establish some form of process and system in their problem solving activities. The strategies employed by the various groups ranged from quite unstructured processes with no obvious leadership or coordination through to highly organised processes managed and coordinated by a single student.

The most common method was for all students in a group to commence an initial exploration of the solution and to post emails among themselves describing their understanding of the problem and their initial thoughts for a problem solving process. Most groups agreed to appoint a student each week a student whose job it was to synthesise the various suggestions of the team and to create the summary of 250 words required for the posting. In teams that followed this method, the team members undertook their research individually and posted their information back through email to the coordinating student. Usually the coordinator posted the intended response to the groups for feedback before submitting it to the bulletin board to be marked. In instances where time was short, the coordinating student often posted the response to the bulletin board without any consultation.

Among the groups that employed this method, the students tended to converse a lot through email and to share tasks well. In instances when a student was sick or could not fulfill his/her responsibility, others assumed the role with the student in question taking another turn at a later date. These groups demonstrated high levels of cooperation and the students all tended to express quite positive views about the process. On average, this process usually involved up to 5 or 6 emails within the group in the development of the solution. The solutions that resulted from this process were often mixed. Depending on whose task it was to submit, the response could be quite strong or quite weak.

Among other groups, alternative strategies were evident. In several groups, one student acted as a coordinator for the group and organised the others to complete various tasks, the results of which were submitted back to the coordinator who then compiled the group's response and posted it to the bulletin board. The leaders of these groups assumed these roles and typically the other students were happy to be guided and led in this fashion. These groups tended to post sound responses to the problems because the leaders tended to be highly motivated students who were strongly achievement-oriented. In several instances, some students assumed a leadership role but were discouraged and prevented by their groups from exerting too much dominance. Often in such instances, the process tended to move back to a shared coordinator as described above.

Several groups ended up acting in quite anarchic fashions. It was not clear who the leader or coordinator was and the students found it difficult to work together to create the solutions. In such instances the groups adopted such measures as making it one student's responsibility to do all the inquiry and to create the solution and to post the results. This form of organisation was evident in a very small number of groups and tended to be found only where the students were not particularly achievement oriented. At times these groups developed very good solutions but also experienced the disadvantage of solutions failing to be posted.

One of the aspects we were interested to explore was the level of task sharing that students achieved. In collaborative learning settings, there is always the prospect of students not carrying their weight and this was evident in a number of groups. It tended to be more evident in the groups where there was a single coordinator and appeared to be influenced by the level of responsibility students had to assume. Students who were identified as *not participating* by other group members had the alternative of completing a written examination for their assessment in place of this component of their course. This prospect tended to encourage participation and helped to make contributors of students whose interest had waned.

The feedback showed that students used a variety of methods to coordinate and organise their collaborative activities and the methods resulted in widely differing contributions among the learners. It was evident that the setting would benefit from the Web-environment imposing or encouraging some form of consistent structure within the groups whereby tasks and the responsibilities were more evenly shared.

2. Student Responses

The study sought to explore the response of the learners to this alternative form of learning environment. In particular we were interested in discovering students' responses to 4 particular aspects of the learning environment: the problem-based learning activities, working in groups, the student-centred modes of learning, and use of the technology to support learning. The questionnaire at the end of the course asked students to provide their responses to a series of questions on these topics. The questionnaire used a Likert scale response with 5 categories arranged so that the middle category indicated an expected level of satisfaction with the item while the other responses enabled students to show higher or lower levels of satisfaction. In interpreting the results, we tended to use the middle response (*reasonably*) as what would be expected from satisfied students and the higher scales (*quite a lot* and *lots and lots*) and the lower scales (*not at all* and *not much*) as responses from students who were expressing more positive and negative attitudes.

a. Problem-Based Learning. Students' responses to questions concerning their impressions of the problem-based learning activities were generally quite positive (Table 1). Eighty nine percent of the students appeared satisfied with what they learned from the activities while 11% claimed not to learn very much (Question 1). The other responses showed that the learners were generally encouraged to read and think by the activities (questions 2 & 4) although in both instances a large number of learners (24% and 19%) claimed not to have done this much. In terms of the difficulty experienced in the problem solving activities (question 3) 27% found the tasks to be of a reasonable level of difficulty while the remainder of the students found them either too difficult or too easy.

