Problem-based Learning: A Teaching Method to Enhance Learning Experience for Students in Service-learning

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ABSTRACT

This paper compares and contrasts lecture-based learning (LBL) and problem-based learning (PBL) as a teaching method for international service-learning projects. We use surveys and interviews in the context of a robotics workshop in Myanmar, organized as an international service project, to uncover uncertainties and limitations associated with LBL. Our results suggest that LBL is not a suitable teaching method for service-learning settings, while PBL is more feasible and effective. We elaborate on the teaching process and implementation, and describe benefits on students' learning outcomes.

Key Words: International service-learning, problem-based learning, robotics.

1. INTRODUCTION

Interest in international service-learning projects is rapidly growing in higher education. Service-learning (SL) provide opportunities for students to obtain a multitude of benefits, including increase in understanding of class topics, gaining hands-on and team-work experience, discovering personal values and beliefs, developing research and problem-solving skills, and growing in interpersonal skills (Furo, 1996a; Astin & Sax, 1998). Kuh (2009) acknowledged that development of these generic skills is crucial for students to facilitate solving complex multidisciplinary problems when entered to working environment after graduation. The projects that take place overseas, namely the international projects, offer unique experience for students to broaden their views in social responsibility, civic engagement, and global citizenship (Hunter and Brisbin, 2000; Hutchinson, 2005). Deeley (2010) stated that such experience provides positive growth to students in their global outlook, racial and cultural sensitivity, and even their languages.

To ensure targeted learning outcomes, complex and carefully designed instructional protocols for international service-learning projects, including well-designed scaffolding at different phases, are required. Over the past 20 years, research has been carried out in preparation phase and reflection phase. Furco (1996b) established types of SL activities that can bring about different civic, social, emotional and skill-acquisition impacts. Florida (2013) presented planning and structures of short-term, large-scale international SL projects. Stacey et al. (1997) prepared an evaluation handbook for instructors to monitor and evaluate student learning progress. Shumer et al. (2000) identified multiple forms of SL

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assessment. Ash and Clayton (2004) investigated the effectiveness of different assessment methods to enhance students' educational and professional outcomes. These frameworks provide concrete fundamentals for instructors to guide students to articulate their responsibilities and service objectives in the preparation phase and facilitate "reflection sessions" for students to delve, think, and analyze their observation obtained during the execution phase to achieve the learning outcomes. However, to the best of the authors' knowledge, guides for students in execution phase, specifically for teaching methods feasible in SL settings, are lacking.

Recent observation discovers that teaching methods used in typical classroom environment, such as lecture-based learning (LBL) teaching method, is not suitable for teaching in SL settings. It was observed that LBL is i) passive as service recipients mainly learn by listening, taking notes, and memorizing, ii) biased to teacher-specified knowledge, and iii) preclusive to interactivities and discussion such that students are unable to obtain feedbacks from service recipients on their learning progress. The authors believe that targeted learning outcomes can be achieved if and only if service objectives are successfully met in preparation, execution, and reflection phase. Sigmon (1994) stated that service is of equal weighted at different phases and highly coupled together.

Indeed, meaningful experience obtained during execution phase is crucial as a key parameter that affects outcomes achieved from reflection sessions. However, the lack of an effective teaching approach appears to be a serious obstacle for students to reach expected objectives and consequently leads to failure in achieving the potential learning outcomes. Utilizing observation obtained from an international SL project (a robotics workshop), this paper seeks to 1) identity uncertainties and limitations associated with the LBL teaching method, 2) present an alternative pedagogy, problem-based learning, that is suitable for students to use for teaching in SL settings and its implementation, and 3) analyze its benefits on students' learning experience and outcomes.

2. CASE STUDY

2.1 Background

The background of our paper is a service-learning project that took place in Yangon, Myanmar. Twenty undergraduate students were enrolled and divided into two teams of ten to provide an introduction to robotics workshop to two groups of 45 Computer Science students (service recipients) in two universities: University of Computer Science, Yangon and Dagon University. The workshop lasted for 5 days and was designed to cover knowledge related to design and operation of robotics systems such as computer programming, hardware/computer interfacing, sensors and signal conditioning, feedback control, and actuators and power electronics.

