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To cite this article:

Travero, A. S. (2023). Integrating workbook-making in learning calculus during the pandemic: A phenomenological study. *International Journal of Studies in Education and Science (IJSES), 4*(1), 19-30. https://doi.org/10.46328/ijses.40

IJSES International Journal of Studies in Education and Science
2023, Vol. 4, No. 1, 19-30 https://doi.org/10.46328/ijses.40

Integrating Workbook-Making in Learning Calculus during the Pandemic: A Phenomenological Study

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Article Info

Article History

Received:
12 September 2021
Accepted:
19 June 2022

Keywords

Calculus
Workbook-making
Phenomenological study
Thematic analysis

Abstract

Calculus is one of the courses considered frustrating and difficult by most learners. This frustration, along with difficulty encountered, is coupled with the challenges brought about by the paradigm shift to online learning. In an effort to address some of these challenges, the teacher-researcher employed project-based learning through workbook-making in hopes of improving students' learning. The study used a phenomenological approach to investigate the second year Bachelor of Secondary Education- Mathematics students' lived experiences in workbook-making during the pandemic. The study utilized simple random sampling among the students who were taking Calculus course during the second semester of the school year 2020-2021. Eleven (11) students responded and were subjected to semi-structured interview questions. Using thematic analysis, three themes emerged: (1) Difficulties and Challenges in making Calculus workbook during the Pandemic, (2) Strategies employed to make Calculus workbook during the Pandemic, and (3) Workbook-making as a tool in learning Calculus. The result of the study may be a springboard for other Mathematics educators to devise learning interventions or apply project-based learning, specifically workbook-making, in enhancing students' learning, not only in Calculus but Mathematics in general, during the pandemic. It can also serve as a baseline in conducting related studies in other fields and levels.

Introduction

Learning Calculus is considered hard by most learners. Students taking Mathematics courses find Calculus frustrating, claiming that the abstraction and the complexity of the course make it deemed as main source of undergraduate level's failure (Sahin et al., 2015). This leads to various researchers and mathematics educators venture on interventions to make Calculus learning easier. Computer-assisted interactive teaching, Microsoft mathematics, and writing activities were among the interventions found to have effectively correct misconceptions, improve students' conceptual understanding and enhance achievement in Calculus (Idris, 2009; Tapare, n d; Mendezabal et al, 2018). As much as educators integrate various strategies to help learners learn Calculus better, the difficulties of learning Calculus concepts has been worsened by the shifting of world's educational system to online learning because of the challenges brought by the COVID-19 Pandemic. The study of Susilawati et al. (2020) revealed that online learning is not effective in learning Calculus 2 during the

pandemic. The learning outcomes of the students decreased upon the implementation of online learning.

The struggle of the new learning set-up has been felt by the Universities and schools in the Philippines. Cuaton (2020) considered online learning not ideal for Philippine context citing that, teachers at all levels were technically, psychologically, and educationally not ready for the set up, and that, poor internet connection and students' socioeconomic status are also barriers for online learning. This is supported by Alipio's (2020) online survey to Filipino students which concluded that most students considered themselves not ready for this modality. Teachers, on the other hand, are not sure on whether to favor online education or not (Moralista & Oducado, 2020). Nevertheless, school year 2020-2021 happened with the set-up.

Project-based learning (PBL) is found to be effective in online learning. Even before the pandemic, and before the wide implementation of online learning, PBL is known to be a promising approach in improving learning of higher education students (Guo, 2020). PBL allows the students to apply the theoretical and technical knowledge they learned from books (Sharma, et al, 2020). PBL promotes i.) teachers' or students' motivation and learning; ii.) a sense of community and collaboration; iii.) student-centered learning; and iv.) versatility in the instruction (Aksela & Haatainen, 2019). This made PBL to be carried out through online activities, allowing students learn in online learning and solve real-world problems in their own way (Noviyanti et al, 2021).

In the case of a state University in Cagayan de Oro City, Philippines, the instructor handling Calculus 2 of second year Bachelor of Secondary Education major in Mathematics students utilized online learning in the delivery of the topics. Further, to encourage collaborative and learner-centered learning, and knowing that project-based learning is considered a promising approach in improving higher education students' learning (Guo, et al, 2020), the instructor tasked the students to create a workbook in Calculus. They were grouped with two or three members. The Calculus workbook covered the topics from the Theorems of Differentiation up to Indefinite Integration. The students were tasked to create or modify their own problem related to the topics, and provide a solution of the problem created at the latter part of the workbook. This workbook was assigned as the Performance Innovative Task of the students.

