The effect of problem based learning on the attitude, motivation and reflection of students

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Abstract

This study investigates if problem-based learning (PBL) can be used supplementary to the traditional lecturing mode with 'under prepared' students in an extended stream 'analog electronics course' at Walter Sisulu University of Technology (WSU), South Africa. A comparison was made between students in the lecturing mode, supplemented by PBL afterwards and those in the PBL mode, followed by the lecturing mode. The PBL problem was designed in the format of a mini-project that integrates various concepts, in order to match a real-life situation. Surveys show many significant items of the attitudinal and motivational effects as well as the amount of reflection, favouring those students who were in the lecturing mode followed by PBL. Students who did PBL first find it more strenuous and they became negative once supplemented in the lecturing mode. The PBL component improves the student's teamwork and communication skills whilst they also learn to apply their knowledge to solve complex engineering problems. There is a real need to address gaps between employer expectations and higher education outcomes in South Africa and it might be worth it for WSU to move at least in part to PBL, especially where it followed the lecturing mode.

Introduction

The majority of black children are still receiving an inferior education in South Africa, and only 10% of them qualify to further their studies at a university (Bloch, 2010). According to Heckroodt (2005), some of the reasons why children do not achieve satisfactorily results at school level are: learners without one or more parents, poverty, not taught in their mother tongue in lower grades, classroom in a very weak physical conditions, lack of essential services at school such as electricity, water, sanitation and no fencing. Only 22.6% of the Mathematics learners and 24.4% of the Physical Science learners achieved a final mark of 50% or more during 2012 National Senior Certificate (NSC) examinations in South Africa (Education, 2012). Both of these subjects are required for most engineering studies.

The National Diploma: Engineering: Electrical Extended Programme at Walter Sisulu University of Technology (WSU) in the Eastern Cape, South Africa, targets applicants who are deemed to be "under-prepared" for the National Diploma programme. A student who obtains a mark below the required mark for entry into National Diploma: Engineering: Electrical, but above the absolute minimum threshold mark, might be offered a place in the four year Extended Programme. The threshold mark is determined by the university and students who may have slightly underperformed in the matric Mathematics, English or Physical science subjects, may be considered for this program. Traditionally, the foundational provision can be in the form of additional material necessary to facilitate the students understanding of the course material.

Students should be able to apply knowledge, but our experience with learners is similar to Miller, Bradford, and Cox (1998) who inform that in any kind of assessment, learners are very good at remembering and repeating material from lecture notes and textbooks but unable to solve problems which they have not previously seen or discussed. Problem solving requires the ability to create something new, the ability to break up information logically and the ability to evaluate usefulness for a purpose.

Alternative teaching and learning methods such as PBL is used with great success today, especially in professions where knowledge needs to be applied (Brodie, 2007). PBL involve learning in ways that use problem scenarios to encourage students to engage themselves in the learning process (Savin-Baden & Major, 2004). Some of the characteristics that Boud (1985) outlined in many PBL courses is as follow: acknowledge the base of experience of learners, students take responsibility of their own learning, crossing of boundaries between disciplines, intertwining of theory and practice, focus on the processes of knowledge acquisition rather than the products, staff role is to facilitate and not to instruct, a change in focus from staff assessment of outcomes of learning to student self and peer assessment, and a focus on communication and interpersonal skills.

Giving problems from the end of a chapter to students after a lecture or conducting laboratory experiments is not PBL (Yusof et al., 2004). PBL is also not project work that may include an extended piece of work on a particular topic, where the content and the presentation mainly be determined by the learners. Project Based Learning is very similar to Problem Based Learning and both are based on self-direction, collaboration and have a multidisciplinary orientation according to Perrenet, Bouhuijs, and Smits (2000). Some of the differences that they noted include:

- Project tasks usually take a longer time to complete since it is closer to professional reality than problem-based problems.
- Project work focus on the application of knowledge while problem-based learning focus on the acquisition of knowledge.
- Time and resource management as well as task and role differentiation by the student is very important in project-based learning.
- Self-direction is stronger in project work.