Interpretation of these findings suggested to us that while the students generally were quite positive about the problem-based learning environment, there were many students whose responses suggested a degree of discomfort with the changed setting. It is important to remember that a figure of 20% unsatisfied learners in this course was in fact nearly 50 learners and this appeared to us to be a number that was too big to be ignored. The results suggested that we needed to revisit the problems we were giving and to explore ways to make them more suited to the mainstream students. A possible solution here might be to give students several questions to choose from rather than providing one question for all.

Question	Not at all	Not much	Reasonably	Quite a lot	Lots & lots
1. How much did you find doing the weekly problem helped you to learn?	0	11	16	65	8
2. How much did you find doing the weekly problem encouraged you to read?	0	24	10	53	13
3. How difficult did you find it to get a good answer to the weekly problem?	5	27	27	34	7
4. Doing the weekly problem made me think about the weekly content	0	19	19	57	5

Table 1.
Student Feedback and Responses to Problem-Based Learning Activities

b. Student-Centred Learning. In response to questions concerning their preference for learning by themselves or being taught, the group appeared equally divided (eg questions 6 & 8). The spread of responses in the table suggested that among these students there was a preference towards higher levels of teacher direction in their learning as distinct from total learner control. Interestingly in response to a question seeking their impressions of how much they learned by being active learners (question 7), the results demonstrated that the vast majority of these students, 92%, saw active learning as more effective than passive learning.

The high level of student preference for environments where they are taught rather than having to learn by themselves was not surprising. Student-centred environments are typically more work for the students and require them to be more organised and more responsible. It appeared to us that having 50% of the students claiming to favour student-centred learning was quite a good outcome and one that suggested that this form of environment might be able to be altered to raise this number even higher. It would be interesting to see the responses from learners in totally teacher-centred environments. One suspects that there might be an even higher preference in such instances.

Question	Not at all	Not much	Reasonably	Quite a lot	Lots & lots
5. How enjoyable did you find doing the weekly problem was?	3	24	24	45	3
6. How much would you prefer the material to be taught to you?	10	41	15	18	16
7. How much more do you learn by being active rather than just listening to the lecturer	3	5	21	44	27
8. How much do you prefer to be taught things than to have to learn them myself	17	37	32	11	3

Table 2.
Student Feedback and Responses to Student-Centred Learning

c. Group Activities. The group work tended to be viewed quite positively by the majority of the students (question 9), but still 15% gave negative responses. Nearly 75% of the learners indicated that they felt the group activity aided their learning (question 10), still leaving a sizeable proportion (24%) who saw little value from it. Responses to question 11 revealed that 50% of the learners would still prefer to work on their own and this was despite nearly 80% indicating that they felt the group work was shared (question 12).

These results provide yet further evidence of a considerable mismatch between learners' expectations and this form of learning environment. Despite high levels of enjoyment and equally high perceptions of perceptions of shared learning and effective learning, half the cohort were still not predisposed to the forms of collaborative learning provided in this environment.

This finding was consistent with the feedback gained from the student interviews described earlier. It is highly likely that students' lack of appreciation of group work was connected to the unstructured processes that many tended to use and the fact that little guidance was given to direct the students as to what might be appropriate ways to work in groups. As first year students, most would have had little experience with groupwork and would probably have benefited from some form of structure being imposed or encouraged. These

results provided some strong indications for modifications which we could consider making to the Web system in terms of its support for collaborative groupwork. The forms of support that we could include in the Web-based system might be:

- Making explicit the various roles for group members;
- Defining intermediary steps in the problem-solving process and placing these against the defined roles;
- Providing a private bulletin board for students within each group to use for communication during the problem-solving process; and
- Providing a means for students to record the roles and activities of each group member across each problem activity.

Question	Not at all	Not much	Reasonably	Quite a lot	Lots & lots
9. How much did you enjoy working in a group?	7	8	27	48	10
10. How much did you find doing the weekly problem in a group helped your learning?	5	19	22	27	27
11. How much would you prefer to do the weekly problem on your own?	19	31	18	22	10
12. How much did people in your group share the work?	10	11	11	60	8

Table 3.
Student Feedback and Responses to Group Activities

d. Learning with Technology. A characteristic feature of this learning setting was its strong use and reliance of Web-based tools and facilities to support the learning. We were interested to find out from the learners how the use of the technology impacted on their learning and whether there were ways to modify this aspect of the course to improve learning outcomes. Nearly 90% of the learners expressed positive views about the utility of the Web as an information source and its capacity to support this learning activity (questions 13 and 15). This was not an unexpected result given the nature of the tasks and the support provided by the web for their information seeking activities. Seventy percent of the learners expressed positive views about the use of the Web and email as a learning support (question 14). This number could have been higher but probably reflected the number of learners who met face to face and didn't need email to communicate.

