

学位論文要旨

Mathematics Teachers' Challenges in Practicing
Project-Based Learning in Their Classrooms

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Abstract

Project-based learning is viewed as an instructional approach that promotes student engagement and can equip learners with skills for life and work. In this regard, it is very important for teachers to have a clear understanding of project-based learning for them to be able to provide sufficient student support and guidance for its successful implementation. In this study, we explored the challenges and solutions perceived by high school mathematics teachers in Japan in practicing project-based learning approach in their classrooms. Data was collected from an open-ended online questionnaire survey which was administered to 25 high school teachers and semi-structured interviews on 7 high school teachers. Regarding challenges, the study revealed that, teachers have difficulties in creating authentic project-based learning tasks that contain relevant content and fits the learners' level, creating tasks that learners are interested in, securing time to plan and reflect on the practice, balancing students' independence and student support, students' lack of knowledge, collaborative activities in student groups and evaluating learning outcomes. Regarding the solutions to the challenges, the following were revealed, the importance of creating tasks for project-based learning in small scales that can be completed over a short period of time, cooperation, and collaboration among (mathematics teachers, other subject teachers, and experts in mathematics education), involving students in creating evaluation criteria, and investigating previous studies on project-based learning. Based on the study results, the study recommends the need for mandatory inclusion of project-based learning in the mathematics course of study/curriculum among others. The study concludes by giving suggestions for future research on project-based learning in mathematics education.

Purpose of the Study

The purpose of this study was to explore the challenges that mathematics teachers face in practicing project-based learning in their classrooms, it includes challenges in designing good project-based learning tasks for the learners, challenges in organizing the process of teaching and learning of project-based learning, and challenges in evaluating project-based learning activities and how they respond to all the challenges.

Research Questions

The following research questions were designed to guide the exploration of the challenges and solutions perceived by high school mathematics teachers in practicing project-based learning in their classrooms. These questions also guide the analysis of the results. The research questions are as follows.

Research Question (1): What are mathematics teachers' challenges in practicing project-based learning?

Research Question (2): What are the teachers' solutions to the challenges in implementing project-based learning?

Significance of the study

The results of this study are expected to contribute to the body of literature by filling in the existing gap of knowledge on the challenges and their solutions perceived by mathematics teachers in practicing project-based learning. Thus, it provides mathematics teachers with common answers to common problems associated with the practice. The study results might help to inspire decisions regarding project-based learning implementation and how to design professional development in project-based learning. It helps researchers and implementers to have a full description and understanding of project-based learning within mathematics classroom context. This study could also act as a base or framework for other researchers who are interested in researching learner-centered mathematics teaching and learning approaches. Thereby promoting successful implementation of these approaches in mathematics classrooms and maximizing the gains associated with them.

Methodology

The study followed a qualitative design descriptive-case study as prescribed by Creswell (2014). Participant teachers for this research were selected using purposive sampling technique. Purposive sampling refers to an intentional selection of individuals based on the understanding that they are information rich on the topic of interest (Creswell, 2003; Patton, 1990). The researcher used two data collection instruments: open-ended online questionnaire and semi-

structured interviews to collect the data from the participant teachers on the challenges they perceived they face in practicing project-based learning in their mathematics classrooms and how they respond to these challenges. This was done to ensure credibility and validity of the study as well as to have a balanced explanation of the study results. The collected data was analyzed using qualitative content analysis as prescribed in Yildirim and Simsek (2013).

Phase I: The first phase was the use of an online questionnaire from 15 July to 31 August 2022. The online questionnaire was designed to give answers to the following research sub-questions.

1. What are the challenges in practicing project-based learning?
 - i. *What are the challenges in preparing and designing tasks for project-based learning?*
 - ii. *What are the challenges in the project-based learning implementation process stage?*
 - iii. *What are the challenges in evaluating project-based learning?*
2. What are the solutions to the challenges mentioned above?
 - i. *What are the solutions to the challenges in the preparation and task designing phase of project-based learning?*
 - ii. *What are the possible solutions to the challenges in the implementation processes phase of project-based learning?*
 - iii. *What are the possible solutions to the challenges in the evaluation phase of project-based learning?*

The online questionnaire was made up of 10 questions. The intention of the first five questions from the questionnaire guide was to enable participant teachers to contextualize their responses to questions 6 and 7 which were the main objective of the study. The intention of question 6 and 7 was to allow participant teachers to specify the challenges they face in practicing project-based learning in their classrooms in all the three main stages of project-based learning as well as specifying on how they respond to the challenges. The last three questions on the guide were mainly to allow participant teachers to give their suggestions and recommendations on areas that they think needs improvement when it comes to the implementation of project-based learning approach in mathematics classrooms.

Phase 2: The second phase involved the use of semi-structured interviews done from July to September 2023. The semi-structured interviews aimed to seek for clarifications based on the open-ended online questionnaire and to gain a deeper understanding of how high school mathematics teachers perceive project-based learning (primarily task-based learning that mathematically solves real-world problems) and how they practice it in the classroom. The interviews were based on a semi-structured protocol. The interviews were guided by the following two sub-questions.

