Students' Perceptions of Implementing Problem-Based Learning in a Physics Course

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Abstract
This study was undertaken to assess students' perception towards implementing an instructional method known as problem-based learning (PBL) in a physics course. Thirty science physics students from the School of Science and Technology (SST), and twenty pre-service science teachers from the School of Education and Social Development (SESD) at the University Malaysia Sabah were involved in this study. The findings in general come up with two themes: communication and sharing knowledge; and help in understanding concepts in Modern Physics/Physics content knowledge.

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1. Introduction
There has been much interest in the instructional design field around the concept of constructivism (see e.g., Driscoll, 1994; Duffy & Cunningham, 1996; Jonassen, 1991a; Wilson, 1996). Problem-based learning strategies are among the most frequently used constructivist designs approaches (see e.g., Ahlfeldt, Mehta, & Sellnow, 2005; Bowe, 2005; Constantino, 2002; Dahlgren & Dahlgren, 2002; Gossman, Stewart, Jaspers, & Chapman, 2007). Problem-based learning strategies have been used successfully with a variety of learners in a variety of context (see Duffy & Cunningham, 1996) including distance learner (Adelskold, Aleklett, Axelsson, & Blomgren, 1999), higher education (Ahlfeldt et al., 2005), medicine (Albanese & Mitchell, 1993), teacher education (Albion & Gibson, 2000), nursing (Baker, 2000), K-12 settings (Fosnot, 1988), engineering (Jayasuriya & Evans, 2007), doctoral

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education (Candela et al., 2009) and economic (Son & VanSickle, 2000). Problem-based learning strategies are becoming well established as a method and an area of study within the field of instructional design. Knowledge in this millennium is increasingly characterized by creative integration of information and learning from diverse disciplines. For these disciplines, PBL is probably the most extensively used tool (Ward & Lee, 2002), and many educational institutions worldwide have used PBL in educational reform and curricular innovation (Tan, 2004). Various studies using PBL in many disciplines, including in science, chemistry, biology, marine, and management suggest that PBL works especially well for complex, multi-disciplinary subjects like medicine. Koh, Khoo, Wong and Koh (2008), for example, reported that trainee doctors who learnt via PBL in a medical school showed enhanced social and cognitive competencies, such as coping with uncertainty and enhanced communication skills (Koh et al., 2008), and Colliver (1993) likewise reported gains in clinical skills (see also Blake, Hosawaka, & Riley, for more work on medical schools, 2000)

Although research indicated that the use of PBL in several context and other disciplines is engaging, and enabling students to develop a number of cognitive skills (e.g., Albanese & Mitchell, 1993) until now, little research has been done about to seek the students’ perception about PBL. With respect to improvement of education in higher education especially the science students and pre-service science teachers and the enhancement of the students’ engagement it is important to know how good PBL classroom practices can be enhanced and what are the views of students about effective PBL discussion and working together. Hence the purpose of this study is to explore the students’ perceptions about PBL that been implemented in a physics course to better know what is the real engagement deal between PBL and students. Two groups of students been participated in this study which is science physics students and also pre-service science teachers.

### 2. Problem-Based Learning Model

In this study, the researcher employed a model based on a combination of three models: that used by McMaster University (Barrows & Tamblyn, 1980); the Torp and Sage Model (IMSA, 1998); and the model used by Pastirik (2006). The main purpose of choosing a hybrid model was to ensure students explores their own learning, especially in terms sharpening their analytical skills, improving their critical justification in making decision, being a creative observer, and practicing their communication skills. All of these characteristics can be sharpened through these established learning models. Thus these PBL models were modified to suit undergraduate students.

There are five main stages that consist in this PBL which are: i. problem presented; defined the problems which is ill-structure and complex situation; ii. student recognizes learning issues and potential sources of knowledge and information; iii. engage in independent study by gathering and analyzing essential scenario information; iv. student then meet with the small group, they critically discuss the practical application of the information to the scenario; and v. student then critically reflect on both the content learned and the process.

These theories are important in this study to maintain the key features of PBL and which, at the same time, can be applied to undergraduate level physics students in Malaysia. This is because the learning process that is embraced in these PBL models also needs to be acceptable in Malaysia, and to promote the soft skills that are deemed important in Malaysian institutes of higher education. Hence, the researcher integrated these models in order to create new PBL model to address the research questions for this study.

