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Attendance and Achievement in Problem-based Learning: The Value of Scaffolding

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Abstract

The impact of problem-based learning (PBL) in improving academic achievement compared with other forms of teaching is equivocal. This paper argues that poor tutorial preparation and vague reporting of the brainstorming stage of PBL are major contributing factors. To address these issues this study incorporated a scaffolding mechanism into the pre-tutorial brainstorming stage of the PBL process based on de Bono's (1995) Six Thinking Hats. Results confirmed that pre-tutorial preparation, when measured by attendance and academic achievement, increased across all levels of the undergraduate program for the PBL groups that used scaffolding, when compared to PBL groups without scaffolding and lecture-based delivery groups. This study supports the inclusion of scaffolding during the brainstorming stage of PBL.

Key words: attendance, academic achievement, scaffolding, time management, problem-based learning, Six Thinking Hats, sport and exercise psychology

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Introduction

For some researchers problem-based learning (PBL) has been an accepted method of delivering the curriculum in higher education, where previously it has been shown to increase student motivation (Mauffette, Kandlbinder, & Soucisse, 2004) and student satisfaction (Strobel & van Barneveld, 2009). However, despite these positive effects, PBL has not always improved academic achievement when compared to traditional lecturer-led approaches (Colliver, 2000; Smits, Verbeek, & de Buisonjé, 2002; Lucas et al., 2006; Hartling, Spooner, Tjosvold, & Oswald, 2010). For instance, Strobel and van Barneveld (2009) reported in their meta-synthesis that while PBL may be beneficial for long-term retention of knowledge, a traditional teaching approach was better for standardised examination achievement. While in a review of undergraduate medical education, Smits and colleagues (2002) found limited evidence that PBL increased participants' knowledge and performance. Similarly, a recent study comparing students' motivation in a PBL and traditional curriculum concluded that PBL does not always seem to foster higher intrinsic motivation (Wijnia, Loyens, & Derous, 2011).

In light of this mixed evidence it seems highly unlikely that a significant number of academics would spend large amounts of time restructuring their curriculum to accommodate a PBL approach, if the outcome in terms of student achievement is potentially no different from traditional approaches (Albanese & Mitchell, 1993). The present study aims to investigate the effect of introducing a structured form of scaffolding in the PBL curriculum on student attendance and academic achievement.

Attendance and Academic Achievement

One reason for the differences in academic achievement in the PBL literature may be due in part to the variations in student attendance. For example, McCarey, Barr, and Rattray (2006) reported that student attendance significantly correlated with academic achievement. Students who attended the most achieved the highest marks. Also, Sharma, Mendez, and O'Byrne (2005) reported that student-centred tutorials in physics subjects increased examination performance. Furthermore, students who worked in the same group and attended regularly increased their performance the most.

In contrast, although students did regularly attend tutorials, Hutcheson and Tse (2006) found that nearly 60% were unprepared, with only 15% of their second-year finance degree students preparing answers for most or all of the tutorials. Reasons given by students for the lack of preparation were that there was no point in preparing as the tutor gave the answers to most questions in the tutorials, which then resulted in little time for discussion. Interestingly, a high proportion of students who did not attend the tutorials reported that they learnt more in their own time than in tutorials or lectures, indicating a possible preference for a more self-directed approach to learning.

From the evidence it seems that assessing tutorial attendance alone does not necessarily measure whether students have managed their time adequately enough, when preparing for the imminent tutorial session. Therefore, measuring the number of students who have not only attended, but also prepared sufficient material for the forthcoming sessions, would seem to be a far more accurate measurement of the relationship between attendance and academic achievement. We propose that this can be achieved through the inclusion of a scaffolding mechanism that simultaneously facilitates pre-tutorial preparation and the problem-solving process.

Time Management and Attendance

An additional issue that students may have when researching and assembling pre-tutorial material is how to manage their time effectively. The positive effects of PBL on time-management skills have already been reported by Nash, Schwartz, Middleton, Witte, and Young (1991), who delivered PBL to third- and fourth-year clerkship students. However, these students would have already developed some time-management skills during their years in education. This suggests that the inclusion of some form of time-management support early in the educational program would be most beneficial.

However, facilitating time-management skills in isolation may not be the complete answer, as it has been shown that although time-management training enhances time-management skills, it does not automatically transfer to better academic achievement (Claessens, van Eerde, Rutte, & Roe, 2007). An important point to make here is that in their review, Claessens and her colleagues argue that time itself is actually an inaccessible factor and therefore cannot be managed. Consequently, they claim it is how an individual uses his or her time effectively to complete work within certain deadlines that should be investigated. We agree with this statement and argue that to encourage tutorial attendance a greater relationship must be formed between time-management strategies and problem-solving skills.

Scaffolding the Journey from Problem to Solution

The journey from problem to solution can be a difficult one and has been described by Hays and Simon (1974) as the solution path length. This includes obstacles and issues that have to be conquered when attempting to arrive at a credible solution (Jonassen & Hung, 2008). However, according to Jonassen and Hung (2008), problem difficulty has received little attention in PBL research. They argue that the two most important factors related to problem difficulty are complexity and structuredness, with structuredness being rated more important than complexity by students, when attempting to arrive at a solution more easily (Jacobs, Dolmans, Wolfhagen, & Scherpbier, 2003). In light of this evidence we propose that implementing some form of scaffolding in the problem-solving process, which supports the learner in his or her understanding of how the problem is structured, would consequently reduce the complexity of the problem.

Support for the use of scaffolding in the problem-solving process comes from Hmelo-Silver, Duncan, and Chinn (2007), who propose that scaffolding changes difficult and complex problems to more manageable and accessible tasks within the learning constraints of the student. One type of scaffolding that has been extensively used by PBL enthusiasts is the Maastricht Seven-Jump strategy (Schmidt, 1993). This uses a linear approach to problem solving (Segers, Van den Bossche, & Teunissen, 2003), during which students are encouraged by the tutor to collaborate with other group members, whilst also developing their independent learning skills (Moust, Bouhuijs, & Schmidt, 2001).

