Analysis on Existing Project-Based Learning Application in Various Education Levels and Technology- Integrated Project-Based Learning

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Abstract: Project-based learning is a new and high-quality teaching methodology that has been put into use in the past few decades. Through the use of literature review and case analysis, the paper evaluates how PBL and support learners' study in all levels of education and how emerging education technology is integrated into PBL, aiming to elevate all stages of project-based learning.

Keywords: project-based learning, technology integration, teacher training, problem-based learning

1. Introduction

In traditional teacher-center education system, students may ask "why do we need to learn these concepts?" The teacher may respond with "Because these contents will be on the tests" or "Because these are included in the courses plan", which are obviously not satisfactory answers. Project-based learning (PBL) provides learners with a dynamic, student-center education approach to actively explore real-world problems. By learning with a self-developed project and aiming to solve the determined problem, students will be able to organize their learning approach around projects, and always know why and how to learn for the contents. This learning methodology becomes widespread in the world.

2. Problem-Based Learning & Project-Based Learning

Teacher-centered teaching methodology had played a dominant role over thousands of years. However, various forms of teaching methods have emerged, such as flipped classrooms, project-based learning, problem-based learning, and blended learning, in the past few decades. Among this newly risen teaching method, there has been a controversy of Project-based learning and problem-based learning going on in recent years. Project-based learning and problem-based learning are two methods that have been widely used in schools and share the same abbreviation, PBL. With the same acronym, people often get confused about these two learning methods. Some scholars claimed that problem-based learning is different from project-based learning, saying that the trigger point for problem-based learning is an observed problem in real life. With this problem, students will conduct a series of works or experiments to determine the results or possible solutions to the problem. But for project-based learning, the initiating point is a driving question, and the following works will be planned to find the feasible solutions to the proposed question. Even though the definitions for the

two learning methods are different in words, the two core principles have much in common. The observed problems and the driving questions are both used to help students propose, prepare, and plan meaningful projects for students to explore the related fields, and seek possible solutions or insights. In this case, project-based learning and problem-based learning could be viewed as one learning method to some extent.

3. PBL Application in Different Education Levels

Nowadays, PBL has been widely used in all levels of educational institutions, from Pre-K to Postgraduate studies, and utilized in teachers' professional development training as well. This part of the paper will discuss the similarities and differences when PBL is applied to varied educational levels. Three previous PBL studies from kindergarten, middle school, and teacher professional development are used for reference. PBL is known as a method of learning by practicing, rather than solely listening to theoretical knowledge from the instructors. Learners need to self-purpose learning contents, activities, and technology tools or platforms is needed to meet the projects' objectives. Three major components have been concluded by Krajcick and Blumenfeld [1], which are the driving questions that guide learners throughout the project, the developing artifact that could represent learners' findings or solutions, and the collaboration with peers or teammates.

3.1 PBL in Kindergarten

Numerous experiments and research have been conducted in middle and high schools, but few scholars have focused on PBL utilization in kindergarten. The following passage is a PBL study, with a theme of "What's So Terrible About Swallowing an Apple Seed", conducted in a kindergarten early 2011 [2]. Normally students in kindergarten will take teachers' instruction and complete scheduled teaching plans step by step. Some students might ask some questions, but usually, they will not be persistent in figuring out the answers by themselves. Since students in kindergarten do not have much storage for scientific knowledge and the ability to gather information needed to solve the questions on their own. Stories can be an age-appropriate way to trigger students to have a driving question. The storybook "What's So Terrible About Swallowing an Apple Seed" [3] was selected for this study. After the stories were read, the teacher collected information from children and put them into two categories: What we know and What we need to learn. Based on the collected information, the story did successfully introduce the driving question "what earth materials are used to grow plants" to students and trigger students' curiosity as well. Some students first came up with irrelevant information or thoughts, what teachers did was to emphasize the major idea multiple times and seize the good relevant thoughts. Subsequent discussions among students allowed them to exchange information and thoughts on the driving question. The teacher then provided them with informational books and interactive videos, which even aroused the students' willingness to do experiments to test their ideas. Through discussions, educational videos, and materials, students would be able to locate key materials that plants need to grow, such as water, soil, air, and sun. Assessments were arranged immediately before and after the PBL lesson, and four months after the lesson to see how well students can remember those key elements for plants' growth. The result showed that more students were able to retain the key elements, and fewer students presented irrelevant ideas to the studied theme.