- i. *How do high school mathematics teachers understand project-based learning (mainly task learning that mathematically solves real-world problems)?*
- ii. *How do high school mathematics teachers choose to practice project-based learning (primarily task-based learning that mathematically solves real-world problems)?*

Findings

Online questionnaire analysis (Chomunorwira and Koyama, 2023)

Question (6): *What are the challenges in practicing project-based learning?*

- i. *What are the challenges in preparing and designing tasks for project-based learning?*

The analysis of the 25 teachers' responses to this question identified challenges teachers perceived they face in preparing and designing project-based learning mathematics tasks for the learners. These were the three themes identified: ***creating authentic project-based learning mathematics task, learner interest, and time availability.***

The first challenge is Creating Authentic Project-based Learning Mathematics Task. Participant teachers mentioned that creating tasks that make authentic connections or link between mathematics concepts and real life at the same time matching the level of the learner is a big challenge for them. Teachers find it difficult to organize real world learner mathematics activities that enable learners to achieve their learning objectives that are to obtain mathematical knowledge and understanding, as well as having a sense of accomplishment and progress in the subject. Thus, teachers have difficulties in constructing mathematics tasks to solve real world problems at the same time giving learners an opportunity to learn and meet the requirements of their mathematics curriculum.

The second challenge is Learner Interest, coming up with mathematics tasks or assignments that learners are willing to work on or are interested in is another challenge that responded teachers mentioned. Learner interest becomes a challenge because it is a component that is emphasized in project-based learning approach.

Third one is Time Availability. Responded teachers also mentioned time availability as another challenge they face when they try to prepare and design project-based learning tasks that are engaging to learners. Teachers suggest that it takes a lot of time for them to create project-based learning tasks that are authentic or as they try to modify the given tasks from colleagues and experts to suit their own mathematics classes. This could be because of inexperience or lack of knowledge on task creation.

ii. What are the challenges in implementing project-based learning?

The analysis of participant 25 teachers' responses to this question identified four main themes which are *the extent of learner support, time availability, learner group collaboration, and resources/technology*.

The first theme is the Extent of Learner Support. Teachers faced challenges in finding specific guidelines on how to support learners and the extent to which that support must be taken to leaving room for learners to be free and overseeing their learning. Thus, it is difficult for teachers to know how much support they should give so as not to interfere with learners' freedom to self-study. The data shows that teachers are not sure of whether they are giving their learners inadequate support or excess support which either way nullifies the real purpose using project-based learning in their mathematics classes. This challenge can be attributed to teachers' lack of scaffolding instruction skill.

The second theme is Time Availability. Responded teachers mentioned time as another challenge they face in the implementation of project-based learning in their mathematics classrooms. This suggests that project-based learning is time consuming to teachers making it difficult for them to implement the approach and at the same time trying to meet the demands or the requirements of their mathematics syllabus.

The third theme is Learner Group Collaboration. Most responded teachers perceived project-based learning as an approach that is implemented in group format and each individual member

is expected to collaborate and contribute to the task at hand. But they found it challenging to develop and foster that meaningful collaboration among learners' groups. This data revealed that teachers find it difficult to manage learner groups and to create a collaborative environment to ensure that all learners are actively involved and are learning from the project-based learning mathematics activities being done.

The fourth theme is Lack of Resources particularly PC emerged.

iii. What are the challenges in evaluating project-based learning?

The analysis of this question's responses identified two main themes which are ***general evaluation and individual evaluation***.

The first theme is General Evaluation. Learner evaluation emerged to be a challenge for teachers as they implement the project-based learning approach in their mathematics classes. As project-based learning is a multifaceted approach, respondent teachers find it difficult to come up with evaluation criteria that can cater for all aspects.

The data suggests that the issue of evaluation is unclear to most respondent teachers. They found it difficult to develop authentic evaluation to understand what their learners have learnt. Some attributed this challenge to lack of mathematics project-based learning evaluation cases in the literature to guide them, some attributed it to their lack of skills to develop evaluation tools aligning project-based learning goals, and others attributed it to lack of mathematics content mastery on the learners.

The second theme is Individual Evaluation. As project-based learning being a group format approach, teachers pointed out that it is a challenge to assess individual performance for individuals working in a group. Though some teachers mentioned about the recently established rubric evaluation, they still found it difficult to come up with standard criteria to evaluate individual performance and group performance in their project-based learning mathematics classrooms.

Question (7): What are the teachers' solutions to the challenges in all the stages of project-based learning implementation?

i. What are the solutions to the challenges in the preparation and design phase of project-based learning?