However, application of the Seven Jump strategy is not without its critics. For example, Moust, van Berkel, and Schmidt (2005) report that in some instances students only use a five-step strategy, with the step 3 (brainstorming) and step 4 (elaboration) phases omitted from the problem-solving process. Consequently, any activation of prior knowledge is lost through a lack of in-depth analysis of the problem. We argue that adopting a five-step approach will consequently have a negative effect on pre-tutorial preparation, which will ultimately reduce the quality and depth of subject knowledge being reported during reporting phase (step 7) of the Seven-Jump strategy.

For a number of reasons, brainstorming (step 3) is a quintessential part of the PBL process. It facilitates group development, whilst also allowing roles to be identified. Furthermore, in addition to establishing group and individual expectations, a structure will emerge of how everyone will work together (Weaver & Farrell, 1997). As group members enter this stage their different thoughts, opinions, and ideas compete for consideration, which in the past has been shown to be an integral part of small-group development (Tuckman & Jenson, 1977). However, without a method of scaffolding the opinions and ideas of the group, important information may be lost.

Therefore, we propose that if a PBL group is to significantly increase their subject knowledge, then scaffolding the brainstorming stage is extremely important. This approach will allow both student and facilitator to closely monitor the progress from problem to solution. Furthermore, to successfully arrive at a credible solution, a point of debate may have to be revisited on more than one occasion, which provides additional support for the introduction of a structured but flexible form of scaffolding in the pre-discussion stage of the PBL process. This approach would also allow opportunity for innovative discussion and ideas to take place in a controlled manner, which is extremely pertinent when introducing PBL to anyone who has no previous experience with this form of learning.

The Six Thinking Hats

One scaffolding mechanism that has been used in different problem-solving contexts is de Bono's (1995) Six Thinking Hats, which are designed to encourage participants to investigate problems from a number of different perspectives. Each hat represents a different style of thinking and none of the hats are viewed as "good" or "bad" (Bradbury-Jones & Herber, 2011). The white hat is used to assess the amount of information the group currently has, gaps in the knowledge, and how to acquire additional information. The red hat represents an emotional response to a particular decision, while the black hat focuses on the risks involved with a particular decision. With any decision there will be positive benefits, and the yellow hat promotes this type of thinking, while the green hat encourages creativity, allowing learners to "think out of the box" when looking for a solution. Finally, the blue hat is worn by a leader who could be a member of the group, the facilitator, or both. When ideas are drying up, (s)he is responsible for re-directing the thinking back to a previous hat, allowing a new discussion to take place (de Bono, 1995).

The Six Thinking Hats have already been used with a number of different populations. For example, in encouraging students to think and reflect more creatively and consequently become more critical about their practice, Kenny (2003) implemented "the Six Hats game" in palliative care. Kenny used this approach in place of the traditionally used reflective models approach, which the author argues are either too simplistic or complicated to use, which may then leave the student feeling anxious and de-skilled if they arrive at the wrong solution. Kenny concluded that the game taught students to think constructively about their practice from different perspectives.

Counselling is another subject area in which the Six Thinking Hats have been used. For instance. Li, Lin, Nelson, and Eckstein (2008) employed the technique with couples having marriage difficulties. Findings suggest that the collaborative process helped minimize opposing views between couples by using a shared language. While Karadağ, Saritaş, and Erginer (2009) used the Six Thinking Hats to develop nursing students' critical thinking skills, a group that reported that the method encouraged the sharing of different opinions and ideas, whilst at the same time looking at the positive and negative aspects of their decision making. While pertinent to the present study, Karadağ and colleagues concluded that their findings are particularly important because of the limited number of investigations that have reported the use of the Six Thinking Hats in university education.

Facilitator's Role when Scaffolding with the Thinking Hats

The success of any PBL program is not only reliant on how students adapt to the process, but also to the often overlooked and important fact of how well the lecturer turned facilitator can carry out his or her role in what has now become a student-centred epistemology

(Olmesdahl & Manning, 1999). In an attempt to educate potential facilitators in a Pakistani Medical College, Zaidi, Zaidi, Razzaq, Luqman, and Moin (2010) implemented a faculty development, two-day PBL facilitator training workshop conducted five times over the year. Findings indicated a significant increase in staff regard for PBL, with many reporting that they were more interested in using this technique. However, according to faculty, a limitation of PBL is the need for more time commitment from faculty for teaching, which strongly suggests the need to include some form of scaffolding strategy to manage staff time more effectively.

Both the facilitator and student experience of PBL has been investigated by Lekalakala-Mokgele (2010) in a nursing undergraduate program of four universities in South Africa. The study revealed three main limiting themes from the facilitator's perspective. Specially, that facilitator control was a challenge, the facilitator feared loss of control, and the facilitator was wary of becoming a member of the group. From the students' perspective, the three limiting themes were a dominating facilitator, lack of skills from the facilitator, and a denial of lack of knowledge by the facilitator. Based on these findings, they strongly support the inclusion of a mechanism that can be used by both students and facilitator to steer the problem-solving process in the right direction. For example, when the group debate stalls, either the facilitator or a member of the student group can wear the blue hat to initiate new discussion and redirect the conversation back toward black hat thinking (de Bono, 1995).

Also due to the diverse nature of PBL, a lack of facilitator's knowledge is not uncommon. Students can arrive at a solution from a number of different points of view, which in some cases may not be an area of expertise for the facilitator. For example, when delivering a leadership problem in sport it is not unusual for students to arrive at a credible solution using a theoretical approach from business. As the green hat represents and encourages innovative thinking, it ensures that any unconventional knowledge does not become an embarrassment to both students and facilitator, but opens up discussion and the possibility of a new and exciting solution to the problem.