3.2 PBL in Middle School

A PBL study was also conducted for middle school science with both quantitative and qualitative data [4]. The instructor used Alien Rescue, which is an online interactive education toolset developed and improved by researchers from University of Texas at Austin. The story plot of Alien Rescue was

six alien species leaving their home plant and came to the Earth due to the fact that their homes have been destroyed, which introduced the driving question for students "Which planets in the solar system can be home to each alien species". The majority of students were able to determine and understand the driving question as soon as they finished watching the introductory video. In the platform Alien Rescue, there were lots of information provided. Unlike directly giving the corresponding information to students in kindergarten, students were divided into groups to engage in various information-gathering and problem-solving discussion activities. With the simulated probes and given databases, students were also able to determine some characteristics of our solar system and planets as well. With more rounds of peer discussion, students matched the discovered information with the characteristics of the six alien species. Finally, each group present their agreed findings and matching results of the planet and six species to the class. Assessment tests, including multiple-choice science knowledge tests, motivation questionnaires, and open-ended response questions, were arranged before and after the PBL course. With the ANOVA test and multiple regression analysis on the collection of the quantitative test results and evaluation of the open-ended questions for how students felt about the PBL study, the statistical results and students' response to the open-ended questions showed that the PBL learning method benefit students 'learning.

3.3 PBL in Teacher Professional Development

PBL does not only play a pivotal role in underage students' learning but also contributes to teachers' professional development, which aims to provide their students with better learning settings. Using PBL study to develop English as Foreign Language (EFL) teachers' Computer-Assisted Language Learning (CALL) competencies was conducted in Taiwan [5]. The language teaching method is no longer limited to teacher-centered lectures, written homework, and tests. Technological tools, such as Twitter, Facebook, and Google Docs, are also integrated to improve students' language skills. Aiming to make this new teaching method could operate smoothly and well in class, EFL teachers should master the technical skills as well as the language knowledge. Based on previous studies, many teachers stated that most EFL teachers have difficulty making good use of the technology to support their teaching contents and activities in class. This study provided the elected teachers the chance to conduct a hands-on project, applying technology tools or platforms to their teaching materials and activities. The 12 participants were divided into three groups and observed two English classes and came up with their driving questions for this training. Once each group's driving question got confirmed. Through Online English tools exploration, group discussion, selected tools implementation, and teaching activities planning, each group needs to design a CALL lesson plan, which can be used in an actual class for their students. In the end, each group presents the plans to the class. Rounds of discussions and peer evaluation were performed after the presentation and each group received constructive feedback from both the instructors and their peers. Apart from that, all participants were asked to write a 500–700 words reflection paper on this PBL study. Quantitative computer competency tests were taken before and after the PBL study. Statistical tests on quantitative test and their reflection paper revealed that this PBL study plays a beneficial role in teachers' computer-assisted language learning.

3.4 Analysis on PBL Application in Different Education Levels

Three studies all clearly showed the three major components of the PBL study, including the driving question that can lead the PBL study, the developed artifacts that can conclude the main idea of this PBL study, the collaboration among teammates to enhance leadership and communication skills. However, the emphasis was placed varied with different educational levels and assorted learners' learning abilities. In kindergarten, even though students are curious about the surroundings, but their

learning abilities are not ample enough to come up with a feasible driving question themselves and stick with the questions to seek for possible explanation or solution. In this case, the instructor needs to spend a great amount of time introducing a driving question that students will be interested in and guide them to a deeper understanding of the selected topic. Students might get distracted by other interesting phenomena that took place around them, and the instructor needs to concentrate students' attention for this study group. Sophisticated discussions and findings are normally not required at this educational level. PBL serves as a problem-finding project in this scenario.

As students grow older and move to middle school and high school, students can locate the driving questions and focus on the study. The central task of the PBL for this study group is collaboration. This group of learners starts to gain their understandings of the world, and their learning styles will not be identical. During discussions, students may have different opinions and disputes might occur. Through PBL study, the instructor needs to teach them how to listen to others and how to be a team player, learn to conduct analysis, arrange discussion activities with peers, and solve problems together.

When PBL is applied to teacher professional development, the mentor does not need to spend as much time as they need in underage student groups to come up with an interesting story plot to attract learners' attention to introduce the driving question of the project. This student group also has enough knowledge storage and research skills to accomplish this study and is capable of working as a team using skills gained from their past work experience. What they focus on throughout this study is learning about how PBL works and how PBL can be used in their classroom. Experiencing the PBL provides them a unique and valuable journey to know how it feels being a learner in PBL, instead of a supervisor or a mentor. Apart from that, they also need to utilize gained knowledge and skills from PBL and integrate them into their future teaching, like the CALL lesson plan mentioned above.