Students develop a positive attitude towards the PBL method and they find it more enjoyable compared to the traditional teaching methods which can be boring and irrelevant (Schmidt, Lipkin, de Vries, & Greep, 1989). This study investigates the effect of using PBL supplementary to the normal lecturing mode. The PBL is meant to provide an additional foundation to under prepared students' to facilitate the students understanding of the course material. Comparisons were made between students who were in the PBL instruction followed by the lecturing mode and those who were in the lecturing mode followed by PBL.

Research Questions

We want to explore the potential impact of supplementing the traditional lectures with PBL. Which sequence will be the most effective, PBL followed by the lecturing mode or vice versa in terms of:

1. Attitudes
2. Motivation
3. Reflection

Independent variable

The independent variable for the research study was the instructional strategy. The first level of the independent variable is the traditional lecturing mode followed by PBL strategy. The second level of the independent variable is PBL followed by the lecturing mode strategy.

Hypotheses

The research questions examined the effect of PBL on the attitude, motivation, and reflection and the differences of these were measured for those students who received PBL followed by traditional instruction (G1) versus those who received traditional instruction followed by PBL instruction (G2). The following three hypotheses were developed based on three research questions.

1. *Effect on student attitude toward analog electronics.*

It is hypothesized that the overall attitude will be more positive among students who cover all related prior knowledge first before participating in PBL activities, compared to those who participate in PBL activities first and then covering related theory thereafter by means of the traditional lecturing mode.

2. *Effect on student motivation toward analog electronics.*

It is hypothesized that the overall motivation will be higher among students who cover all related prior knowledge first before participating in PBL activities compared to those with lower prior knowledge.

3. *Reflection by the student.*

It is hypothesized that the amount of reflection is felt higher among students who cover all related prior knowledge first before participating in PBL activities compared to those who participate in PBL activities first and then covering related theory thereafter by means of the traditional lecturing mode.

Experimental Setup

Students should work in groups when the PBL method is followed. Each group should preferably have a separate venue, equipped with a library and internet facility, as well as a knowledgeable tutor. This research was done, using the Electronics 1 extended stream class of 29 students at WSU and the computer and electronics labs were used instead of separate small venues. Student groups therefore had to space themselves within these two venues to avoid interference from other groups, and a wandering tutor had to serve all groups. The wandering tutor scenario generally involves a faculty member as the tutor being available to many small groups that operate concurrently in one classroom (Northwood, Northwood, & Northwood, 2003). An institutional library is available within the same building and students had to go two floors down to visit it. It was possible to use the PBL method under these conditions due to the low student numbers, but it would have been more convenient for the students and wandering tutor if the Electronics lab contained some internet enabled computers.

The students were allocated to one of the two conditions: group one (G1), who did the PBL instruction, followed by the lecturing mode and group two (G2) who did the lecturing mode followed by PBL as shown in Figure 1. The two groups were balanced, based on their matric results and the students had to group themselves in dyads (pairs) according to their preference within each condition. The first year students had very limited knowledge in the design, construction and testing of electrical circuits and the problem that had to be solved during PBL was based on a suitable project-based laboratory, like a mini-project instead of a larger project for the whole course. Students had the opportunity to work on a real-world engineering project and gain and practice skills in wiring and testing electrical circuits, the proper use of electronic instruments and interfacing various components, similar to those of Nedic, Nafalski, and Machotka (2010).

The students who were busy with PBL activities used a computer lab for research, circuit design and simulation and the electronics lab for the circuit construction and testing. Students in the lecturing mode used a lecturing venue during the theory and the electronics lab during the practical experiment. The researcher and his colleague made turns to lecture and facilitate between the two groups.

Both groups completed various attitude-, motivation- and reflection surveys during the normal contact time of the course. The "tests and surveys" function on Blackboard was used to complete these. All the data were compared and the differences were analyzed with SPSS 20. The response rate was high with 100% in most cases and close to 100% where some students were absent for the day.