Therefore, to facilitate pre-tutorial preparation and consequently increase tutorial attendance, we advocate that some form of scaffolding is an essential component of any PBL approach. To achieve this, the present study implemented a scaffolding mechanism based on de Bono's (1995) Six Thinking Hats into the brainstorming stage of the PBL process, across all three levels of a UK higher education institution's undergraduate sport and exercise psychology program. The research questions are;

1) Will scaffolding the brainstorming stage of the PBL process facilitate pre-tutorial preparation when measured by student attendance?
2) Will academic achievement increase the most for PBL with scaffolding, when compared to PBL without scaffolding and previous lecture-based delivery?

Method

Participants

Participants were recruited from all three levels of an undergraduate sport and exercise psychology degree program in a UK higher education institution. A total of 973 participants enrolled in the course over a six-year period (see Table 1). This strand of the course consists of one module per level, which is mandatory in the first two levels, and an option module in level 3.

Table 1. Student numbers for all three levels of the sport and exercise psychology program

	2004-5 Lecture-led	2005-6 Lecture-led	2006-7 Lecture-led	2007-8 PBL No Solution Sheets	2008-9 PBL Solution Sheets	2009-10 PBL Solution Sheets
Level 1	70	82	54	55	68	80
Level 2	50	54	73	55	50	65
Level 3	30	35	31	32	47	42

Measures

Attendance

As tutorial attendance is interconnected with the development and submission of completed solution sheets, attendance in the PBL sessions was chosen as an indicator of pre-tutorial preparation and time management. For analysis purposes any student who attended without his or her solution sheet (<10) and were unable to contribute to the session were given a mark of zero and marked as absent.

Academic achievement

For the whole of the study each module required students to complete two assessments, one coursework and one exam, which varied across the academic years. For levels 1 and 2, coursework consisted of an accumulation of group/individual oral presentation and tutorial marks, while at level 3, coursework assessment was by case study and tutorial marks. The level 1 and 2 cohorts sat a one-hour end-of-year exam, and level 3 sat a two-hour end-of-year exam. To measure any differences in academic achievement, mean module marks were compared between lecture-led, PBL (no solution sheets), and PBL (with solution sheets).

Solution sheets

The solution sheets were constructed in Microsoft Word and based on the Six Thinking Hats (de Bono, 1995). Each coloured hat has a separate section that must be typewritten and completed by all students as preparation for each tutorial. At the end of the Thinking Hats section, there is an additional part in which students are required to provide an individually written solution based on information that the group has discussed and recorded. A blank solution sheet (for a copy, see Appendix A) and a completed exemplar were posted on to the CUOnline module webpage. Students were required to download a blank solution sheet immediately after the problem was first presented. The completed solution sheet was then submitted at the end of the last tutorial.

Procedure

Lecture and PBL delivery

During 2004 to 2007 (inclusive), the program content was delivered using mainly a lecture-based (~20hr) and tutorial (~8hr) approach. Each lecture focused on a different topic area, and students were required to revise the content in preparation for the following tutorial. In addition, there were a small number of labs at level 1 and 2 but none at level 3, so due to comparative inconsistencies the lab data has been omitted from the study. In 2007 and 2008, PBL was introduced for the whole of the academic year in all three levels of the sport and exercise psychology program. At level 1 and 2 students were selected alphabetically and divided into small groups (~5 per group) and at level 3 students were allowed to choose their group members. From 2008 to 2010 (inclusive), the solution sheets were introduced in to all levels of the PBL program.

Problem delivery

For all students in 2007 there was an introductory lecture on the Six Thinking Hats (de Bono, 1995) and guidance was given as to how to complete the solution sheet. This procedure continued for each new cohort of level 1 students who were new to this form of teaching. The "PBL for Professional Action" model (Savin-Baden, 2000) was used and each problem lasted for approximately four weeks, during which time students attended an introductory lecture, where each group problem was presented and based on a current real-world problem in sport (Pierrakos, Zilberberg, & Anderson, 2010). Subsequently, due to differences in student numbers across all levels and available members of staff (3 or 4), student groups attended two 30-45 minute tutorials, usually a week apart. The larger cohorts of level 1 and 2 attended for 30 minutes whilst the smaller level 3 groups attended for 45 minutes.

Tutorial procedure

In the lecture-led and PBL curriculum students attended eight tutorials throughout the year. In the lecture-led tutorials students worked in groups within each session and individual marks were allocated in relation to each student's overall contribution. In preparation for each PBL tutorial, students were required to meet as a group in their own time to discuss and agree what subject information would be gathered. During this meeting individual research goals were set to ensure no information was duplicated by another member of the group.

In the first tutorial each student had approximately five minutes to verbally defend his or her evidence in relation to the problem and, where appropriate, the facilitator asked questions to deepen the discussion. After the first tutorial the group again set individual goals to collect further information that was brought to the final tutorial, where the process of the first tutorial was repeated. To assess the progress students were making when travelling from problem to solution, a marking scheme was used that awarded marks in the first tutorial for *relevance of evidence* (Level 1 marks: 1-15; Level 2 marks: 1-10; Level 3 marks: 1-5), *clear explanation of evidence and how it relates to the problem* (Level 1 marks: 1-65; Level 2 marks: 1-55; Level 3 marks: 1-45), and *critical analysis of evidence* (Level 1 marks:1-20; Level 2 marks: 1-35; Level 3 marks: 1-50).

For the second and final tutorial the word "additional" is added to each section of the marking criteria. The individual solution sheets were submitted and marked (out of 100). Written feedback was provided and returned to the students before the next problem was presented. Each final individual mark was calculated by adding 25% of tutorial one and tutorial two marks and 50% of the solution sheet mark together.