When responding to what they do to overcome the challenges they face in designing authentic tasks that connects learner's daily life and mathematics concepts, participant teachers pointed out the importance of collaboration among teachers when designing tasks, consulting experts in the field of mathematics education as well as keeping on practicing the approach in their teaching. This form of collaboration equips them with the knowledge and expertise in designing authentic tasks. They also suggested practice and reading through a lot of literature on designing project-based learning tasks as another solution since they get information that will equip them with the required task designing skills.

ii. What are the possible solutions to the challenges in implementing project-based learning?

When responding to the question on the possible solution to the implementation challenge, teachers highlighted the need for project-based learning to be a school-based approach rather than an individual teacher practice. This suggests the need for collaboration within the whole school, through to staff development sessions addressing implementation issues among teachers.

Regarding time challenge, respondent teachers pointed out that project-based learning must not be implemented in a random way, but there is need to allocate specific time for the practice when creating the course of study and stick to it during its implementation. They also suggested the need for implementing project-based learning tasks on small scales that can be completed within a short time.

iii. What are the possible solutions to the challenges in the evaluation phase of project-based learning?

When responding to how they go about resolving the challenges they face during evaluation phase, participant teachers mentioned the importance of collaborating with other teachers in creating evaluation criteria, involving learners when creating evaluation criteria and reviewing past efforts on evaluation to get some knowledge and skills as a way of solving their current evaluation challenges.

Collaboration emerged to be the common way of solving all the challenges teachers face in all the three stages of project-based learning implementation, that is the planning and designing stage, the implementation process stage, and the evaluation stages.

Semi-structured interview analysis

In response to the question (Q6) on challenges they face in implementing project-based learning, the following challenges emerged from the teachers' responses.

Task design challenge: Teachers find it difficult to come up with mathematics tasks that contain the relevant content under study, and fit the learners' level, and that learners are willing to work on.

Time challenge: They mention that project-based learning is a time-consuming approach. Respondent teachers perceived project-based to be time consuming in terms of handling activities in all the stages and trying to foster cooperation and collaborate with other subject areas.

Participant teachers also mentioned learners' lack of knowledge as one of the challenges they encounter. For example, T_6 said, "*The main difficulty in supporting students is the lack of knowledge in students, they have difficulties in building researchable questions*".

This may suggest the need for students to be exposed to the approach from lower grades for them to be equipped with enough knowledge to handle such tasks at high school level.

Respondent teachers also mentioned that the other challenge is project-based learning approach usually leads to change of class discussions from mathematics to non-mathematics, making them fail to achieve the intended objectives.

Evaluation challenge: Since project-based learning involves giving learners some independence and work on a task over a period, teachers find it difficult to evaluate such tasks. For instance, T_1 said, "*it has not yet been clear how to evaluate what has been done over time.*"

Responding to (Q7) which was on how they respond to the above challenges, regarding solving the time challenge, the idea of incorporating project-based learning in the mathematics curriculum at the start of the academic year emerged. This implies that mathematics teachers

should plan for the project-based learning approach well on time to avoid unplanned or short time planning which will make it difficult to secure enough time.

In addition, the idea of cooperation and collaboration among mathematics teachers to share ideas also emerged to be another way to address the difficulties faced in implementing the approach.

Regarding the challenge of students' lack of knowledge and interest, the idea of including project-based learning in lower grades as well as encouraging and motivating students to read many books emerged to be the way to solve this challenge.

Conclusion

Overall, the analysis of both the open-ended online questionnaire and the semi-structured interview revealed the same challenges that teachers face including, the challenge of designing authentic tasks for project-based learning that contains relevant content and fits the learner level, creating tasks that learners are willing to work on, the issue of securing time and class group discussion. However, analysis of semi-structured interview revealed clear explanations on some challenges, for example on the issue of time, teachers clarified that they do not have enough time not only to plan and implement the tasks for project-based learning but also to reflect on the whole process to improve on the practice. Regarding the evaluation challenge, interviewed teachers pointed out that there is no clear and well-defined way to evaluate project-based learning tasks. In addition, on the issue of learner group collaboration and class discussion challenges, interviewed teachers revealed that project-based learning approach usually leads to change of class discussions from mathematics to non-mathematics, making them fail to achieve the intended objectives. Interview analysis also brought out a new challenge of learners' lack of knowledge where teachers pointed out that their students have difficulties in building researchable questions because they are not exposed to the approach from the lower grades. However, the analysis of online questionnaire also clarified two challenges which did not emerge from the interviews, these include, the extent of learner support challenge where teachers clarified that it is difficult for them to balance between teacher support and learner independence as well as the resource challenge where they mention the issue of lack of PCs on their learners.

When it comes to addressing the challenges, analysis of both the open-ended online questionnaire and the semi-structured interviews emphasize on the importance of incorporating project-based learning in the mathematics curriculum or course of study at the beginning of the academic year to avoid unplanned or rash planned implementation. They also agree on the importance of collaboration among teachers to share ideas, the importance of going through previous studies as solutions to the challenges. However, the questionnaire analysis clarified the importance of creating tasks for project-based learning in small scales that can be completed in a short period of time to address the time, student interest/motivation and evaluation challenges.

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