But question 16 identified an inherent weakness in the environment and one that we all became very aware of during the course, the question of Web reliability. The learners were very critical throughout the course of the reliability of this form of learning environment. Problems arose in a myriad of ways. Students reported such problems as broken Web links, servers not responding, long download times, insufficient access to computers and network

problems as strong impediments to their learning. These problems were exacerbated by the relatively large number of students, the narrow time frames for completing the tasks and the heavy reliance on a functioning network and infrastructure. It was quite evident ahead of this data that the learning environment that we were using required a high level of reliability in the technology being employed. Despite our best efforts this was not always delivered and this probably led to a good deal of the dissatisfaction expressed by some learners.

Question	Not at all	Not much	Reasonably	Quite a lot	Lots & lots
13. How useful did you find the WWW as a source of information for the problems?	0	12	20	23	45
14. How useful did you find the Internet for communication with group members as part of the problem solving process?	6	24	11	37	28
15. How useful did you find the WWW as a means for organising the problem-solving process?	0	11	27	44	18
16. How reliable did you find the technology in supporting the learning process in this unit?	26	46	19	9	0

Table 4.
Student Feedback and Responses to Learning with Technology

3. Problem-Solving Skills Development

One of the assumptions behind the adoption of this alternative learning approach was that it would benefit all students equally and that the process would contribute to the development of students' problem solving skills. There was the prospect in this environment, that students success in the problem solving tasks could be unduly influenced by previous experience. It was possible that the assessments of the problem solutions might simply be providing a measure of students' problem solving skills rather than a measure of students' learning and knowledge acquisition. If this was the case, it was also likely then to find some Groups where there were skilled problem solvers consistently outscoring others whose group composition was less favourable.

To explore these aspect of the students' problem solving skills and their development we chose one Workshop class of students at random from the 12 involved in the course. Table 5 provides a summary of the results for this Workshop class and shows how these were spread between the groups on a weekly basis. The results show some general patterns.

These results appear to reveal some differences among the groups in terms of their problem solving skills and their abilities to develop successful solutions to the weekly problems. Group 5 for example shows quite low scores compared to the other groups from week to week while Group 3

appears to score consistently higher. The question that this poses is whether the mark achieved is based primarily on the skills and experiences of the group or whether it is a reflection of the amount and quality of the work done and consequently the knowledge acquired through the process. When the composition of the groups was considered and their problem solving strategies observed, it became apparent that achievement tended to reflect the amount of effort expended.

	Group 1	Group 2	Group 3	Group 4	Group 5	Total
Problem 1	7	6	8	9	7	37
Problem 2	8	7	7	6	6	34
Problem 3	6	9	8	7	6	36
Problem 4	8	6	10	6	6	36
Problem 5	9	7	8	7	6	37
Problem 6	6	8	7	6	9	36
Problem 7	6	8	7	5	7	33
Problem 8	8	6	8	7	7	36
Problem 9	6	8	7	10	6	37
Total	64	65	70	63	60	

Table 5.
Scores achieved for the weekly problems by groups in a Workshop

Group 3 was comprised of 4 part-time students who were highly motivated and who spent considerable time together solving the problems. Group 5 was comprised of several students in full-time employment who had to ration their time between studies and work. They indicated that on a weekly basis they spent the time needed to create a reasonable solution although with more time, they felt they could do better. Confirmation of this view was apparent in Problem 6 when Group 5 achieved the highest grade of all Groups. This problem coincided with a week when more time was available to members of the group and their solution reflected this extra effort.

Close inspection of the data in Table 5 reveals that during the course each Group managed at least once to achieve the highest score for at least one problem solution. In fact while Group 3 scored the largest aggregate marks for their efforts, it was Groups 1 and 2 that achieved the highest number of high scores. This form of analysis cannot be taken as completely reliable given the nature of the marking system and the fact that this data comes from only one Workshop. It does however provide some credible evidence to support our contentions that the problem solving process does not necessarily favour particular students and is a process that can provide benefit to all learners.

One other factor that we explored in this study was evidence of the development of students' problem solving skills. The problems were being marked in a consistent fashion

using a set of pre-determined criteria. If students were developing skills from one week to the next, it was likely that this would be reflected in the scores achieved each week and across the semester, it was likely that the scores would show a positive movement. Inspection of the weekly total scores in Table 5 does not indicate that there was any development in these skills for the Groups in the Workshop in question. The weekly averages tended to remain consistent through the course with no discernible increase between the first and last problems. This may have been caused by the insensitivity of our marking system to reflect skills development but more likely we feel it shows that the process did not really help students to develop these skills.