Statistical Analysis

Attendance

Due to small differences in the number of tutorials when comparing attendance between the lecture-led and PBL programs, the academic year was divided into four time periods. Tutorial attendance was recorded by allocating a "1" if the student attended and a "0" if the student attended unprepared or was absent. From this information percentage attendance for each cohort over all time periods was calculated. As an indicator of pre-tutorial preparation, attendance for all forms of teaching was measured. For the PBL "with solution sheet" tutorials this meant students attended with their completed solution sheets.

Academic achievement

Academic achievement was analysed by grouping assessment data into three categories, which were lecture-led teaching, PBL without solution sheets (No PSS), and PBL with solution sheets (PSS). For each element of academic work across all levels, a one-way ANOVA with Tukey post-hoc tests was used to analyse potential differences between the three categories.

Results

Attendance

Results indicated that attendance for the PBL (with solution sheets) was highest in comparison to PBL (no solution sheets) or lecture-based delivery, apart from period 1 for the level 1 cohort. More specifically, analyses revealed that over 90% of level 1 and level 2 students handed in their solution sheets for all problems over the four time points. For level 3, the hand-in rate was over 90% for time periods 1 and 2 before decreasing to approximately 80% for time points 3 and 4.

Figure 1a. Level 1 Percentage Attendance Over the Course of the Academic Year for Different Teaching Methods

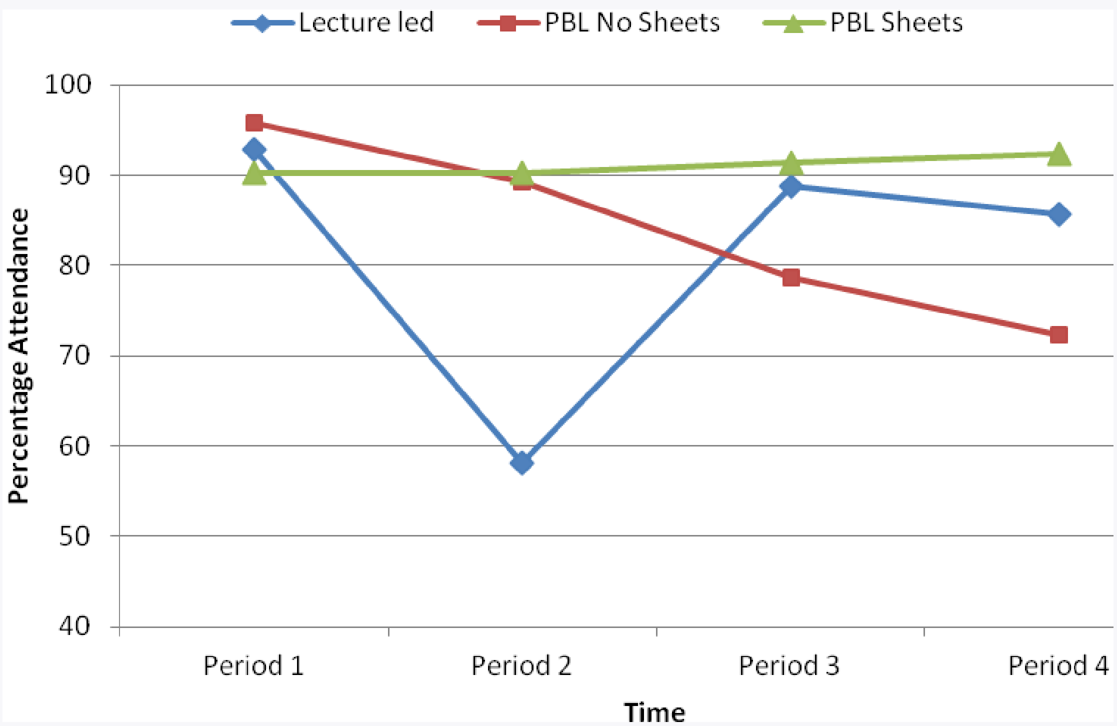


Figure 1b. Level 2 Percentage Attendance Over the Course of the Academic Year for the Different Teaching Methods