The 'Adaptive Learning Engagement in Science' questionnaire from (Velayutham, Aldridge, & Fraser, 2011), composed of 32 attitude questions, was adapted to assess students' attitudes toward the Electronics I course. It contains three factors of attitudes and perceptions; (1) learning goal orientation, (2) task value, and (3) self-regulation. A five-point Likert scale was used to measure the level of agreement of the student with the statement, with a score of 5 Strongly Agree, 4 Agree, 3 Neutral, 2 Disagree, and 1 Strongly Disagree.

The level of learning motivation was assessed by using a 36-item questionnaire that was modified from an Instructional Materials Motivation Survey (IMMS) of Keller (1993), who applied the theory of ARCS (attention, relevance, confidence, and satisfaction). A five-point Likert scale was also used to measure the level of agreement of the student with the statement, with a score of 5 Very True, 4 Mostly True, 3 Moderately True, 2 Slightly True, and 1 Not True.

The National Council for Curriculum and Assessment (NCCA) (2011) key skills student reflection sheet, composed of 54 reflection questions was adapted to assess students' reflection towards the Electronics I course. It contains six factors of reflection; (1) information processing, (2) critical and creative thinking, (3) communicating, (4) working with others, (5) being personally effective, and (6) class experience. A five-point Likert scale was used to measure the level of agreement of the student with the statement, with a score of 5 Strongly Agree, 4 Agree, 3 Neutral, 2 Disagree, and 1 Strongly Disagree. The reliability of the surveys was evaluated by means of Cronbach's Alpha coefficient. The coefficient calculated from the data of all surveys was ≥ 0.8, showing the reliability of the surveys. An independent t-test with a 95% confidence interval was used to compare the mean scores between the G1 and G2 for each of the individual items as well as for the different factors within the attitude-, motivation- and reflection surveys of the experiment. It should be noted that the sample size of 29 students were rather small.

Experimental Condition

The Electronics 1 Extended class already covered the "Instruments", "Semiconductor theory", "Diode theory" and "Diode characteristics" modules in the lecturing mode, when this research started. The next module, "Diode applications" lends itself towards a mini-project and was therefore used during the research. PBL classes based on solving real-life problems that students may face in their future jobs were done in a way as shown in Figure 1. During the 1st phase of the experiment, students from G1 were excluded from any lectures and were immediately confronted with a PBL problem while G2 continued in the lecturing mode. The groups exchanged roles during the 2nd phase, with G1 repeating all the relevant theory in the lecturing mode, followed by a traditional practical, while G2 were confronted with a PBL problem. Various surveys were done to determine the attitude; motivation, reflection, and knowledge of the students at the different phases (see Figure 1).