Backed up by the studies that showed the effectiveness of project-based learning, the present study would like to explore the Calculus students' lived experiences during the pandemic as they engaged in workbook-making in their Calculus class. Primarily, it sought to 1.) discuss the participants' difficulties and challenges in making workbook during the pandemic 2.) discuss the participants' strategies overcoming the challenges in making Calculus workbook during the pandemic; 3.) determine the participants' realization on integrating workbook-making in Calculus class.

Methodology

Design and Data Gathering Procedure

The study applied phenomenological research methodology. This research methodology seeks reality from the narratives of individuals' feelings and experiences, thereby producing in-depth descriptions of phenomena

(Yüksel & Yıldırım, 2015). In education setting, phenomenological research generally embodies perceptions, feelings, and lived experiences of the participants towards a certain phenomenon (ibid). Phenomenological research methodology involves four essential steps: bracketing, intuiting, analyzing, and describing (Greening, 2019). This methodology is deemed to be fitting in this study as the researcher gathers the lived experiences and feelings of the participants towards workbook-making in Calculus amidst pandemic.

The researcher utilized semi-structured interview questions to gather the data. These interview questions were validated by three professionals using a validity assessment tool. E-mail interviewing was employed wherein the questionnaires were floated to the respondents through messenger group chat. Follow-up questions were asked by the researcher through chat whenever deemed necessary. The researcher kept in mind the ethical considerations in the conduct of the study. Consent, and permission to record and publish were asked from the participants; and data privacy and confidentiality were ensured.

Participants of the Study

The participants involved in the study were the eleven (11) second year Bachelor of Secondary Education major in Mathematics students enrolled in Calculus 2 in the second semester of the school year 2020-2021 in a State University in Cagayan de Oro City. To generate the number of participants, random sampling was utilized. The researcher created a messenger group chat to easily give the participants the instruction.

Data Analysis

Participants' responses were subjected to Thematic Analysis. Thematic analysis is utilized to recognize themes, or interesting and significant data trends, then using the themes in addressing research (Maguire et al., 2017). In the present study, themes from the participants' experiences in workbook-making during the pandemic were generated.

Results and Discussion

From the data analysis, three themes emerged, (1) Difficulties and Challenges in making Calculus workbook during the Pandemic, (2) Strategies employed to make Calculus workbook during the Pandemic, and (3) Workbook-making as a tool in learning Calculus.

Difficulties and Challenges in Making Calculus Workbook during the Pandemic

Participants' difficulties and challenges in creating calculus workbook during the pandemic can be best explained by three subthemes. These subthemes include technological constraint, poor communication among group members, and difficulties in understanding the topic and formulating the questions (see Table 1). Even though the Commission on Higher Education (CHED) defined flexible learning as a combination of digital and non-digital technology and this does not require internet connection (Magsambol, 2020), to follow protocols

given by the competent authority, online learning became inevitable to colleges and universities as school year 2020-2021 started.Cuaton (2020) argued that online learning or e-learning is not ideal for teaching and studying in the Philippine context. The researcher claimed that poor and costly internet connection and the socioeconomic status of the students who can barely provide their educational needs were also barriers to this set up.

Table 1. Difficulties and Challenges in Making Calculus Workbook during the Pandemic

Theme Description	Subtheme Analysis	Responses	Theme Descriptive Analysis
1.Difficulties and Challenges in making Calculus workbook during the Pandemic.	***Technological constraint.***	1.Student A stated, *"I guess the only problem is the poor internet connection…and also there are just few of us who has a laptop or personal computer and it's difficult to encode equations using mobile phones."* 2.Student G claimed the poor internet connection leads to difficulty "*to communicate with my partner … it's somehow difficult because of the availability of the gadget to be utilized in making the workbook."* 3.Student H expressed their frustration with the lack of gadget, *"Challenging kaayo sya kay kami tanan sa among group kay walay laptop/pc so nag tagsa2 mig encode sa phone sa mga item, tapos ang pag usa ang kuti layt."*	Technological constraint involves internet connection and gadget availability. All eleven participants describe technological constraint as their main difficulty and challenge in doing the workbook during the pandemic. In connection with the lack of internet connection and gadget availability, the students found it hard to communicate with their group members and discuss the necessary delegation of tasks. Moreover, understanding the topic and formulating the questions for the workbook posed a challenge to the learners.
	Poor communication among group members.	1.Student C stated, "*The challenge we have encountered in making the workbook was the communication with other groupmate*." 2.Student F added *"The workbook is a group work, so we brainstormed online and that so difficult. We cannot meet personally because we are under a pandemic."*	
	Difficulties in understanding the topic and formulating the question.	1.Student D said *"Challenging lang sya kay need gyud og studyhan para masabtan og makabuhat ka."* This is supported by Student K expressing that their difficulty is on *"ang pagsabot sa lesson nga na assign saamoa."* 2.Student J stated *"For me sguro ang pag formulate ug questions and ang pag checking if sakto ba ang solutions."* 3.Student I expressed their difficulty in *"finding enough content for the workbook."*	