### 3. Methodology

The intervention done in this study was administered in Semester II during the 2008/2009 academic year at the School of Science and Technology (SST) and at the School of Education and Social Development (SESD) University Malaysia Sabah (UMS), Malaysia. The sample consisted of students from the Bachelor of Physics and Electronic Programme (science physics students) and also from the Bachelor of Education with Science Programme (pre-service science teachers) students who was taking Modern Physics course during the semester. There were 50 students who took part in the study. The students were separated into two main groups. One group formed the PBL group for SST (N= 30) and the rest formed the PBL group for SESD (N=20). Error! Reference source not found. show the group sample for the study.
The intervention was conducted over 16 weeks. During the intervention the entire learning activities delivered by using Learning Management System (LMS) provided from the Educational Technology and Multimedia Unit (ETMU) from the Universiti Malaysia Sabah. The researcher prepared and organised the LMS followed the PBL (including the problem’s design) approach to fulfilled the learning and teaching activities via online learning. Thereupon students can access the LMS anywhere and at anytime they prefer suite to their own period and space. The university’s library also provides student with five hundreds computers that have the Internet connection. Thus those who did not have their own computer can use the computer at the Mega Lab.

There were five problems need to be solved by each group. The students learned in collaborative groups of 4-5 students, and there were a total of 10 groups involved all together (6 group from SST and 4 groups from SESD). Students were engaged in variety of synchronous and asynchronous PBL learning activities, such as chat rooms; forum; sending and receiving e-mail from group members and facilitator; uploading their own materials to be used by other friends; downloading materials from the Internet; sending assignments and also get feed-back from facilitator. Since there were no fix times during the learning process, they can choose their own flexible time to carry out all the activities by online. A facilitator guided the PBL groups cognitively in collaborative atmosphere all the way throughout the semester, in a very minimum direction.

Data were collected through an open-ended questionnaire they completed, and a semi-structure focus group interview after the intervention finished. The survey consisted of questions about the PBL approach used during the intervention. The main objective of this survey is to seek students’ opinions about using PBL approach, which is the learning outcome that they felt they obtained. In addition a focus group interview was conducted a week after the intervention completed. The interview questions were based on their confidence to do PBL tasks, their feelings about the learning and teaching process, their views of the modern physics content after finish with the course, and the influence of the instructional design towards their learning process.
4. Findings and Discussions

The data finding suggests that as far as the PBL online approach is concerned the students were positive in their feedback about the approach. Feedback for the physics science students and pre-service science teachers is first presented combined mixed and any differences between the cohorts then discussed.

Table 2 shows the themes that been categorised upon the open ended questionnaire and interview of students’ perception towards PBL. The themes been formed by a question which is: *What are the learning outcomes that you felt you obtained?* and also from focus group interview questions based on their perceptions after experiencing PBL.

| Generally                              |
|----------------------------------------|
| i. Communication and sharing knowledge |
| ii. Help in understanding concepts in Modern Physics/ Physics content knowledge |

| SST                                   |
|---------------------------------------|
| i. Problem solving skills             |
| ii. Being able to connect and build different ideas |

| SESD                                   |
|---------------------------------------|
| i. Improved English Language          |
| ii. More hardworking                  |

The findings from this study can be categorised into several themes: in general; SST’s feedback; and SESD’s feedback.

As shown in Table 2, analysis of the open-ended questions and interview data indicated that students felt they learned and gained two principle learning outcomes: *i. Communication and sharing knowledge; and ii. Help in understanding concepts in Modern Physics/ Physics content knowledge*. Here the researcher provides more detail to support this finding.

4.1 Communication and sharing knowledge

One of the key outcomes that the students talked about was their ability to communicate with others, and in particular with other group members.

Able to communicate and share my knowledge with team members. More responsible to my work. Thinking more deeply and creatively. Sustained interest in one subject. (R9, SST, M, *questionnaire*)

One thing that emerged from this was that they appreciated the importance of cooperation within the team when engaged in communication and sharing knowledge. Thus, enhanced communication resulted in a feeling that they learned how to cooperate with team members.