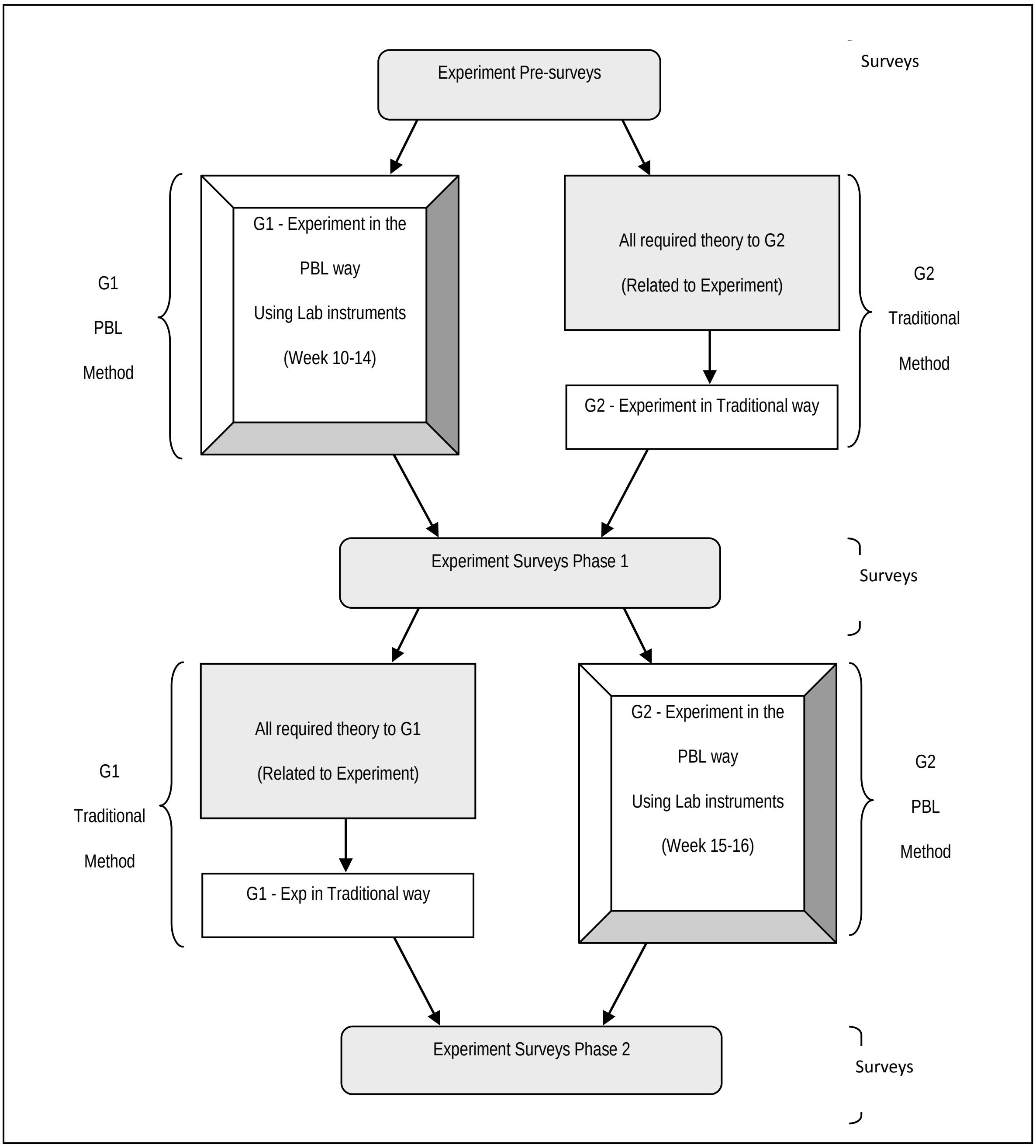

Figure 1. Illustration of how the experiment was conducted.

This experiment was done during the allocated class time for the subject, and the time-on-task was similar for both groups during each of the phases as shown in Table 1. The 2nd phase needed less time to complete since both groups were already familiar with the content which was mostly covered during the 1st phase.

Table 1. Overall time spent on the various activities

		Time Spent	
	Activity	**G1**	**G2**
Phase 1	Lecturing Mode	-	21%
	Traditional Practical	-	33%
	PBL Problem	54%	-
Phase 2	Lecturing Mode	13%	-
	Traditional Practical	17%	-
	PBL Problem	-	30%
	All Tests and Surveys	16%	16%
	Total	100%	100%

PBL problem - Power supply

Students in the PBL condition had to solve a real life problem while assuming that they were working for a real company. They had to develop a commercial modular power supply that can fulfil various clients' needs. The flagship model should include voltage regulation, capable of handling unstable incoming supply voltages from the electricity provider within certain limits. This problem was based on a real project and it was possible for the students to demonstrate its operation in the laboratory. Student had to use instruments such as a variac (variable transformer) to emulate a fluctuation in the supply voltage and most of them were not familiar with it. The students also had to use different loads, some with a higher power rating than what they were used to. These items together with the integration of various modules are not necessary covered during any theoretical lessons, and further research from the internet or library may be required. To solve this problem requires a lot of critical thinking, which makes this a more suitable PBL problem in the engineering field. Details of the problem are shown in Appendix 1.