Table 1 shows the outline of the robotics workshop prepared by the students and the daily arrangement for morning and afternoon sessions in detail. The first 3 days of the workshop focused on delivery of materials including programming in Arduino environment, basic concepts of electric circuits, functions of electronic components, and soldering techniques, with the main mode of delivery being lectures, supplemented with powerpoints. Students believed that a lecture-based teaching environment was a straightforward way in which to impart knowledge to the recipients efficiently and allow them to have a greater control on recipients' learning progress. Some labs were included as means for the service recipients to explore and get hands-on experience with the robots. On the 4th and 5th day of the workshop, they would need to build mini-car robots (Figure 1) to solve a maze problem

	Day 1	Day 2	Day 3	Day 4	Day 5
Morning Session	Welcoming Notes	Concepts of Movement	Expansion on Mini Car Robot Testing and Calibration	Preparation for Competition 1	Preparation for Competition 2
	Introduction to Robotics	Interaction with surroundings			
	Expectation and Challenges	Line following exercise 1 (Hard-coding)		Competition 1	
	Introduction to Arduino C	Improvement on robot performance			
Afternoon Session	Basic concepts in electronic components	Basic concepts in soldering	Demonstration for Competition 1	Competition 1 (continued) Discussion/reflection Demonstration on Competition 2	Competition 2 Discussion/reflection Closing notes
	Training exercises	Line following exercise 2 (Using feedbacks)			

Table 1: Original outline for the 5-days robotics workshop.

	Day 2	Day 3	Day 4	Day 5
Morning Session	Recap of Basic Electronics	Working Principle of Photoresistors	Working Principle in BJT	Solving the Maze
	Basic Arduino Programming	Programming on Photoresistors	Programming in BJT	
	LED Labs/Discussion	Photoresistors Lab/Discussion	BJT Controlled Sensors Lab/Discussion	
Afternoon Session	Working Principle with LEDS and Piezo Plate	Working Principle with Ultrasonic Sensors	Working Principle of Motors	
	Programming structure with PWM	Program Control with Ultrasonic Sensors	Program Control with Motors	Solving the Maze (continued)
	Piezo Plate Lab/Discussion	Ultrasonic Sensors Lab/Discussion	Motor Labs/Discussion	
	Integration Lab: Traffic Lights	Integration Lab: Invisible Weight Scale	Integration Lab: Line Detection	

Table 2: Workshop outline with PBL teaching process.

(Figure 2). The recipients were given different sensors (i.e. light and ultrasonic) and were expected to apply programming skills that they have learned to solve the problem. Different levels of difficulties were built into the problem. The ultimate goals for these activities were 1) to facilitate problem-solving with robotics, 2) to elaborate two problem-solving techniques: divide and conquer and trial-and-error, and 3) to emphasize the idea of "things that work in theory, but not in practice".

2.2 Assessment of LBL Teaching Method

Evaluation forms were distributed at the end of the first day of the workshop. The forms were composed of 2 parts: a questionnaire of 3 questions and a 10-question problem set. The purpose of the questionnaire is to allow the students to collect feedback on their teaching performance. The questions are: "What do you think of our teaching method?", "How well do you feel you learned the workshop materials?", and "How would you describe your overall learning experience?" 80% of the recipients completed the questionnaire. However, the feedback on the first-day workshop experience is relatively discouraging.

Critics were that the teaching environment is passive:

> "Teachers speak well ..., power-point slides are good and organized ..., but learning should not be only listening, copying texts ... and memorizing them."

Another complaint was that the lectures on electronic components are deductive:

> "[He] introduced ... BJTs, [its] theory, characteristics, functions, models, and equations like voltage and current ... these fundaments can be helpful, but they are not for building the robots."

Many recipients also reported that lecture materials are abstract and difficult to understand:

> "Even I've learnt Java in the previous semester, I don't know the "priority" criteria when using the "if" statement ..., without practice, logic flow is hard to understand."

