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Surviving a Calculus Class during the Pandemic: Affordances and Constraints of a Fully Modular Instruction Class

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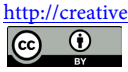

Abstract

The suspension of in person classes due to the global health pandemic caused by COVID-19 led to abrupt changes in the mode of instruction delivery and assessment. This action research using the Plan-Do-Study-Act (PDSA) model explored the opportunities and challenges in a Differential Calculus (DC) class on a fully online modular form of instruction (MFI). Using an approved syllabus and available online and offline resources, self-learning modules (SLMs) on DC were developed and the students' views and experiences on the use of the SLMs during synchronous and asynchronous classes were determined. Survey questionnaires, reflective journals, and focus group discussion (FGD) were utilized for data gathering. Using descriptive and thematic analysis, the results revealed that students welcomed the use of online modular instruction because of accessibility and flexibility. They experienced independent learning, had better understanding of their own learning, appreciated calculus better, and were inspired to do their best. However, they experienced challenges in reading the modules and had difficulty understanding some lessons, thus, the need for group studies was evident. The modular form of instruction provided the learners with positive learning experiences leading to opportunities for self-regulated learning and collaboration yet gave challenges in reading literacy.

Keywords

Flexible Learning System, Bichronous Class, Self-Learning Modules, Modular Instruction

1. Introduction

In March 2020, the World Health Organization (WHO) declared a global health

pandemic; the increasing number of cases of coronavirus disease 2019 (COVID-19) spreading territories and confirmed human-to-human transmission was considered a public health emergency of international concern (PHEIC) (WHO, 2020). A state of calamity throughout the Philippines for a period of six (6) months was declared and an enhanced community quarantine (ECQ) throughout Luzon was imposed. Republic Act (RA) 11469, Bayanihan to Heal as One Act was signed on March 24, 2020, declaring the existence of national emergency arising from the dreaded COVID-19. This prompted the Commission on Higher Education (CHED) to issue Advisory #1 suspending all in-person classes and subsequently CMO No. 4 series of 2020, adopting the use of Flexible Learning System in all public and private higher education institutions (HEI). The avoidance of physical contact to limit the risks of infection among the community became the immediate response of the HEIs. Immediately, in-person classes were suspended in all HEIs in the country and the formidable challenge of continuing teaching-learning experiences beyond the physical classroom and face-to-face instruction became apparent.

Anchored on CHED CMO #4 s 2020, the administrators of Cavite State University particularly, the Office of the Vice President for Academic Affairs released a memo instructing all faculty to adopt the flexible learning arrangement in the middle of the semester, in particular bichronous learning composed of synchronous and asynchronous classes. A survey was conducted to determine the students' online learning landscape in the campus using a multiple response questionnaire. Results revealed 94.7% of the students have cellphones as their learning device, only 34.7% have laptop while 15.3% have desktop. Almost forty-four percent (43.6%) have limited accessibility to these gadgets, meaning the devices are shared with other members of the family and 58.1% have intermittent connection status. The survey revealed the inadequacy of the students as regards online learning equipment; very few have laptops and desktops and only rely on their mobile phones as their learning device. This predicament was aggravated by very unstable Internet connection and poor mobile phone signals in their areas. This would mean online lectures and discussions during synchronous classes would be extremely difficult to conduct and implement.

These considerations led to a decision of implementing a fully modular online calculus class; self-learning modules will be provided online which will serve as the primary learning materials for the course differential calculus. It should be noted that calculus is a course which involves conceptualizing quantities and making arguments for the importance of covariational reasoning in defining meaningful functions to model relationships in word problems (Carlson et al., 2015).

This study sheds light to the question: is the teacher-researcher's implementation of a fully modular online calculus class a viable form of instruction delivery? It is geared towards evaluation of ones' own practice through the views and experiences of the students. It is imperative to find out how the modular instruc-

tion (MI) provided learning experiences in calculus. This action research anchored on the PDSA problem solving model is an evaluation of the researcher's own practice while experiences of the students on the modular instruction were explored to determine its affordances and constraints.

On Flexible Learning System. As a concept of openness and flexibility, Joan (2013) asserted that flexible learning provides learners with choices about where, when, and how learning occurs. With the advent of the pandemic, the CHED espoused that the flexible learning system which combines different methods of teaching will be the new norm in the education sector even beyond the pandemic (Mateo, 2021). Flexible learning, according to Naidu (2017) is a state of being in which learning, and teaching is increasingly freed from the limitations of the time, place, and pace of study and where the approach of flexibility goes beyond the boundaries of a physical school. The challenge to universities to provide students with online teaching and learning settings that were both immediately applicable and supportive of quality learning resulted to a variety of synchronous and asynchronous online settings of teaching and learning (Fabriz et al., 2021). Synchronous online learning is a course which allows students to participate from anywhere with real-time online meetings happening at the same time while asynchronous class lets students participate in the online course from anywhere and anytime without real time online or face-to-face meetings (Martin et al., 2020). In synchronous instruction, the teacher and learners meet usually online for a session at a predetermined schedule while students during asynchronous classes have access to course content through the Internet at their convenience (Fidalgo et al., 2020).