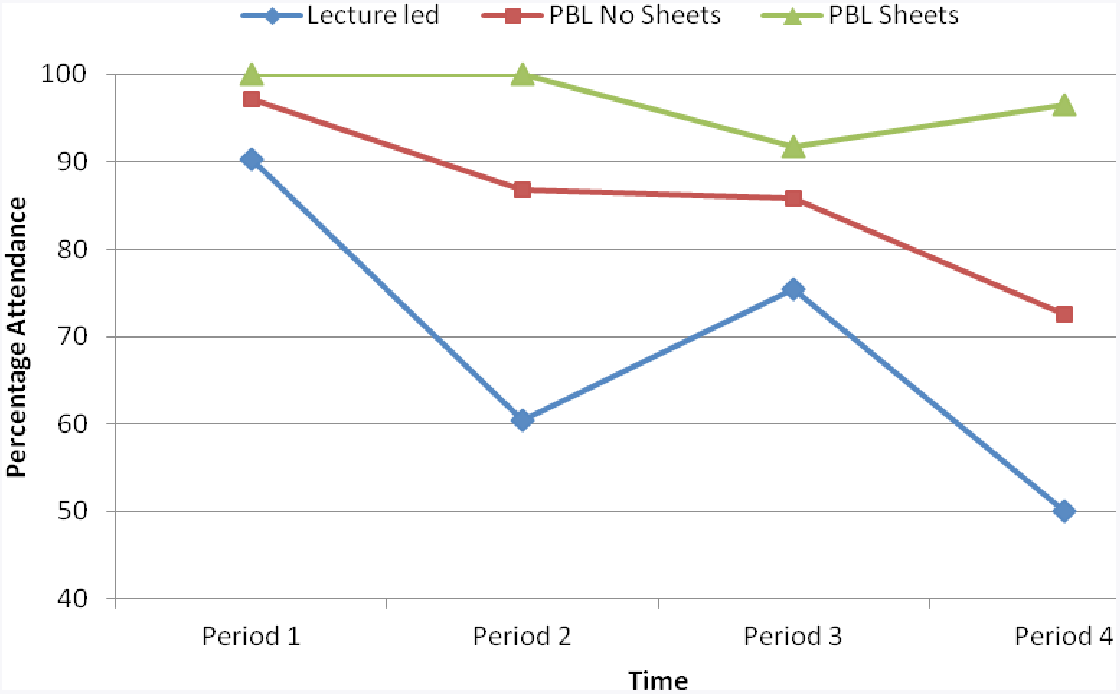
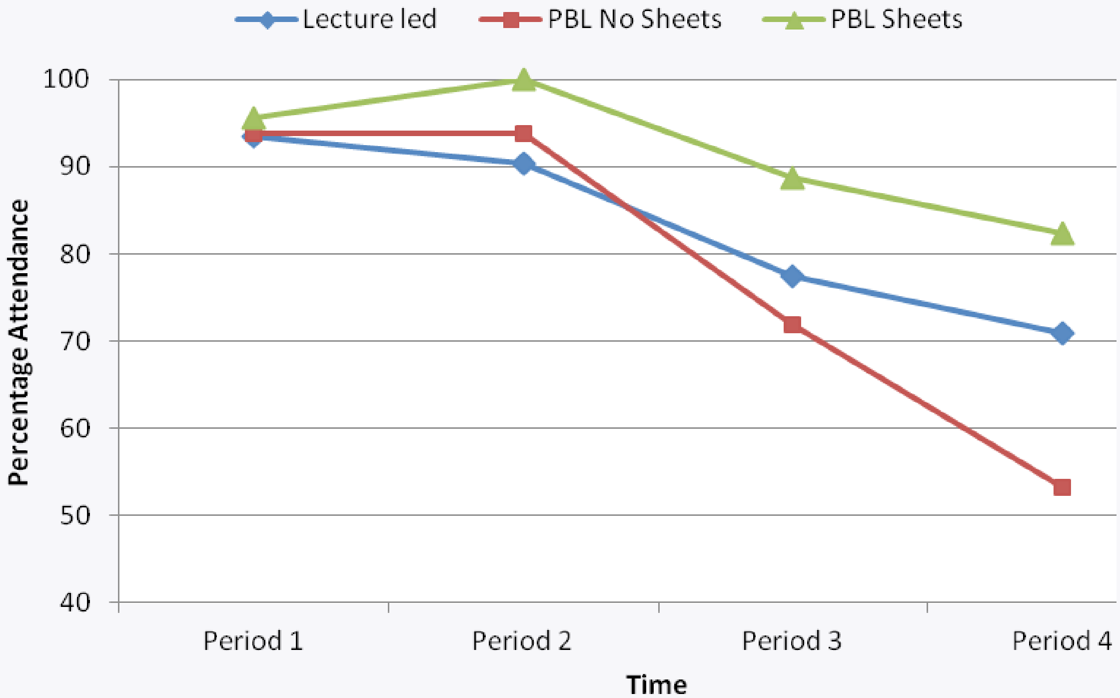


Figure 1c. Level 3 Percentage Attendance Over the Course of the Academic Year for the Different Teaching Methods



Summary of Attendance

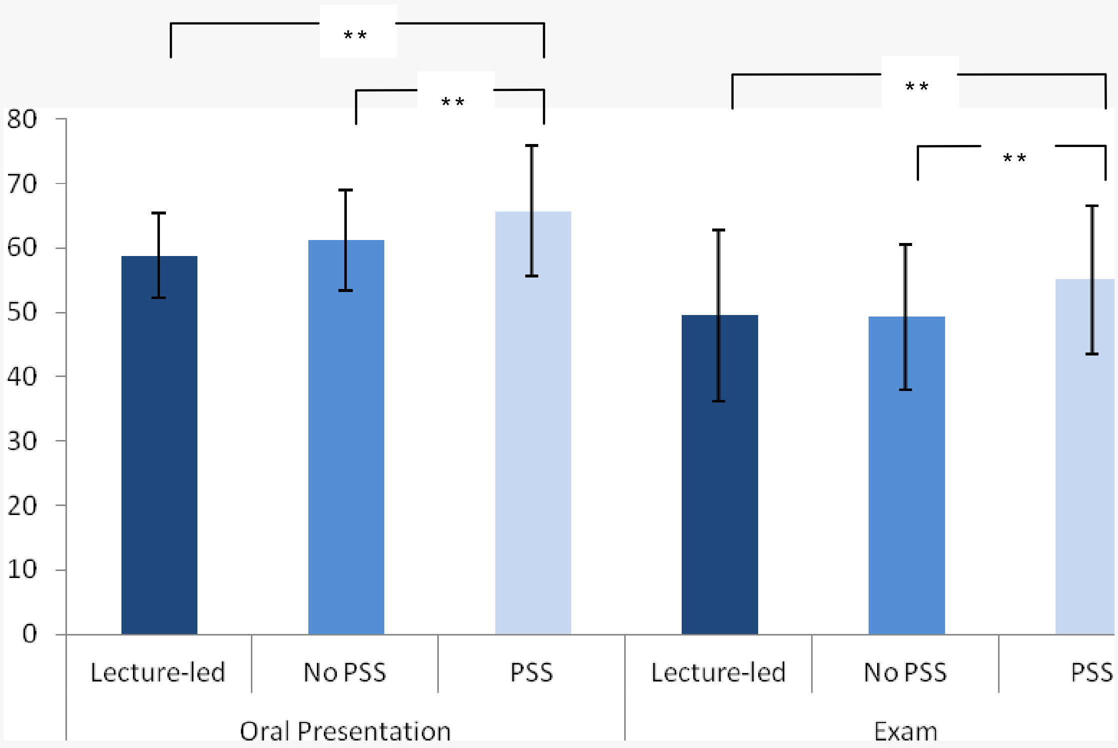
The results in Figures 1a, 1b and 1c indicate that for the majority of time periods, attendance was higher for both forms of PBL in comparison to lecture-based delivery. Specifically, level 1 attendance increased from period 1 to period 4 for PBL with solution sheets, whereas PBL without solution sheets decreased across the same time periods. While attendance for the level 1 lecture-led group decreased from time period 1 to 2 before rising again to over 80% for period 4.