Baticulon et al (2020) classified technological as one of the five categories of barriers to online learning during COVID-19 pandemic experienced by medical students in the Philippines. These technological barriers include lack of devices or limited access to gadgets, slow or no internet connectivity, and issues with online learning platform. Issues related to network instability include occurrence of delays; teaching materials and teacher's voice are not synchronous; and, network difficulties disrupt online classes (Fatoni et al, 2020). Also, limited opportunities to interact with peers and gaps in knowledge and skills are categorized under institutional barriers (Baticulon et al, 2020). Due to poor internet connection, direct interaction is almost impossible, leading to difficulties in team projects and reduced class understanding (Fatoni et al, 2020). Putri (2020) summarized challenges of students during online home learning as limited socialization and communication among students, challenge for students with special needs, and longer screening time.

Understanding Calculus topics and concepts and formulating questions to write in the workbook also posed a challenge to the students. Abstraction and complexity of Calculus made it deemed as the main source of failure of undergraduate students (Sahin et al., 2015). Learning Calculus concepts through online learning is accordingly not effective (Susilawati et al., 2020). Students' learning outcomes decreased during the implementation of online learning (ibid.). Finally, the study of Rotas and Cahapay (2020) conducted to university students in the Philippines during the wake of the pandemic heavily supports the present study. The result of their study categorized the following difficulties in remote learning unstable internet connection; lack of learning resources; electrical power interruptions; unclear learning contents; difficulty in communicating peers; conflicts with household responsibilities; too much lesson activities; limited teacher scaffolds; financial constraints; lack of conducive learning environment; physical health compromises; and mental health struggles.

Strategies Employed to Make Calculus Workbook during the Pandemic

To pursue learning Calculus and perform the assigned tasks, the students developed their own strategies. Theme 2 can be best explained by looking for other source of information and asking help from classmates and friends; dividing tasks among group members; and possessing positive attitude in pursuing the task (see Table 2). The most prominent strategy the students did was to look for other source of information and by asking help from classmates and friends. Over the past months, YouTube has gained acceptance from the students as a learning resource, as related to the perceived easiness of usage, social influence and perceived usefulness (Yaacob & Saad, 2020). Also, students who become stress because of a remote learning program tend to seek support from their friends and peers (Gore et al., 2014). Moreover, dividing the tasks among group members is one of the strategies of the students. The students prefer group activities more than having the task individually. Being in a group allows the students to ask help from their peers, since it is not easy to ask clarifications from the teacher, and perhaps due to formal relationship between students and teachers, students understood an explanation better when their question is answered by their groupmates (Alfares, 2017). Burke (2011) discussed the advantages of working as a group as follow: group stimulates creativity; group discussions are better remembered; student gains better understanding of own self; and group work promotes teamwork which is highly valued by employers. Dividing the tasks among group members lessens the burden of each of the member.