The appropriate outcome based on the subject level, should be a power supply, allowing the client to choose from various voltages, regulated or unregulated and also filtered or not. Students should be able to design all possible power supplies, using a given transformer, including the use of any rectifier type, zener diode voltage regulator circuit and a capacitor filter. It was stipulated in the problem that students should avoid using any Integrated Circuits (IC's) to prevent them from moving out of the scope of this subject.

Results

It was observed whether there was a significant difference in students' attitude, motivation and reflection due to the sequential position of PBL. The results from the attitude, motivation and reflection surveys followed the same trend. One item related to attitude and four items related to reflection were significant, all in favour of the students who participated in the PBL activities during the 1st phase (G1). There was however a big turnaround in the results after the 2nd phase in favour of the G2 students who did the theory during the 1st phase and PBL during the 2nd phase. What they did during the 1st phase was used as prior knowledge and almost all of the 118 individual items related to the attitude, motivation and reflection surveys favour G2, 31 of them shows significance, confirming the posed hypotheses.

Attitude

Almost all of the thirty one individual items related to attitude favours G2 after phase 2. An independent-samples t-test showed significance ($p < .05$) for eight of these items as well as the "task value" factor (see Table 2).

Table 2. Individual and category items related to attitude during phase 2

	G1			G2				
Individual items	***M***	***SD***	***n***	***M***	***SD***	***n***	***p***	***t***
In this Electronics 1 class, One of my goal to master Electronic skills.	3.93	.799	15	4.64	.633	14	.014	-2.638
In this Electronics 1 class, What I learn can be used in my daily life.	3.87	.640	15	4.50	.650	14	.014	2.642
In this Electronics 1 class, It is important to me to improve my Electronic 1 skills.	4.20	.561	15	4.69	.480	13	.020	-2.474
In this Electronics 1 class, What I learn is useful for me to know.	4.07	.458	15	4.50	.519	14	.025	-2.378
In this Electronics 1 class, I can complete difficult work if I try.	3.87	.516	15	4.36	.633	14	.030	-2.293
In this Electronics 1 class, I do not give up even when the work is difficult.	3.73	.884	15	4.36	.633	14	.039	-2.171
In this Electronics 1 class, What I learn satisfies my curiosity.	3.60	.737	15	4.21	.802	14	.041	-2.150
In this Electronics 1 class, I can understand the contents taught.	3.60	.632	15	4.14	.770	14	.047	-2.080
Factor								
Task value.	3.28	.488	15	4.28	.647	14	.041	-2.146

These results support Hypothesis 1 that the overall attitude will be better among students who covered all related prior knowledge first before participating in PBL activities (G2) compared to those who participate in PBL activities first and then cover related theory thereafter by means of the traditional lecturing mode (G1).

Motivation

Most of the thirty-six individual items related to motivation favours G2 after phase 2. An independent-samples t-test showed significance ($p < .05$) for nine of these items as well as for the “attention”, “satisfaction” and “relevance” factors, all in favour of G2 (see Table 3).

Table 3. Individual and category items related to motivation during phase 2

	G1			G2				
Individual items	***M***	***SD***	***n***	***M***	***SD***	***n***	***p***	***t***
In this Electronics 1 class, The way the information is arranged on the pages helped keep my attention.	2.81	1.167	16	4.08	.862	13	.003	-3.247
In this Electronics 1 class, There was something interesting at the beginning of this lesson that got my attention.	3.19	1.167	16	4.23	.725	13	.009	-2.807
In this Electronics 1 class, I could relate the content of this lesson to things I have seen, done, or thought about in my own life.	2.60	1.121	15	3.77	1.092	13	.010	-2.270
In this Electronics 1 class, The content and style of writing in this lesson convey the impression that its content is worth knowing.	2.75	.931	16	3.69	1.109	13	.019	-2.488
In this Electronics 1 class, There are explanations or examples of how people use the knowledge in this lesson.	2.56	1.031	16	3.46	.967	13	.024	-2.400
In this Electronics 1 class, Completing the exercises in this lesson gave me satisfying feeling of accomplishment.	3.31	.873	16	4.15	1.068	13	.027	-2.336
In this Electronics 1 class, I felt good to successfully complete this lesson.	3.25	1.065	16	4.15	1.068	13	.031	-2.270
In this Electronics 1 class, The wording of feedback after the exercises, or of other comments in this lesson, help me feel rewarded for my effort.	2.69	1.138	16	3.54	.967	13	.042	-2.138
In this Electronics 1 class, It was a pleasure to work on such a well-designed lesson.	3.13	1.310	16	4.08	.996	12	.044	-2.133
Factors								
Relevance.	3.06	.558	16	3.641	.554	13	.009	-2.822
Satisfaction.	3.17	.915	16	3.923	.747	13	.024	-2.399
Attention.	3.34	.582	16	3.833	.551	13	.029	-2.307