For the level 2 PBL students who used the solution sheets, attendance was highest for all time periods, than either PBL without solution sheets or lecture-based delivery, with both groups who did not use the solution sheets demonstrating dramatic falls in their attendance. This culminated in the lowest attendance for the lecture-led group at 50% for time period 4. The level 3 attendance results followed a similar pattern to the level 2 cohorts, although there was more of a decline from time periods 3 to 4 for all groups, with the PBL group without solution sheets attending the least for time period 4 at just over 50%.

Academic Achievement

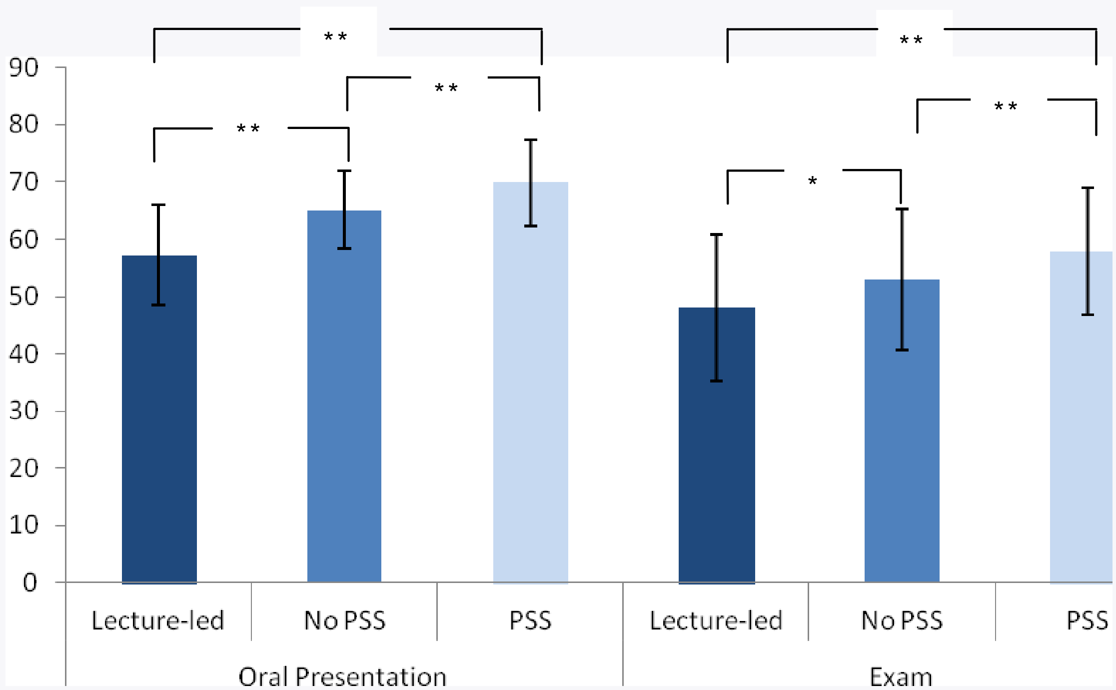
Academic achievement was analysed by grouping assessment data into three categories; lecture-led teaching, PBL without solution sheets (No PSS) and PBL with solution sheets (PSS).

Figure 2. Level 1 Academic Achievement.



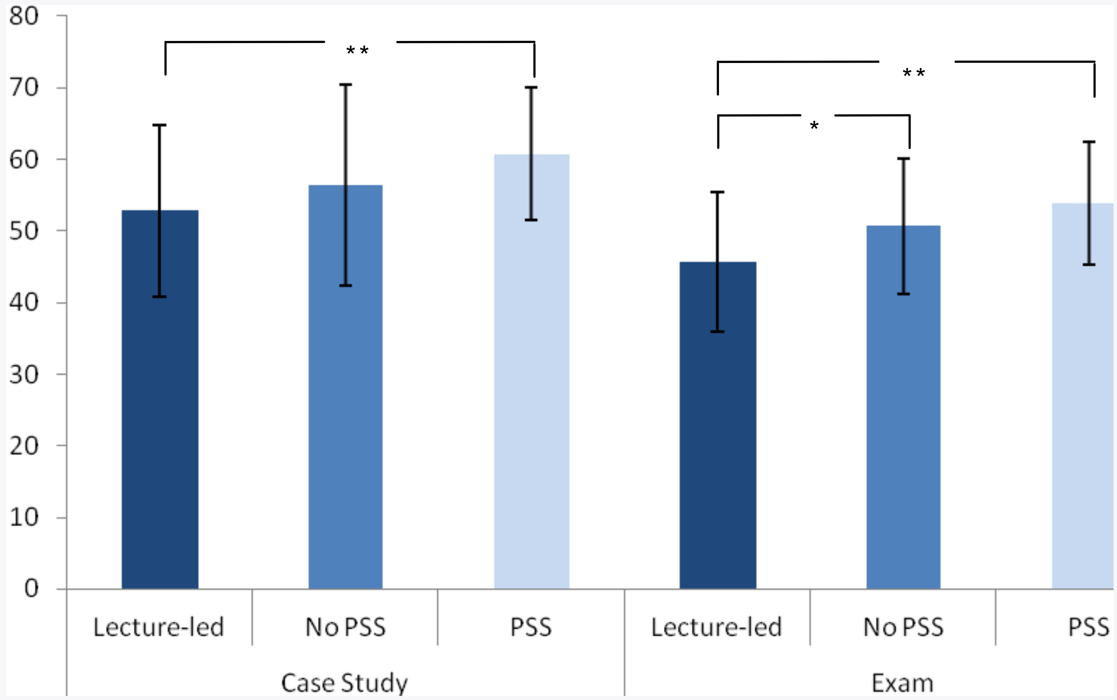
Data is shown as mean ±SD (** *P*<0.01). A one-way ANOVA with Tukey post hoc tests revealed that level 1 students achieved significantly higher marks in the oral presentation and examination assessments (p<0.01) when using the solution sheets compared to both the lecture-led approach (p<0.01) and PBL with no solution sheets (p<0.01).