I also became able to communicate with much more confidence my opinion to others. More than that, I realize that cooperation between each member is important. (R9, SESD, F, *questionnaire*)
This collaboration helped the participants work better as group members, and they felt that by discussing the problems, they could solve the problems they were presented with during the intervention. The online component of the intervention meant this was not location-dependent:

By doing this PBL, we can make contact with other group members, we can chat with them although we are in separate places. Thus we can share thoughts and information to solve the problems that been given. (R8, F, SESD, interview)

4.2 Help in understanding concepts in Modern Physics/Physics content knowledge

The participants also felt that learning through the intervention helped them to understand that physics modern concepts relate to everyday life and activity. It seems this was due, in part, to the online nature of learning, as they could search for the topics on the Internet, and found, to their surprise, many sources which indicated that the physics concepts were related to everyday life:

I have gained lots of new experience through this programme. I know the concept and theory of physics modern more deeply and clearly. Via the Internet searching, I find extra information. Moreover, it also give us a chance to survey and find out the most ideal solution for the task given since our aim is to solve the task given. By having the internet discussion, I can exchange my idea with my group members. This make us know more deeply about the concepts which need to go through. (R13, SST, F, questionnaire)

Moreover, they have to critically select their appropriate information sources from the Internet:

I feel that I become more understand about what modern physics' theory is all about and I know how to apply it into our daily life to solve problems. I also know how to search for information, choose my source of information and decide which information I should take. (R16, SST, F, questionnaire)

As well as feeling that they understood the modern physics concepts better, the students also recorded that they felt more motivated during the intervention, and that this led to them becoming more independent learners:

[the PBL online intervention] helped increase my view of modern physics in real life. [It] introduced me to a new student centred approach which motivated the learning process because I could use the new technology of the Internet to solve physics problems. [I think it] trains the student to be independent, especially in ways to obtain information (R10, SESD, M, questionnaire)

Although there was feedback common to both cohorts of students as described above, some different comments were made by the different groups. For example, the SST students said that they also gained knowledge on their i. Problem-solving skills, ii. Their ability to connect and build different ideas, and the iii. Enhancement of computer skills, and this is described below.

4.3 Problem-solving skills

An interesting example was noted by a participant about how this instructional method helps her in her problem-solving skills, especially when it comes to solving problems online where they need to become accustomed to the online requirements:

I know how to find information via multimedia. I also know how to submit or send and assignment via e-mail. I also know how to solve a problem even not in 3D. (R2, SST, F, questionnaire)

4.4 Ability to connect and build different ideas

Another student commented on how she is now able to connect and build different ideas, saying that:

From what I had experienced, I felt that I manage to obtain most of the learning outcomes that are supposed to be obtained by each of student that take this kind of learning. Problem based learning makes me tune in with this subject, what I mean is I can develop, connects and build my ideas and this rises my self-confidence in learning modern physics. (R15, SST, F, questionnaire)
In contrast, the SESD students felt that they i. Improved their English language while experiencing this PBL program and were ii. More hardworking than before experiencing this PBL program, probably as a result of what they saw as a more novel and exciting mode of learning.

4.5 Improved their English language

Since the PBL intervention was delivered in English, one of participants noted that it is their opportunity to improve their English proficiency in talking, speaking and learning in English:

...then the second thing, from time to time we also can improve our English language, because usually in traditional class we have very limited vision, so with PBL program we can improve our English usage. (R26, M, SESD, interview)

4.6 More hardworking

One thing about PBL is the need of students to become self-directed learners and they also need to drive themselves to take full charge of their learning process, thus it managed to motivate them to become more punctilious in their learning activities, as a participant commented:

By going through the PBL I become more hardworking, because I also go through the Internet to search a lot of things not only to find information for the PBL, but for the others courses assignment. (R26, M, SESD, interview)

Besides reporting working harder, the SESD students also commented out that they felt they had become an ‘advanced learner’ compared with traditional students, and in this way they were attracted to the learning process itself.

Honestly, I had gone through this and that’s why I think this kind of learning will be far more effective than traditional. Also, I had the opportunity to be an advanced learner of modern physics. It is exciting in this way and I prefer it this way for this is the basic idea for the student to begin in liking this subject. Sometimes, I get this kind of excitement when I learn something new. I think if I don’t pick problem based learning, it will be a bit boring doing all those tutorials because I like something that is more independent and a step ahead of all traditional learning styles. (R15, SST, F, questionnaire)

These findings agreed with works done by Gijbels, Dochy, den Bossche, and Segers (2005) and Shore, Shore and Broggs (2004), where learning in PBL format can lead to long-term retention of knowledge, it can also improve the combination of knowledge and result in an increased intrinsic interest in course subject. Pea (1993) accentuated that in PBL, students work together on complex problems, thus sharing out the cognitive load among group members as well as taking benefit of the distributed expertise within group. Swapping knowledge and information is a vital part of learning together as knowledge is constructed socially through joint efforts towards common objectives. As some would disagree, the very essence of collaboration is the construction of shared meaning (Rochelle, 1996). Thus from this socio-cultural perspective, as learners participate in activities, they internalise what they have learned from working together (Palincsar & Herrenkohl, 1999; Vygotsky, 1978).