4. Gamified Learning System

With our fast pacing developed technology world, educational workers have begun to think about how these advanced technologies can be applied to teaching and benefits students' learning experience. In the past decades, gaming has become more and more popular among teenagers, and even caused addiction for a great number of students. While gaming has brought negative impacts on the youths, it has also provided a positive influence in the education field.

Teachers have always found it difficult to get students' attention and engagement in class. When teachers raise questions in class, students hesitate or are not willing to answer the questions because they are afraid of getting it wrong, which could be embarrassing from their perspectives [6]. However, gamified learning platforms have emerged and become the technology twist for this awkward situation. Gamified learning platform can create an immersive environment for students, and this setting gains popularity among students because it's highly interactive and interesting.

Kahoot! is one of these online gamified platforms, that is widely used in the classroom now. Teachers need to generate and input questions and corresponding answers on Kahoot!. The flashy interface, dynamic music offers a gaming and competitive environment for students, which quickly catches students' attention to the entertaining settings. There is also a team feature in Kahoot! that could contribute to simulating students' discussion in the classroom to certain extents. However, Kahoot! does not support having a comment area or discussion area for interactions. Therefore, previous studies that involved gamification with the instant feedback system, such as Kahoot!, showed it can maintain students' attention in class, but it was not capable of promoting communications between teacher and students. [7]. Scholars, Jerry Chih-Yuan Sun and Pei-Hsun Hsieh from Taiwan claimed that advanced level of gamified interactive response systems can simulate students' intrinsic and extrinsic motivation, which is helpful to students' learning.

A research study was conducted in Taiwan to see how the combination of the gamified element and interactive response system (IRS) would affect junior high students' intrinsic and extrinsic

motivation, engagement, and attention in their English course [8]. This research was conducted with a total of 144 seventh-grade students and their two English teachers, and the length of the experimental process is 2 weeks. Before the experiment started, students needed to fill out one questionnaire proper to qualify for this research. Qualified students were divided into three groups, one control group of 43 students, and two experimental groups including Group A with 39 students and Group B with 36 students. Three teaching models were designed differently for these three groups. The control group would use the traditional teaching mode, which uses small whiteboards for the polling questions in class. Group A would be equipped with a normal clicker for polling questions. Meanwhile, Group B students utilize the interactive, feedback-based in-class teaching system (IFIT3) that was specially designed for this research, and each participant in Group B would be provided with a tablet or mobile phone for in-class polling activities. In class, the control group wrote their answers on the whiteboard and show them to the teachers, and the Group A student used the general gamified method, a clicker to choose the answers. Group B students used the game token in IFIT3 to select their preferred answers and could be able to submit questions to teachers. Apart from these, there was also a leaderboard function in the IFIT3, which could promote a friendly competitive atmosphere among students.

Learning Questionnaire (MSLQ) developed by Pintrich, Smith, Garcia, and Mckeachie [9] was used for the intrinsic and extrinsic motivation evaluation but revised to a 6-point Likert scale for this study conducted in Taiwan. There were eight intrinsic and extrinsic questions in total. For engagement, evaluation was also used 6-point Likert scale testing with five, six, and eight questions for behavioral, emotional, and cognitive engagement respectively. As for the attention measurement, this part included four questions using a 6-point Likert scale.

ANOVA testing was performed on intrinsic and extrinsic motivation, and results of intrinsic motivation showed that both experimental groups were significantly different from the control group but results for extrinsic motivation indicated that there were no significant differences in the three groups. Analysis outcomes on student engagement, students who used gamified IRS had a higher level of learning engagement, compared to the two groups who used the traditional method and the general IRS. Apart from the above, analytical results showed that experimental Group B had a higher attention level than the control group and experimental Group A.

The emergence of gamified learning system is aimed to change the traditional teaching to replace the initiate- respond- evaluate pattern [6] when it comes to interaction in the classroom. Students were forced to study and get involved in class, but these rising gamified learning systems provide them the "spark" to get engaged in the study and promote them to act in class and interact with peers and the instructors. The teaching model can be gradually shifted to student-center, while students can be the person who generates questions and discussion. Interactions enable teachers better monitor and evaluate students' learning process and performance on the contents, which can be utilized for teachers' teaching planning for the future. Some types of competing settings on these platforms offer students a healthy competition environment to push themselves to bring better performance and assist students to develop and promote their leadership and teamwork skills when the group competition feature is applied.