Figure 3. Level 2 Academic Achievement.



Data is shown as mean ±SD (* P<0.05; ** *P*<0.01). A one-way ANOVA with Tukey post hoc tests revealed that level 2 students achieved significantly higher marks in the oral presentation and examination when using PBL with the solution sheets compared to both the lecture-led approach (p<0.01) and PBL with no solution sheets (p<0.01). In addition, students achieved significantly higher marks in the oral presentation (p<0.01) and examination (p<0.05) using PBL with no sheets compared with lecture-led learning.

Figure 4. Level 3 Academic Achievement



Data is shown as mean ±SD (* P<0.05; ** *P*<0.01). A one-way ANOVA with Tukey post hoc tests revealed that level 3 students achieved significantly higher marks in the case study when using PBL with the solution sheets compared to the lecture-led approach (p<0.01). In the examination students with the solution sheets achieved significantly higher marks than the lecture-led approach (p<0.01), while the PBL without the solution sheets achieved significantly higher marks than the lecture-led approach (p<0.05). In both assessments no significant differences were seen in academic achievement between the two PBL approaches (p>0.05).

Discussion

This study examined the effects on attendance and academic achievement of a structured form of scaffolding in the pre-tutorial PBL brainstorming stage. Several studies have found that when compared to traditional forms of teaching, PBL does not increase academic achievement (Colliver, 2000; Smits et al., 2002; Lucas et al., 2006; Hartling et al., 2010). Possible reasons for this negative effect could either be the lack of student engagement in the brainstorming stage of the PBL process (Moust et al., 2005), the lack of pre-tutorial preparation (Hutcheson & Tse, 2006), or a combination of both. Our first research question asked "Will introduction of scaffolding in to the brainstorming stage of the PBL process facilitate pre-tutorial preparation the most for students who used scaffolding, when measured by student attendance?"

Effects of Scaffolding on Student Pre-Tutorial Preparation and Attendance

Results of the study fully support the first research question and confirm that with the exception of level 1 (period 1) attendance was higher across all four-time periods for the PBL groups that used the solutions sheets, when compared to PBL groups who did not and the lecture-led group. The positive effects on attendance for the PBL group who used the solution sheets might be explained first of all by the pre-tutorial preparation and tutorial structure. In the present study, a requirement of the tutorial is that each student has to provide a verbal defence of the information that they have accumulated. Therefore, any failure to pre-prepare would automatically result in non-attendance or in some cases a lack of engagement in the tutorial process.

An additional explanation for the increase in attendance for the PBL group that used the solution sheets is related to how students manage their time effectively. When students are faced with meeting a number of different and often looming deadlines, there is a temptation to reduce or leave out the often challenging brainstorming stage. We propose that the scaffolding mechanism acted as a form of time-management strategy, which then facilitated the students' time allowing them to effectively brainstorm in readiness for the next tutorial. However, including only time-management training does not automatically result in the acquisition of subject knowledge (Claessens et al., 2007; Hammel et al., 1999). Therefore, in this study we included a time-management strategy that formed a stronger relationship between time management and the accumulation of subject knowledge.

Although the present study did not measure student motivation and, therefore, our discourse is speculative, another possible explanation for the attendance results is that the scaffolding increased the motivation of the students to engage in pre-tutorial preparation, which then allowed them to attend the PBL tutorial fully prepared for their verbal defence. In sport it has been known for some time that goal setting has a positive effect on maintaining motivation through difficult periods (Weinberg & Gould, 2007). The scaffolding (i.e., solution sheets) used in this study can be seen as a series of short-term goals that encourage motivation until the eventual solution (long-term goal) is achieved. Indeed, as Mauffette et al. (2004) point out, it is the workload of students that influences their capacity to learn. If students feel they cannot reach their learning objectives in a given time frame, then major problems with maintaining motivation are prevalent.

Furthermore, Macdonald and Savin-Baden (2004) reported that PBL is motivational when students accept that time spent outside of the classroom is the most beneficial to their learning, especially when it relates to how they will operate in their future employment. We propose that in the current economic climate, it may now be time to change the much-represented focus of comparing the effects of PBL on academic achievement to other forms of teaching. More specifically, the focus should shift to investigating how these different modes of curriculum delivery facilitate the acquisition of important employability skills.

However, a cautionary note must be included here as Wijnia and colleagues (2011) who investigated the effect of lecture-based and PBL environments on student motivation rightly pointed out that any structured learning environment must have a balance of controlling elements and autonomy, if the goal is to facilitate the motivation of students. A limitation of the present study is that the delivery and design of the PBL program was the same for all levels and may be one reason for the largest drop-off across time in attendance for the level 3 students. If a justified reason for adopting a PBL approach is to develop the autonomous learner, then as students progress from level 1 to level 3, future investigations should include a curriculum design that caters for this, by reducing the controlling element of the scaffolding.

Effects of Scaffolding on Academic Achievement

Although PBL may be beneficial for long-term retention of knowledge, more didactic forms of teaching achieve higher examination results (Strobel & van Barneveld, 2009), which is one possible reason why some academics refuse to spend time redeveloping the curriculum, if the potential gain in terms of academic achievement are minimal and, in some case, reduced (Albanese & Mitchell, 1993).