Table 2. Strategies Employed to Make Calculus Workbook during the Pandemic

Theme Description	Subtheme Analysis	Responses	Theme Descriptive Analysis
2.Strategies employed to make Calculus workbook during the Pandemic.	***Looking for other source of information and asking help from classmates and friends.***	1.Student A mentioned *"I downloaded tutorial videos from YouTube as a reference and supplementary material."* 2.Student I added that they overcome the difficulty *"by asking help with my classmates or to my members of the group, on how to find the contents."* Student I added that their classmates were there *"for clarification and for guide."* 3.Student J mentioned that *"I asked my classmates and groupmates if our solutions and questions were okay. I also asked my friends who took calculus 2 last year to check our output. Siguro sa strategy is asking for help."* Student J expressed their gratitude to their classmates who helped them throughout the task, "*I was very thankful for my groupmates that were helpful."*	One of the strategies students employed is looking for other source of information, specifically, tutorial videos from YouTube for topics they found hard to understand. Moreover, asking guidance from classmates and friends was also of big help. The given task was a group activity, this became favorable to the students since it allowed them to discuss with their groupmates.
	Dividing tasks among group members.	1.Student C mentioned "*The strategies we have made to surpass the difficulties and challenges in making the Calculus workbook was we divide the topics and assigned to each of the members."* 2.Student D agreed with Student C *"Para madali ang trabaho assign kag topic sa each member then tagaan nimo silag time para makabuhat og makasabot. Be responsible lang na members para man pud ni sa amoa. If ever naay isa maglisod tabangan."* 3.The same thought was given by Student F, *"We overcome the challenges as a team by doing and assigning task in every member. Every member must give one example in every topic."*	Among the 11 participants, 9 preferred the task to be given by group; the remaining two preferred the task as individual output. Student J preferred it as individual output *"since it was for only two questions per topic*" while student E reasoned "*para walai mahay or walag salig-salig. kai ang uban ga salig ras kauban."*
	Possessing positive attitude in pursuing the task.	1.Student E, on the other hand, emphasized on positivity, *"stay positive lang gyud, more and more Patience and work hard."* 2.This is agreeable with the statement of Student G*, "By a positive way of thinking and believing in ourselves that we finish our workbook despite of the difficulties and challenge we have just experienced*."	Being in a group allowed the students to divide the task among their groupmates. Lastly, possessing positive attitude was considered helpful by the students.

Even if there were a lot of challenges and difficulties in doing the tasks, the students considered having positive attitude as a strategy in accomplishing the activity. Positive attitude towards Mathematics, in this case, Calculus, has been found to be positively correlated to students' academic performance (Alpacion, Camañan, Gregorio & Panlaan, 2014; Mensah, Okyere and Kuranchie, 2013). A study in Filipino university students showed that

students employ the following coping strategies in learning during the pandemic: asking support from peers; seeking guidance from teachers; employing time management; finishing learning tasks ahead of time; looking for good space and time; looking for learning resources; extending the time for learning tasks; diverting attention; regulating the self; having extra jobs; praying; and crying (Rotas & Cahapay, 2020).

Workbook-making as a Tool in Learning Calculus

Theme 3 portrays the general experience and perception of students in workbook-making as a tool for learning in Calculus. The students' responses showed that the task was not easy yet fun and nice experience; helps learning and retaining Calculus concepts; and serves as review and training for future educators (see Table 3).

Table 3. Workbook-making as a Tool in Learning Calculus

Theme Description	Subtheme Analysis	Responses	Theme Descriptive Analysis
3.Workbook-making as a tool in learning Calculus.	***Not easy yet fun and nice experience.***	1.Student C said *"The workbook-making was not easy… but through teamwork, it was a success."* 2.The same idea was expressed by Student A, *"It was fun because we were able to have a rerun in learning and studying our lessons in differentiation and integration along with my partner."* 3.This is supported Student B, *"It was a nice experience because we learn a lot about the topics while making the workbook."* 4.Student J mentioned *"Siguro I regarded workbook-making as a practice in solving the topics covered since ako man nag rewrite if sakto ba ang mga questions ug ilang solutions. It was fun, actually."*	Students expressed mixed experiences in doing the workbook, most of it refer to the task as not easy; however, they also mentioned that it was fun. When confronted with the question "Did the workbook-making in Calculus help retain ideas and content?", the participants affirmed and provided their explanation why they feel such. The students also saw the value of workbook-making as a review and training for them as they aspire to be future educators.
	Helps learning and retaining Calculus concepts.	1.Student A answered, *"The workbook-making process really helped me learn the subject and were able to answer the exercises that I found on the internet on my own. I was so happy that now I can relate to the Calculus memes that I saw on Facebook which I look past before since I have no idea on how to solve."* 2.Student C has the same thought, *"It really helped in retaining ideas and content especially sa uban complicated topics nga wala nasabtan."* 3.Student D said that workbook-making *"is a big help sa amoa kay ma enlighten mi sa ideas og contents na*	