These results support Hypothesis 2 that the overall motivation will be higher among students who covered all related prior knowledge first before participating in PBL activities (G2) compared to those who participated in PBL activities first and then cover related theory thereafter by means of the traditional lecturing mode (G1).

Reflection

Most of the fifty-one individual items related to reflection were higher in the G2 condition after phase 2. An independent-samples t-test showed significance ($p < .05$) for six of these items as well as for the "being personally effective" and "communicating" factors, all in favour of G2 (see Table 4).

Table 4. Significant individual and categorized items related to reflection during phase 2

	G1			**G2**				
Individual items	***M***	***SD***	***n***	***M***	***SD***	***n***	***p***	***T***
I used that feedback to help me to plan my next action and progress further.	3.47	.834	15	4.36	.633	14	.003	-3.221
I received help from my lecturer or lab technician.	3.53	.915	15	4.36	.745	14	.013	-2.646
I made helpful suggestions about ways forward.	3.80	.676	15	4.43	.646	14	.017	-2.556
I received help and feedback from my fellow students.	3.40	.986	15	4.14	.663	14	.026	-2.364
I used critical thinking to understand problems.	3.20	.561	15	3.79	.802	14	.030	-2.293
I helped resolve conflict/disagreement.	3.40	.737	15	4.07	.997	14	.048	-2.072
Factors								
Personally effective (able to accomplish a purpose; functioning effectively)	3.33	.973	16	4.14	.670	14	.015	-2.596
Communicating (be in verbal contact; interchange information or ideas)	3.175	.972	16	3.829	.578	14	.037	-.654

These results supports Hypothesis 3 that the amount of reflection is felt higher among students who cover all related prior knowledge first before participating in PBL activities (G2) compared to those who participate in PBL activities first and then cover related theory thereafter by means of the traditional lecturing mode (G1).

Conclusions

A brief overview of the main findings from the research, in relation to the stated hypotheses for the research study, is presented below.

The overall attitude towards the topic will be better among students who participate in the lecturing mode followed by PBL activities, compared to those who participate in PBL activities followed by the lecturing mode.

The statistical analysis of learner attitude levels supports Hypothesis 1 that the overall attitude towards the topic will be better among students who participate in the lecturing mode followed by PBL activities compared to those who participate in PBL activities followed by the lecturing mode (Table 2). The attitude of the G1 students were actually slightly better after phase 1, confirming the results from a previous experiment that the attitude of student (with a low prior knowledge) who participate in PBL activities will be slightly better than those in the lecturing mode. However, this study actually shows that G2, (those students who participated in PBL activities during the 2nd phase), entered with a higher prior knowledge (gained during phase 1) and had a considerably better attitude by the end of the 2nd phase. These students were now challenged to put their knowledge to the test and solve a related challenging problem instead of just doing a pre-arranged practical. On the contrary, the attitude of students in the G1 were negatively affected when they moved from PBL to lecturing mode during the 2nd phase, probably because they already gained most of the theoretical knowledge during the PBL activities.

The overall motivation towards the topic will be better among students who participate in the lecturing mode followed by PBL activities, compared to those who participate in PBL activities followed by the lecturing mode.