To address the issue of academic achievement, the present study introduced a scaffolding mechanism in to the pre-tutorial preparation stage of the PBL process. Our second research question was: "Will academic achievement increase the most for PBL with scaffolding, when compared to PBL without scaffolding and previous lecture-based delivery?"

Results of the study revealed that, with the exception of level 1 exam performance, the answer to this research question was affirmative. Increases in academic achievement (coursework and exam) were shown across all three levels of the undergraduate program for both PBL approaches, when compared to lecture-led delivery. More specifically, for level 1 there were significant differences in oral presentation and exam grades between the PBL groups who used the solution sheets, the PBL groups who did not use the solution sheets, and the lecture-led group. However, the lecture-led group did achieve a marginally higher grade than the PBL group (without solution sheets) for the exam. While at level 2 the results are similar to level 1 between the three conditions. However, both the PBL with and without solution sheets achieved significantly higher grades than the lecture-led approach, with the PBL group (with solution sheets) achieving the highest grades of all. Finally, for level 3 it is a similar outcome with the PBL (with solution sheets) achieving the highest grades for both the case study and exam.

One very tentative explanation is that scaffolding has been reported to change difficult and complex problems into tasks that are accessible and manageable within in the learning capabilities of the student (Hmelo-Silver et al., 2007). It is possible that reducing the complexity of the problem (Quesada, Kintsch, & Gomez, 2005) through the inclusion of scaffolding facilitated the quality of the pre-tutorial preparation. The scaffolding mechanism based on de Bono's (1995) Six Thinking Hats encouraged the students to accumulate and record subject information from a number of different perspectives. This information was then used as future revision material for the forthcoming tutorials and the various coursework and examination assessments. However, as problem complexity was not measured in the present study, our comments are speculative at best, and further investigation in this area is necessary.

Summary

A possible reason for the differences in academic achievement in the PBL and lecture-led literature may be due in part to the variations in student attendance. In the past, studies have reported a strong correlation between those students who attend and academic achievement, while more alarmingly, even though some students attended tutorials, they did not carry out any pre-tutorial preparation. This lack of effort in preparation may be down to a number of reasons. For example, it has been reported that some students will leave out the brainstorming stage of the PBL process, which will then have a negative impact on the accumulation of subject knowledge.

One reason why students may leave out this important stage may be due to the difficulty of trying to unpack a complex and unstructured problem within a set timeframe (i.e., before the next tutorial). Therefore, it seems logical to suggest that the inclusion of a time-management strategy that could simultaneously scaffold both time-management and problem-solving skills would be beneficial. The present study introduced a scaffolding mechanism based on de Bono's (1995) Six Thinking Hats in to the pre-tutorial preparation stage of the PBL process. This approach encourages participants to investigate problems from a number of different perspectives. The results of the present study are extremely positive with the PBL groups who used the scaffolding showing the greatest increases in attendance and academic achievement, when compared to those without scaffolding.

Conclusion

The inclusion of scaffolding in the brainstorming stage of the PBL process was successful in increasing student attendance and academic achievement across all three levels of the PBL undergraduate program. The solution sheets used in this study can be seen as a series of manageable, short-term goals that facilitate student motivation, until the eventual long-term goal (i.e., solution) is provided. Future investigation should look to implement and moderate this approach in other subject disciplines.

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Appendix: Solution Sheet

Name of Student: *Module:* *Group:* *Problem:* *Date:*

In the following sections please be explicit in referencing your theoretical frameworks, empirical evidence, and examples. SEE THE EXAMPLE SOLUTION SHEET ON MOODLE FOR GUIDANCE ON HOW TO FILL IN THE SPACES.

<table>
<tr><th>Key Questions</th><th colspan="3">Comments</th></tr>
<tr><td>1. What information does the GROUP currently have?

2. What information is missing?

3. How will the GROUP get the missing information?</td><td colspan="3"></td></tr>
<tr><td colspan="4">Please Note: Before you have a proposed GROUP solution you will have to collect additional information until you have enough theoretical and scientific knowledge to provide a solution</td></tr>
<tr><td>1. What additional information does the GROUP now have?

2. Is there any other information missing?</td><td colspan="3"></td></tr>
<tr><td>3. Can the GROUP propose a solution to the problem?</td><td>Please place an X in the relevant section</td><td>YES</td><td>NO</td></tr>
<tr><td colspan="4">If the answer is YES above then move to the next section below and propose a solution.
If the answer is NO then you must collect further information until you are confident that you have all the information to propose a solution.</td></tr>
<tr><td><u>Proposed GROUP Solution</u>
In this section;

ONLY bullet point the important theoretical and scientific information related to answering the problem.

You must reference all the material according to the Coventry University Harvard system (See CUOnline for further information)</td><td colspan="3">Example:
• When extrinsic rewards are removed intrinsic motivation may reduce (Weinberg & Gould 2007)</td></tr>
</table>

THE SECTIONS BELOW ARE COMPLETED INDIVIDUALLY.

Key Questions	*Comments*
1. What do you like about the solution? 2. What don't you like about the solution?	
1. Will the solution work? 2. What are the dangers with the solution?	
1. What are the benefits of the solution? 2. Why should the solution work?	
1. Are there any new creative ideas? **Must be science based, WITH REFERENCES** 2. Are there any alternatives? Maybe from a different subject area.	

INDIVIDUAL Solution to the Problem (Maximum 2 pages in Ariel size 12 font)

Please note: The solution MUST be written in a scientific manner, with appropriate references. For example, when extrinsic rewards are removed an athlete's intrinsic motivation may reduce (Weinberg & Gould 2007) which then may result in reduced performance. For example, in the English Premiership if a player moves clubs and as a consequence his salary is reduced, he may no longer feel like putting in 100% effort in a match.

Start by providing the background theory before providing the final solution.

DELETE THE ABOVE COMMENTS BEFORE YOU WRITE YOUR SOLUTION

Based on the information that MY GROUP has gathered MY INDIVIDUAL solution to the problem is . . .