To more fully explore the extent to which the setting developed learners' problem solving skills, we examined the average weekly score for the students in each of the 9 Workshops across the 9 problems (Table 6). Once again, there were no real patterns evident and the proximity of the averages of the scores from one week to the next did not suggest any significant level of improvement in skills development.

	Wk 1	Wk 2	Wk 3	Wk 4	Wk 5	Wk 6	Wk 7	Wk 8	Wk 9	Average
Prob1	7.2	6.2	8.0	7.4	6.8	7.4	7.2	7.6	7.4	7.24
Prob 2	7.4	6.8	7.2	6.8	7.0	7.2	7.4	7.6	6.8	7.13
Prob 3	6.6	7.2	7.4	7.2	7.4	7.2	7.2	7.4	6.8	7.15
Prob 4	7.8	6.6	7.2	7.2	7.0	7.4	7.6	7.6	7.4	7.31
Prob 5	8.0	7.4	7.2	7.4	7.2	6.8	6.6	7.2	7.6	7.27
Prob 6	7.6	7.2	6.8	7.2	6.8	7.0	6.8	7.0	7.2	7.07
Prob 7	7.2	7.8	7.4	6.6	7.2	7.4	7.0	7.4	7.4	7.27
Prob 8	7.4	7.6	7.0	7.2	6.8	7.0	7.2	7.4	7.2	7.20
Prob 9	7.6	7.4	7.0	7.4	7.0	7.4	7.6	7.4	6.8	7.29

Table 6.
Average weekly scores for the problems for each Workshop

This finding was a little surprising given the amount of problem solving that the students had completed by the end of the course. We had assumed that practising problem solving skills in an environment of this form would have been sufficient to have led to discernible changes in problem solving skills. Factors that could have mitigated against this were the level of difficulty of the problems set, the forms of feedback received by the students and the problem solving processes being used. These findings have suggested to us the need to more fully explore student activities and levels of cognitive engagement in the problem solving process and to see if it is possible in such a setting to provide empirical evidence of skills development.

Summary and Conclusions

This paper has described a project undertaken in an Australian university which explored students' learning strategies and successes in Web-based learning environment designed to support problem-based learning. The study was undertaken within a course comprised of 240 students and sought to explore:

- the ways in which learners familiar with teacher-centred learning would respond to a student-centred environment;
- students' judgements of the learning potential of the alternative setting; and
- whether the problem-based setting could be seen to develop students' problem solving skills.

The student feedback from interviews and questionnaires indicated a general level of satisfaction and contentment with a student-centred form of learning involving problem-based learning in group settings. But the results also indicated that for many, nearly 50% of the class, this was not their preferred form of learning. Similarly, the majority of students stated a level of enjoyment and success in the collaborative learning settings but nearly 50% again said that they would prefer to work alone rather than in a group.

In our teaching, we are committed to developing student-centred and collaborative learning settings. We know they are good for the learners and that they provide among the best forms of cognitive engagement for tertiary students. The task ahead of us is to explore how we can help learners to appreciate these and to show a preference for them over conventional forms of instruction. The findings suggest that a useful first step will to improve the Web system to provide more structure and guidance to students in the organisation and management of the group activities.

The study also revealed that participation in the problem-based learning setting was not sufficient to develop students' problem-solving skills. There was no discernible improvement in the scores achieved by students for problem solutions between the commencement and conclusion of the study. The development of these skills it would appear must come from some deliberate strategy aimed at helping students to reflect on their learning processes and through feedback which informs and encourages their progress. Again, we will look to further explore this issue through some modification to the problem solving system. In particular, we will develop a more structured feedback mechanism to guide the learners in their problem solving processes.

Overall the study has provided us with a considerable number of issues to consider about the use of alternative teaching strategies. It is clear that consideration of the practical issues associated with their implementation is needed if the full range of opportunities are to be

gained. The information from the study is wide and varied and while it provides some sound advice to guide the further refinement and development of the problem-based learning environment, it also poses important questions about how such systems can be implemented to provide the most advantage to all learners. We intend to continue our research and development in this area with the view to refining our Web-based learning environment so that meets all our expectations for supporting and enhancing student learning using a problem-based teaching model.

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