These findings also support by Schank, Berman and Maepherson (1999) suggested that this approach also encourages better student learning through learning by doing and to enable problem-solving, analysis, creativity and communication to take place in the classroom (Bates, 2000). Many scholars in PBL (e.g. Camp, 1996; Edens, 2000; Kaufman, 1998; Major & Palmer, 2001; Rhem, 1998) agreed that it must be student-centered and self-directed learning for the students in order to be more efficient in problem solving. Besides many argue that students are ought to be active and need lots of efforts in discovering the problem situation instead of having problem given to them (King, 2008).

5.Conclusions

The purpose of this study was to investigate the students' perception on implementing PBL in a physics course in terms of the learning outcomes the felt they obtained. In conclusion it is clear that students gained benefits through this PBL approach. The findings come up with several themes focused on their communication skills improved, knowledge they able shared together, it help in to understanding concepts in Modern Physics/ Physics content knowledge. Whilst majority of science physics students agreed that they were able to apply skills in solving problems and being able to connect and build different ideas. In other perspectives, pre-service science teachers
enthusiastically agreed that they become more hardworking and able to improved their proficiency communicating and writing in English. Thus this findings should be able to give some discrisptions and ideas to educators and lectures on what is the real engagement deal between PBL and students when this approach been implemented in a physics course.

References:
Adelskold, G., Aleklett, K., Axelsson, R., & Blomgren, J. (1999). Problem-based distance learning of energy issues via computer network. Distance Education, 20(1), 129-143.

Ahlfeldt, S., Mehta, S., & Sellnow, T. (2005). Measurement and analysis of student engagement in university classes where there are varying levels of PBL methods. Higher Education Research & Development, 24(4), 5-20. 10.1080/0729436052000318541

Albanese, M. A., & Mitchell, S. (1993). Problem-based learning: A review of literature on its outcomes and implementation issues. Academic Medical Journal, 68, 52-81.

Albion, P. R., & Gibson, I. W. (2000). Problem-based learning as a multimedia design framework in teacher education. Journal of Technology and Teacher Education, 8(4), 315-326.

Baker, C. M. (2000). Problem-based learning for nursing integrating lessons from other disciplines with nursing experiences. Journal of Professional Nursing, 16(5), 258-266.

Barrows, H. S., & Tamblyn, R. M. (1980). Problem-based learning: An approach to medical education. New York, NY: Springer Publishing Company, Inc.

Bates, T. (2000). Managing technological change: strategies for college and university leaders. San Francisco, CA: Jossey-Bass Publisher.

Blake, R. L., Hosakawa, M. C., & Riley, S. (2000). Student performance on step 1 and step 2 of the United States medical licensing examination following implementation of a problem-based learning curriculum. Academic Medicine, 75, 66-70.

Bowe, B. (2005). Assessing problem-based learning: A case study of a physics problem-based learning course. In I. M. L. T. Barret, & H. Fallons (Ed.), Handbook of enquiry & problem-based learning (pp. 103-111). Galway, Ireland: Celt.

Camp, G. (1996). Problem-based learning: A paradigm shift or a passing fad? Medical Education Online, 1(2).

Candela, L., Carver, L., Diaz, A., Edmunds, J., Talusan, R., & Tarrant, T. A. (2009). An Online Doctoral Education Course Using Problem-Based Learning. Journal of Nursing Education, 48(2), 116-119.

Colliver, J. (1993). Effectiveness of problem-based learning: A review of literature on its outcomes and implementation. Academic Medicine, 68, 52-81.

Constantino, T. E. (2002). Problem-based learning: A teaching approach to teaching aesthetics. Studies in Art Education, 43(3), 219.

Dahlgren, A. M., & Dahlgren, L. O. (2002). Portraits of PBL: Students’ experiences of the characteristics of problem-based learning in physiotherapy, computer engineering, and psychology. Instructional Science, 30, 111-127.