> "The programming part of the lecture is difficult to follow... quite a lot of time we don't know what to do and how to start writing the program... it is quite discouraging."

The last common feedback from the recipients was that they only study alone and they are fear to interrupt the workshop and raise questions:

> "I wish that the teachers standing aside could help us in the middle of the lecture ... a lot of us have questions ..., but we don't know how to ask questions."

In addition to the questionnaire, a problem set was distributed to the service recipients. The problem set is consisted of 10 multiple-choice questions related to what they have learned in the first day. 33 recipients completed the 10-question problem set. The purpose of this problem set is to allow the students to have a quantitative understanding on recipients' learning process on the first-day workshop. Figure 3 shows the overall result of the problem set with an average score of 4.48 or 44.8 %. Figure 4 shows the results for the programming part and the electronic component part of the problems and the average score are 2.67 or 53.3% and 1.82 or 36.4%, respectively. These results indicate that the learning process is on the lean side. In particular, they seem to have difficulty with the materials associated with the electronic components.

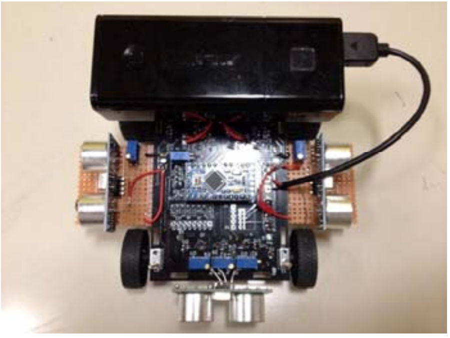

Figure 1: Mini-car robot.

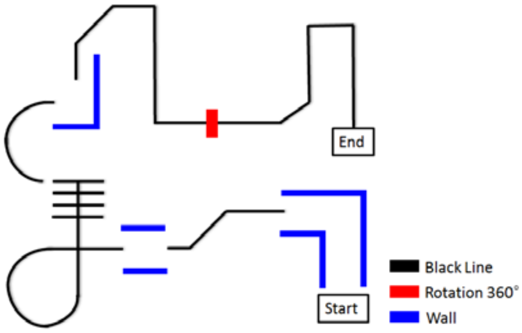

Figure 2: Schematic of maze.

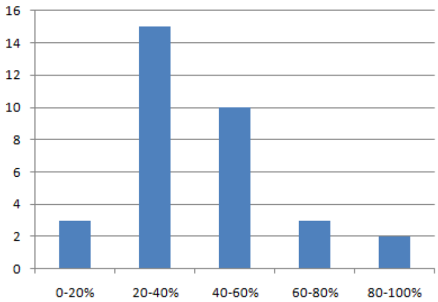

Figure 3: Results for full problem set. Number of service recipients vs score in percentage.

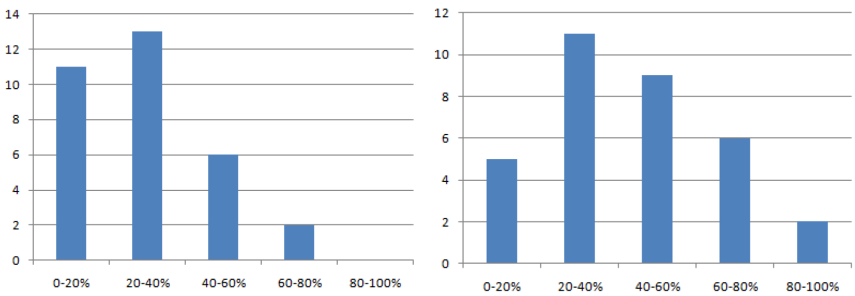

Figure 4: Results for partial problem set. Number of service recipients vs score in percentage. (Electronic components part [left] and Programming part [right])

Together with the feedback from the questionnaire and the results from the problem set, we can summarize the issues as follows: 1) there is no mechanism for students to ensure that recipients are intellectually engaged with the materials, 2) it emphasizes learning by listening in which neglects higher orders of thinking, 3) it is not well suited for teaching complex and abstract materials, 4) it fails to provide students with in-time feedback about the level of service recipient learning, 5) it presumes that all service recipients learn at same pace and are at same level of understanding, and more importantly 6) it precludes discussion and interactions.