Modular Instruction. An instruction which is either partly or entirely based on modules may be defined as modular instruction while a module is a self-contained, independent unit of a planned series of learning activities designed to help the students accomplish certain well-defined objectives (Goldschmid & Goldschmid, 1972). Nardo (2017) mentioned that modular instruction is an alternative instructional design that uses developed instructional materials which are based on the needs of the students. The goal of the modules is to provide resources to instructors that will allow them to transform their classrooms into active, student-centered learning environment (Sadiq & Zamir, 2014). A module is considered to be a set of learning opportunities which are organized around a well-defined topic which contains elements of instruction, specific objectives, learning activities and self-assessment and evaluation using criteria-referenced measurement (Rakova et al., 2018). The modular approach enables the learners to have control over their learning while accepting greater responsibility for learning as well (Dejene & Chen, 2019).

2. Methodology

Action research (AR) enables researchers to develop a systematic, inquiring approach toward their own practices orienting towards effecting positive change in

this practice (Holter & Frabutt, 2012) as cited by Hine (2013). An action researcher draws power from the premises of pragmatism, that belief that one can know through doing (Brydon-Miller et al., 2003). This underpins the decision to adopt an AR to explore the affordances and constraints of a fully modular calculus class in an online setting.

2.1. Plan-Do-Study-Act

This action research was implemented using the PDSA model: plan-do-study-act (**Figure 1**) adapted from Deming 1986 as cited by Magnuson et al. (2019) in a calculus class composed of 79 sophomore students during the 2nd semester of academic year 2020-2021 (Feb.-June 2021). Considering most students only use cellphones during online learning and virtual lectures/discussions were challenged because of slow Internet connection and very weak signals, the study started with the plan of implementing a fully modular calculus class in the absence of in-person classes. The do part involved the preparation of the self-learning modules and uploading of the same in Google Classroom and the CvSU e-learning system. To determine the affordances and constraints encountered by the students in a modular instruction (MI), the teacher-researcher used student journals, survey questionnaire and focus group discussion. Frequency count, percentages, and thematic analysis were utilized to determine the students' views and experiences in a fully modular instruction and subsequently make appropriate decision of whether to continue or discontinue the use of MI.

2.1.1. Plan

As the health situation due to COVID-19 worsened, in-person classes were suspended globally. The Philippines was no exception and as warranted the Commission on Higher Education (CHED) imposed a flexible learning arrangement for all public and private higher education institutions. The Cavite State University

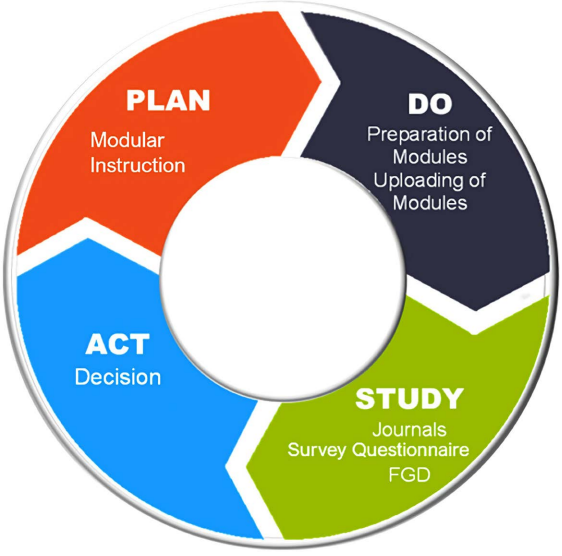

Figure 1. PDSA model of the action research.

followed the directive from CHED Memo #4 s 2020 and adopted the bichronous learning arrangement. The Campus where the teacher-researcher is connected allotted 1.5-hour virtual synchronous class and 1.5-hour asynchronous class for a 3-unit course like Math 2 (Calculus). Since there will be no physical interaction and almost 95% of the students only possess cellphones as learning gadget while 58% have intermittent internet connectivity, it was not advisable to conduct online lecture classes. The teacher-researcher thought of conducting a fully modular calculus class where self-learning modules (SLM) will be provided to the students online. These SLM were uploaded on a weekly basis and students can download the subject content at their most convenient time. They also had the option to have the modules printed out or just use the ecopy. The students' experiences during the entire semester of a fully modular instruction calculus class were determined to assess the opportunities and challenges they encountered.

2.1.2. Do

Development of self-learning modules. With approved syllabus based on CMO No. 25 s 2015 (Bachelor of Science in Computer Science, BSCS, program) and available offline and online resources, 15 self-learning modules (SLM) were developed. The contents of the modules included: objectives, instruction to users/learners, pretest, lesson proper, learning activity, posttest and self-assessment (**Figure 2**). The objectives were formulated in terms of students' specific and measurable performance. The instructions to users were worded following the qualities like clarity, brevity, simplicity, and specificity. The pretest determined the learners' knowledge about the topic. The learner can do a self-check because answers are given in the pretest and a table is provided so they can determine their level of understanding and decide on what to do next based on their scores. If the score is low the user is directed to the lesson proper which is the heart of the module, otherwise, they will be directed to the next module. The lesson proper is where the topic is presented and discussed; terms are defined, and examples are given and thoroughly explained. An activity follows the lesson proper aimed at determining the user's understanding of the lessons presented. Answers to the activity are provided so users can do a self-check where a favorable score allows the learner to proceed to the posttest. The items in the posttest are identical with that of the pretest. Complete solution is provided on the answers for the posttest unlike in the pretest where answers are only given without any explanation or solution. A favorable score from the posttest will allow the learner to proceed to the next module, the topic of which is expressed here.