Theme Description	Subtheme Analysis	Responses	Theme Descriptive Analysis
		among gebuhat." 4.Student I mentioned *"The workbook would be helpful for those students that are behind to the lessons because they can't attend for some valid reasons … the workbook can help remember the lessons that has been taught."* 5.Student J stated that workbook-making helped retaining ideas and mentioned, *"I strongly suggest ang next batch magka project like this kay it promotes teamwork and gives high efficiency sa kung unsai dapat ma learn throughout the topics."*	
	Serves as review and training for future educators.	1.Student A said that workbook-making *"As a future teacher, I learned the importance and effectivity of this teaching approach which I will also apply when I enter the field one day."* 2.Student D agreed, saying *"Workbook making in learning calculus is a big help for us sudents mura syag ma train kag buhat og activities as a future educator … naa pud mi reviewer na nabuhat."* 3.Student D's thought of having the workbook as a reviewer is supported by Student E who stated, *"Actually I like the idea sa workbook kai bura siyag review sa tanan topic nga na cope up sa semester … maka balik tanaw gyud ka unsaon ganihh to pag gamit ani nga theory, unsa ganihh to nga mga theory gagamiton, unsaon ganihh to mag modify, ug bisan ang imong past knowledge sa mathematics kai magamit gyud."* 4.Student F furthered that *"It makes you practice some exercises and also the workbook can be use in reviewing when you take board exam."* They added that workbook making *"retains ideas and knowledge to me."* 5.Student H described workbook making as *"Helpful siya sa amoa sir, labon na mga future teachers mi like naa mi guide puhon … Mas na clear btaw sa amoa kung when to ma apply na mga theorems."*	

Workbook-making is based on the framework of project-based learning. Even before the wide implementation of online learning because of the pandemic, project-based learning (PBL) has known as a promising approach to improving learning of higher education students (Guo, 2020). PBL allows the students to apply the technical and theoretical knowledge they learned from books (Sharma, et al, 2020).

In this case, the contents the students put in the workbook is the application of their learning. The thoughts of having the workbook-making as a review and training for the students as future educators show student-centered learning and a versatility in instruction, while the not easy yet nice experiences because of teamwork shows a sense of community and collaboration among the students. Project-based learning promotes; i.) teachers' or students' motivation and learning; ii.) a sense of community and collaboration; iii.) student-centered learning; and iv.) versatility in the instruction (Aksela and Haatainen, 2019). PBL is also found by other researchers to improve students' curiosity, pleasure, cooperation and interest, which showed that introducing project-based learning improved both attitude and motivation of students (Kortam, et al, 2018).

Conclusions and Recommendations

Based on the findings, it is concluded that Calculus students experienced a lot of difficulties and challenges in making Calculus workbook during the pandemic. These difficulties and challenges include technological constraint, poor communication among group members, and difficulties in understanding the topic and formulating the questions. However, students employed various strategies to cope with these challenges and difficulties encountered. These strategies are looking for other source of information and asking help from classmates and friends; dividing tasks among group members; and possessing positive attitude in pursuing the task. Moreover, the students find workbook-making as a helpful tool in learning and retaining ideas and concepts in Calculus. Calculus students deemed workbook-making as review and training for future educators, and as much as it was not an easy task, students considered it as fun and nice experience.

From these, the researcher recommends the following:

1. Mathematics Teachers, especially those who are teaching Calculus, may provide more comprehensive learning materials to the students and may utilize other sources of information, like Youtube, to supplement students' learning.
2. Universities may continue their initiatives on providing gadgets and free mobile data to students since there are still those who can't afford to have their own.
3. Universities may conduct webinars on mental health to support students' optimism during the situation.
4. Mathematics Teachers, especially those who are teaching Calculus, may strategize project-based activities to facilitate collaborative and independent learning during the pandemic.
5. Workbook-making may be assigned as a performance innovative task to Education students to allow them review previously learned concepts.
6. A quasi-experimental study in Calculus with workbook-making as an intervention may be conducted to a bigger sample size.

Acknowledgement

The researcher would like to extend their sincerest gratitude to Ms. Mary Ann Charmaine O. Tapulayan and Mr. Avelino A. Costanilla, Jr. for validating the interview questions; to Mr. Rolebert Dizon for validating the interview questionnaire and assisting in the analysis of data; and to Leonella Marie T. Silvosa for proofreading the paper, and giving valuable suggestions to enrich the study.

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