The unfortunate experience obtained from the execution phase led to relatively poor outcomes from the first reflection session. Students were worried, disappointed, and discouraged. Discussions were merely concentrated on teaching matters. Little attention was paid to understanding the recipients in terms of the way they learn, the way they think, and the driving mechanisms. The uncertainties and limitations inherent with the LBL teaching method appeared to be a serious obstacle to achieving the targeted objectives and the potential learning outcomes.

3. PROBLEM-BASED LEARNING AND ITS IMPLEMENTATION

Problem-based learning (PBL) is an active learner-centered teaching approach. PBL has been considered in different professional areas, such as engineering, science, and medical, as a method of delivery (Cline & Powers, 1997; Laplaca et al., 2001; Kampen et al. 2004; Awang & Ramly, 2008). It is an effective pedagogical approach that fosters active learning, intrinsic motivation, open inquiry, problem solving, critical thinking, and interpersonal and collaborative skill.

Through PBL, a real-life problem, selected to meet educational objectives, is the starting point of the learning process. Given a conditioned scenario and with the guidance from students, service recipients first define the problem, understand what to be solved, and use brainstorming to make hypotheses and identify necessary knowledge to be acquired. Then, service recipients establish keywords and explore and understand relevant materials. Finally, recipients experiment their learning through mini laboratories and specific the additional information required to solve the problems. In PBL environment, it is not purely about solving a problem, but it uses the problem as a vehicle to increase knowledge and understanding (Brodeur et al., 2002).

PBL promotes discussion and group learning. In our context, recipients work in groups of three to six with a student. Students play a role as instructors providing contents to recipients and simulating meaningful group discussion. In this environment, recipients absorb lessons in a more intrinsic way and allow them to have a more engaged and comfortable atmosphere to raise questions. For students, this provides an effective platform for them to seek for what the recipients need help with and recognize precisely what they have to prepare for next lecture. Discussion also facilitates group learning. It combines acquisition of knowledge with development of generic skills and attitudes, such as communication skills, teamwork, independent responsibility of learning, sharing information and respect for others.

Table 2 shows the modified outline of the robotics workshop and the implementation of PBL. The PBL teaching process consists of 3 stages to promote understanding, thinking, application, and discussion.

3.1 Stage 1. Overview and Review

This is a 10 to 15-minutes opening section of the workshop. The overview section can present an overall picture to service recipients to realize what to be learned. It can also provide an objective summary to emphasize what the take-away messages and materials will be at the end of the workshop. The review section can allow students to reiterate important materials learned from previous workshops and provide justification on how they are important to meet future objectives.

3.2 Stage 2. Learning, Application, and Discussion

There are 3 levels in this stage: 1) lectures, 2) mini labs, and 3) discussion sections.

Level 1. Lectures

The lectures, approximately 30 to 45 minutes, are to provide basic understanding of a subject matter to service recipients. In contrast to LBL teaching environment, fundamental concepts are introduced with real-life related analogies and service recipients learn the materials through step-by-step worked-out examples with hand-in-hand fashion.

Level 2. Mini Labs

These are short lab sessions in a structured environment, for example, measuring and observing certain electronics phenomena. Problems are designed to be completed in approximately 15 to 20 minutes and can be "mass-produced", as in each recipient team solves the same problem as other teams at the same time. Examples in the robotics workshop include LED and piezo-plate labs in Introduction to Basic Electronics, color recognition and length detection in Sensor Labs, and voltage/current control and motor rotation in Dynamics Labs. These exercises simulate not only learning and application, but also lead to group and class discussion.

Level 3. Discussion Sections

These sections facilitate group and/or class level discussion. Students can discuss, explore, and investigate interesting observation/phenomena with recipients to engage learning, add interest on specific matters, provide and obtain feedback, promote lecture preparation, encourage dialogue among and between students, develop important communication skills, and have opportunity to practice using the language of the discipline.