Driscoll, M. (1994). Psychology of learning for instruction. Boston, MA: Allyn and Bacon.

Duffy, T., & Cunningham, D. (Eds.). (1996). Constructivism: Implication for the design and delivery of instruction. New York, NY: Macmillan.

Edens, K. M. (2000). Preparing problem solvers for the 21st century through problem-based learning. College Teaching, 48(2), 55-60.

Fosnot, C. (1988). The dance of education. Paper presented at the Association for Educational Communications and Technology.

Gijbels, D., Dochy, F., den Bossche, P. V., & Segers, M. (2005). Effects of problem-based learning: A meta-analysis from the angle of assessment. Review of Educational Research, 75(1), 27-61.

Gossman, P., Stewart, T., Jaspers, M., & Chapman, B. (2007). Integrating web-delivered problem-based learning scenarios to the curriculum. Active Learning in Higher Education, 8(2), 139. 10.1177/1469787407077986

IMSA. (1998). An introduction to problem-based learning. Retrieved September 1, 2008, from http://score.rims.k12.ca.us/problem.html

Jayasuriya, K., & Evans, G. (2007). Journeys in problem-based learning during the first year in Engineering. Paper presented at the 2007 AaeE Conference, Melbourne, Australia.

Jonassen, D. H. (1991a). Evaluating constructivist learning. Educational Technology, 28(11), 13-16.
Kaufman, D. (1998). Problem-based learning: Using cases to teach about how to deal with ethical problems. *NCEHR, 8*(2).

King, E. (2008). Can PBL-GIS Work Online? *Journal of Geography, 107*(2), 43-51. 10.1080/00221340802202237

Koh, G. C., Khoo, H. E., Wong, M. L., & Koh, D. (2008). The effects of problem-based learning during medical school on physician competency: A systematic review. *CMAJ, 178*, 34-41.

Major, C. H., & Palmer, B. (2001). Assessing the effectiveness of problem-based learning in higher education: Lessons from the literature. *Academic Exchange Quarterly, 5*(1).

Palincsar, A. S., & Herrenkohl, L. R. (1999). Designing collaborative contexts: Lessons from three research programs. In A. M. O'Donnell & A. King (Eds.), *Cognitive Perspectives on Peer Learning* (pp. 151-178). Mahway, NJ: Erlbaum.

Pastirik, P. J. (2006). Using problem-based learning in a large classroom. *Nurse Education in Practice, 6*, 261-267. 10.1016/j.nepr.2006.02.003

Pea, R. D. (1993). Practices of distributed intelligence and designs for education. In G. Salomon (Ed.), *Distributed Cognitions: Psychological and educational considerations* (pp. 47-87). New York, NY: Cambridge University Press.

Rhem, J. (1998). Problem-based learning: An introduction. *The National Teaching and Learning Forum, 8*(1), 1-7.

Rochelle, J. (1996). Learning by collaborating: Convergent conceptual change. In T. D. Koschmann (Ed.), *CSCL: Theory and practice of an emerging paradigm* (pp. 209-248). Mahwah, NJ: Erlbaum.

Schank, R. C., Berman, T. R., & Macpherson, K. A. (Eds.). (1999). *Learning by doing* (2nd ed.). Mahwah, NJ: Lawrence Erlbaum.

Shore, M., Shore, J., & Broggs, S. (2004). Allied health applications integrated into development mathematics using problem-based learning. *Mathematics and Computer Education, 32*(2), 183-189.

Son, B., & VanSickle, R. L. (2000). Problem-solving instruction and students' acquisition, retention, and structuring of economics knowledge. *Journal of Research and Development in Education, 33*(2), 95-105.

Tan, O. S. (2004). Students' experiences in problem-based learning: three blind mice episode or educational innovation? [Electronic Version]. *Innovations in Education and Teaching International, 41*, 169-184.

Vygotsky, L. S. (1978). *Mind in Society: The development of higher psychological process*. Cambridge, MA: Harvard University Press.

Ward, J. D., & Lee, C. L. (2002). A review of problem-based learning. *Journal of Family and Consumer Sciences Education, 20*(1), 16-26.

Wilson, B. (Ed.). (1996). *Constructivist learning environments: Case studies in instructional design*. Englewood Cliffs, NJ: Educational Technology.