Gamified learning platforms is one of those amazing education technology tools are utilized in today's education field, and these education technology shares some common goals with project-based learning, such as having a student-center education mode, promoting spontaneous learning, elevating students' collaboration skills. Lots of these technologies have been well integrated in PBL to bring optimized learning environment and teaching mode to the promising education field.

5. PBL & Technology Integration

Project-based learning (PBL) and education technology integration are two popular topics in the education field for the past few years. PBL assists students in actively exploring open-ended, real-world questions to acquire a deeper understanding of the academic contents required by the school curriculum. With the aim to achieve this goal, various types of education technology bring students and instructors an ample number of powerful resources that they can utilize along with their learning or teaching journey. Besides, some pre-service teacher education includes training for technology-integrated project-based learning to ensure and improve the quality of PBL.

5.1 Education Technology Types and Platforms

There are some well-known and widely used resources that successfully support educators with their PBL teaching [10]. PBL Works, created by the Buck Institute for Education, provides a great number of PBL courses, workshops, services, and ideas for different educators group, including individual, small teams, schools, and even districts, and help them gain a more comprehensive understanding of PBL and how to apply PBL in their teaching. *Getting Smart* is one of the leading resources, intending to accelerate and amplify learning innovations, offers inspirational and practical PBL services, blogs, podcasts from experienced educators, professionals, and model schools. *Edutopia*, developed by the George Lucas Foundation, is another influential online blog resource with a focus learning area on the K-12 PBL innovation.

Since PBL is designed as a student-center learning mode, students need to document their driving questions, methods of approach, and group discussions, Poll Everywhere, NearPod and Padlet are some good platforms that can be utilized. Working throughout a project and finding a solution needs a great number of references to help them learn more about the selected topics and back up their thoughts and findings. Google Scholar, JSTOR are two platforms to facilitate high-quality research and obtain academic articles. ProCon, All Slides, and Common Sense Media are good platforms that can be used for project research using media literacy skills. Once the project is finished, students need to accumulate their findings, possible solutions, and conclusions and share these with their classmates, teacher, parents, school, and even society if possible or necessary. The presentation may not only play a role of a sharing session, but also could be an inspiration for future research, a reflection for society, and future reimagination. A great number of PBL schools even arrange showcases or exhibitions to display students' PBL works, and the public often feels surprised and proud to see what students have accomplished and achieved [10]. For these scenarios, Google Slides and Prezi can be great presentation tools, and TED Talks can help students with public speaking. According to our PBL pathfinder, John Dewey's saying: "We do not learn from experience. We learn from reflecting on experience." Both teachers and students should look back and reflect on the finished PBL study and seek possible optimization and other better alternative methods that can be applied in different parts of the PBL study. Reflection can be conducted in a verbal form, which can be part of the presentation, mentioned above, or can be in written formats, such as journals and blog. Then, education tools including Edu Blogs, Kidblog, and WordPress can be useful in this case.

5.2 Technology- Integrated PBL Training for Pre-Service Teacher

As PBL gets more widely used and technology becomes more critical in the education field, having technology successfully integrated into education is truly important. One systematic literature review was conducted earlier to find the current situation of technology integrated PBL in teacher preparation programs, with two driving questions, which are: Q1: How the integration of technology and PBL is applied in the teacher preparation program? Q2: What are the influencing factors at the successfulness of PBL integration in the teacher preparation program? [11]. They used key terms and filters, such as

"project-based learning", "pre-service teacher", "English-Written", "Technology" and "Full Text", to identify relevant articles for this study, and finally, they located a total of 16 articles. The goal of this study was to evaluate what educators have done to implement technology integration in PBL. By carefully reading, annotating, performing case analysis, researchers selected four components to review the chosen articles: project tasks, supporting information, procedures, details, and directed practice. The results showed that there were two types of technology integration used in PBL, which were computer-based technology and technology modeling. Furthermore, social media, cloud computing, learning management system, computer programming, and websites were most common in computer-based technology.