The statistical analysis of learner motivation levels supports Hypothesis 2 that the overall motivation towards the topic will be better among students who participate in the lecturing mode followed by PBL activities, compared to those who participate in PBL activities followed by the lecturing mode (Table 3). G1 students who participate in the PBL activities during the 1st phase were slightly more motivated after this phase, but the G2 students, who participated in PBL activities during the 2nd phase, entered with a higher prior knowledge (gained during phase 1) and were considerably more motivated by the end of the 2nd phase. Students became more motivated whilst busy with PBL activities, and G2 that covers the theory first, increased the students' confidence to solve the PBL problem by means of calculation and critical thinking. The G1 students, who did PBL activities during phase 1, became negatively motivated when they had to repeat similar work in the lecturing mode during the 2nd phase. Their attitude showed a similar tendency. These students already gained most of the theoretical knowledge during the PBL activities (phase 1), and they prefer practicals, working in groups and applying skills above theory. The theory seems to be the least attractive to them.

The amount of reflection is higher among students who participate in the lecturing mode followed by PBL activities, compared to those who participate in PBL activities followed by the lecturing mode.

Analysis of the data on reflection (Table 4) supports Hypothesis 3 that the amount of reflection is higher among the students who participate in the lecturing mode followed by PBL activities (G2) compared to those who participate in PBL activities followed by the lecturing mode (G1). The results suggest that students in the G2 condition learned how to search and present information, increase critical thinking, decision making, idea generation and collaborating with their co-students. Table 4 suggests that the students in the G2 condition experienced the learning as richer and caused a higher involvement during their presentations and working together.

Students in the G2 condition are confronted with a challenging problem that requires the integration of various aspects during the 2nd phase. This forces the students to think "critically and creatively" even though they have covered most of the theory during the 1st phase. In the G2 condition the students worked more in pairs and small groups although both G1 and G2 were grouped in dyads. The PBL method stipulates that each student in a group should explore a certain area within a project and make a specific contribution, which improved these factors. In contrast students who do experiments in a traditional way usually work together in a group, and there is a less-articulated role for an individual. This might cause some group members not to participate, but to rely on the partner to do the experiment instead. PBL is student centered and the G2 students had to take responsibility of their own learning during the 2nd phase, the most likely reason why the "personally effective" factor was significant for them.

Discussions

Results in this study are based on the attitude, motivational and reflection surveys and all quantitative data are thus limited to the five-point Likert scale questions within these surveys. The reflection survey also included a few open ended questions to allow students to reflect on their experiences during the course. Some of the more prominent qualitative data will be disclosed.

Students who did the PBL activity followed by the lecturing mode (G1)

Phase 1 - These students did the PBL activity with minimum prior knowledge, but enjoyed the practical component and preferred to work in groups most of the time. Some of them found it tiring by to search and find information by themselves. They felt satisfied in solving the posed problems but they were not completely confident with what they were doing. They had a marginally better attitude, were slightly more motivated reflected a little bit more and faired substantially better during a presentation than the G2 students, who were in the learning mode during phase 1.

Phase 2 – These students were negatively affected when they had to repeat the work in the lecturing mode during the 2nd phase. They then had to follow the instructions from the handouts during the practicals. The G1 students concluded that the PBL was more enjoyable although it proved to be more time-consuming and more difficult. They also indicated that PBL shows a higher effect on problem solving skills and that PBL caused a longer-term retention effect. This is in accordance with the outcomes of earlier meta-studies (Dochy, Segers, Van den Bossche, & Gijbels, 2003).

Students who did the lecturing mode followed by the PBL activity (G2)

Phase 1 – These students enjoyed the practical component after the theory, and felt that they had learnt most from their mistakes. They enjoyed verifying the theory by comparing calculated and measured values, but they failed to develop problem-solving skills during the lecturing mode.