3.3 Stage 3. Integration with Macro Labs

Problems at this stage are longer in duration than previous stages, ranging from 45 minutes to an hour. Problems are more complex, entailing more planning and combination for different knowledge. Examples at this workshop include *Traffic Lights* with the use of LEDs and piezo-plate, *Invisible Weight Scale* with light and ultrasonic sensors, and *Line Detection* with light sensors and motors.

Stage 3 presents a close-guided, complex, multi-faceted, unconstrained, and highly motivating environment for recipients to full apply the knowledge learned and develop problem-solving and critical thinking skills. Stage 1 and 2 provide a constructed, interactive, and comfortable environment for recipients to learn, practice, and discuss.

Our hope was that the PBL teaching method can overcome the uncertainties and constraints encountered with LBL teaching method and provide encouraging and meaningful experience to students, thus enhancing the overall learning experience in service-learning.

4. DISCUSSION OF PBL TEACHING METHOD

Feedback regarding the learning experience in the PBL environment was obtained at the end of the 5-day workshop. Service recipients were interviewed and students were asked to turn in a reflective report. In the feedback collected from the recipients, the remarks on the method were:

> "Wonderful, it drives me to participate actively."

Many recipients reported that the teaching environment is more pleasant and it motivates one to delve deeper into the subject:

> "I like the lectures, the examples, the mini-labs, and the integration labs. I feel I really learn something … and this is the first time I can make something happen from what I learn … the piezo-plate actually made sound."

PBL encourages teamwork and discussion furthers learning:

> "The labs are hard … but we work together … we discuss … we fail … but we try again and we solve the problem."

> "Teachers are nice … they answer my questions patiently … I like to have discussion with them because I can learn more."

Feedback collected from students was also positive. Students had better understanding and motivation on the service objectives:

> "They can't learn everything in 5 days … it is about a lesson to explore matters and skills that they have never had before."

Some students reported that they were allowed to spend time, have more interaction, and even establish friendship with the service recipients:

> "Solving complicated problems is difficult for them … so I show them how I will break down the problems … I guide them through one by one and step by step … and they like it."
>
> "Most of us are sick on the third day of the workshop … I really did not expect something like this would happen … my student actually gave me a bag of cough drops … and she said we are friends. "

Many students expressed that the friendship relationship allow them to know more about the recipients on their culture and beliefs. Students reported that what they learned from the recipients help them to widen their civic engagement and social responsibility:

> "To keep peace when facing cultural differences … the ideas is about respect."
>
> "Myanmar people are kind and they care about each other and even strangers like me… when I was in Hong Kong, I usually only think about me."
>
> "Using robotics is their dream … even though I can only sleep for only 30 minutes, I still need to provide the best lectures for them."

Some students even mentioned that the problem solving skills, critical thinking, and teamwork would be helpful for them to tackle challenges in the future:

> "As a health-care professional in the future, I clearly understand that I have to work with colleagues effectively to identify what patient needs, organize and analyze information in order to make a clear decision and take action … and communication is essential to achieve this goal."

According to above positive impacts on service recipients and our students, PBL offered interactive communication opportunities for both parties. In addition to providing effective learning environment to recipients, the interaction also allowed students to acquire better understanding and actual needs of the recipients. Under this circumstance, students could make significant changes and positive impacts in the execution phrase. Students' flexibility and adaptability, hence, could be enhanced. As a consequence, students gained rewarding service experience, leading to thoughtful sharing in reflection. Thus, impactful learning gains could be harvested in different dimensions of service-learning.

5. CONCLUSION

This paper presents the use of problem-based learning pedagogy for international service-learning projects. PBL is shown to be an effective pedagogical approach for students to use during service delivery. With the concept of PBL, an active and more learner-centered teaching method is developed and implemented to service-learning settings. Using observation from a robotics workshop as an illustration, the benefits of PBL on enhancement of the overall learning experience for students are analyzed.

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