Based on the findings of education technology types, they interpreted that social media was commonly used in technology based PBL since it was well known among students and good for simulating collaboration skills. Several PBL studies using social media were conducted in teacher preparation training, and the outcome showed that learners' communication and teamwork skills were prominently developed in a short time. By experiencing this, pre-service teachers gained a deep understanding of how this works and how it can implement in their PBL courses. Other research and projects were also conducted for pre-service teachers using ICT tools and computer programming, the results also showed that having exposed and utilized these tools themselves, pre-service teachers could give their reflection, and some were able to develop their class plan for technology integrated PBL course. Based on case analysis, researchers also concluded that the most influential factors that contribute to the success of technology integration PBL, including advanced technology & ICT tools, prior experience regarding technology, students' needs & interests, students' self-efficacy, learning framework, communication ability, and instructor guidance.

Methodology of project-based learning with technology integration has become more and more pervasive and well-rounded as time goes by. There are abundant technological resources, tools, and platforms that can be used for PBL by educators and students. Aiming to guarantee the quality of tech integrated PBL, many pre-service teachers' training of technology integration PBL are held to get pre-service teachers prepared for this teaching mode. Yet there is no systematic tech integrated training system set up for pre-service teachers, national, regional education bureau can consider having a systematic training system for this special purpose and corresponding evaluation standards established soon, aiming to consummate the PBL system.

6. Conclusion

Throughout the above literature review and case analysis, project-based learning is approved effective and beneficial to students 'learning in education at all levels. In order to meet the needs of this promising new teaching method, various technology tools and platforms have appeared on the market and supported all stages of PBL. Besides, many special trainings of technology integrated PBL for pre-service educators have been put in place, ensuring high quality PBL given to learners. On top of these, relevant education authorities can set clear rules and expectations for project-based learning course, as well as the training session for prospective teachers.

References

[1] Krajcik, J., & Blumenfeld, P. (2005). Project-Based Learning. In R. Sawyer (Ed.), The Cambridge Handbook of the Learning Sciences (Cambridge Handbooks in Psychology, pp. 317-334). Cambridge: Cambridge University Press. doi:10.1017/CBO9780511816833.020

[2] Zhang, M., Parker, J., Eberhardt, J., & Passalacqua, S. (2011). "What's So Terrible About Swallowing an Apple Seed?" Problem-Based Learning in Kindergarten. Journal of Science Education and Technology, 20(5), 468–481. http://www.jstor.org/stable/41499416

[3] Lerner, H. G., Goldhor, S., & O'Neill, C. (1997). What's so terrible about swallowing an apple seed? CollinsChildren's.

[4] Liu, M., Horton, L., Olmanson, J., & Toprac, P. (2011). A study of learning and motivation in a new media enriched environment for middle school science. Educational Technology Research and Development, 59(2), 249–265. http://www.jstor.org/stable/41414937

[5] Tseng, S.-S., & Yeh, H.-C. (2019). Fostering EFL teachers' CALL Competencies Through Project-based Learning. Journal of Educational Technology & Society, 22(1), 94–105. https://www.jstor.org/stable/26558831

[6] Wallace, K. B. (2016). Moving Class Discussions to Online Platforms [Review of Kahoot! https://getkahoot.com; Socrative socrative.com; Backchannel https://backchannel.com; Blackboard www.blackboard.com]. Journal of Adolescent & Adult Literacy, 60(3), 359–361. http://www.jstor.org/stable/44011395

[7] Wang, A.I. (2015). The wear out effect of a game-based student response system. Comput. Educ., 82, 217-227.

[8] Sun, J. C.-Y., & Hsieh, P.-H. (2018). Application of a Gamified Interactive Response System to Enhance the Intrinsic and Extrinsic Motivation, Student Engagement, and Attention of English Learners. Journal of Educational Technology & Society, 21(3), 104–116. http://www.jstor.org/stable/26458511

[9] Pintrich, P.R. (1991). A Manual for the Use of the Motivated Strategies for Learning Questionnaire (MSLQ).

[10] Niehoff, M. (2019, June 21). Tech applications that support high quality PBL. Getting Smart. Retrieved November 15, 2021, from https://www.gettingsmart.com/2019/06/21/tech-applications-that-support-high-quality-pbl/.

[11] Rahmawati, A., Suryani, N., Akhyar, M. & Sukarmin (2020). Technology-Integrated Project-Based Learning for Pre-Service Teacher Education: A Systematic Literature Review. Open Engineering, 10(1), 620-629. https://doi.org/10.1515/eng-2020-0069