Phase 2 – These students entered the PBL activities during the 2nd phase with much more prior knowledge and found the problem solving less tiring than those in the G1 condition which resulted in an extraordinarily improvement in their attitude, motivation and reflection. The PBL problem requires the integration of various concepts and G2 students found the problem solving challenging, but they felt that they have learned how to solve problems and develop skills for critical thinking. These students also concluded that PBL was more enjoyable and at the same time more time consuming, more difficult. As positive side effects they reported to have improved problem solving skills with a long retention effect.

Most students from both groups enjoy practicals and experiments more than theory and many of them indicated in the prior reflection survey that they would like to improve their practical, reasoning and most of all, their problem solving skills. Students appeared to be more active and involved while busy with PBL activities, resulting in a positive effect in the attitude, motivation and reflection. This is true for both groups, but it seems to be much more effective when the students enter PBL activities with higher prior knowledge like G2.

Recommendations

Mathematics, physics and much of the engineering rest upon a hierarchical knowledge structure and in many cases, students need to learn the basic concepts first which forms the pre-requisite for the more complex concepts to follow (Perrenet et al., 2000). According to Mills and Treagust (2003), students probably would not be able to repair missing concepts, even if they get used to the PBL method. Students in the G2 condition do not meet such a problem since they have covered the necessary theory first, equipping them with some prior knowledge before attempting to solve a problem, using the PBL method. Educators who want to apply PBL should perhaps cover sufficient theory first before introducing the problem to the students.

Educators should also be aware that PBL can be time consuming because of the student-centered teaching strategy. It is not easy to alter the pace such as in conventional methodologies where the teacher lectures on and the course goes on, even if the students do nothing (de Camargo Ribeiro & da Graça Mizukami, 2005). Assessment in PBL can also be comprehensive to include problem solving skills (Dochy et al., 2003).

A disadvantage of PBL is the additional manpower requirements to facilitate the various groups in larger classes (Wood, 2003). This was not the case during this study due to the small student numbers, and one wandering tutor was sufficient to serve all groups. Ideally, facilities should be adjusted to support the PBL needs. A typical venue with a wandering tutor should accommodate all student groups, but allow each group to share an internet enabled computer, necessary instruments, whiteboard and some desk space. Another disadvantage of PBL is the risk of not covering all the course (Chan, 2008). This is not the case in this study since all of the theory was covered either before or after the PBL.

Northwood et al. (2003) indicated that the skills and knowledge base that engineering students of a PBL curriculum acquire, directly affect and enhance their ability to be more successful engineers upon graduation. This study has shown that there is a big improvement in the attitude, motivation and reflection of those students who were in the lecturing mode, followed by PBL activities, indicating that it is a step in the right direction in creating outstanding engineers.

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Appendix 1 – Power Supply Problem

Assume that you are working for WSU Electronics. They would like you to develop a range of “BASIC” D.C. Power Supply circuits, from the most elementary up to those with regulated output voltages. Your design should be modular, allowing the client to buy any one of three basic units, and adding components according to their needs. Each basic unit should allow the client to select any one from a range of possible voltages. By adding more modules, the client should be able to reduce the voltage ripple of the output. Adding another one of two modules should provide the client with either a 5V or 12V regulated output voltage, regardless if the AC voltage from the Municipality fluctuates between 190V and 230V. The Power supply should signal to the user whether it is Off (Red) or ON (Green).

Your superior insisted that you should only use the transformer from WSU Electronics in your designs. This transformer can supply the following voltages: 0-8 V, 8-0-8 V and 19-0-19 V. No IC’s (e.g. 7805, 7812, LM317 etc.) should be used in any of the designs. You (and your partner) should test and demonstrate some of the various options in C2.8 as requested by your superiors. You should also submit a comprehensive final report (typed) that includes the process of how you solved the problems, showing all the various options including calculations and specifications for each and at least one set of measured values and circuits for each of the designs. Include the advantages and disadvantages of each design in your documentation. Finally, you will need to present your designs to a panel at WSU Electronics, convincing them that your designs are sound and that they should continue with the manufacturing of these Power supplies.