Implementation of the modules. During the 1st week of classes, the syllabus for the course was provided to the students and the modular instruction was discussed. Weekly, since the start of the semester, each topic module was uploaded in the class Google classroom and the university's e-learning management system which the students can download at their convenience. They had a week to read, perform the activity, do a self-check, and decide if they have enough understanding of the lesson presented. A folder for each module was

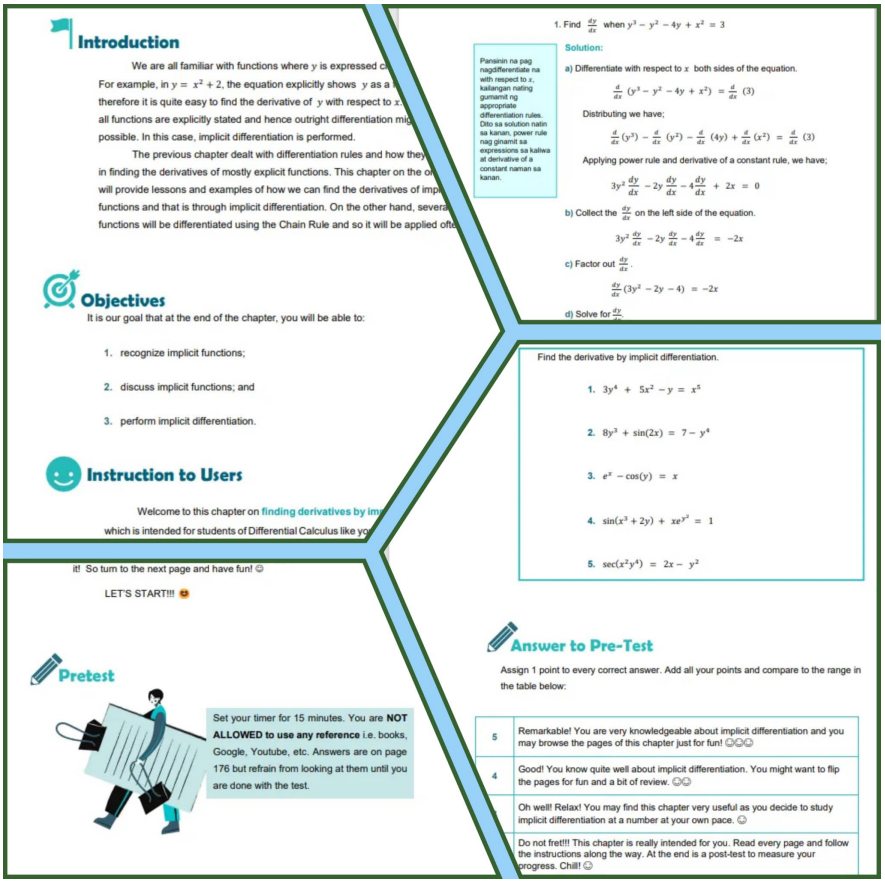

Figure 2. Sample of the relevant parts of the self-learning modules.

created in the Gclasswork for the students' output. Here, the students will upload screenshots of their work on the pretest, activity, and posttest with their corresponding scores which they need to encode in the class scoreboard. A Google link for the scoreboard was also provided. This way, the students were made aware of their progress. The teacher-researcher checked the screenshots of solutions presented by the students and made comments whenever necessary. During virtual synchronous classes, discussions in the form of question and answer about the topic module were conducted.

2.1.3. Study

This constitutes the data gathering and to find out the affordances and constraints on a fully modular instruction calculus class, the teacher-researcher employed reflective journals, survey questionnaire, and focus group discussion (FGD).

Reflective journals. The students were required to submit a journal of their learning experiences, opportunities and challenges alike for every module. They were instructed to write using either English or Tagalog (vernacular). They compiled this and submitted at the end of the semester. However, the teacher-researcher has access to their weekly reflective journal once they upload their output for a particular module.

Survey questionnaire. A self-made questionnaire entitled Assessment Checklist on the Use of Calculus Modules was given to the students at the end of the semester. The 4-point Likert-scale questionnaire with 1-never, 2-sometimes, 3-often, and 4-always described their experience on MI. It was composed of 17 experience descriptors which were based on the students' experiences as gleaned from their written reflections and comments through question and answer during synchronous classes. The experience descriptors on the use of the module included: have access to the lessons anytime, study calculus remotely, study calculus with flexibility, experience independent-learning, be focused in my learning, be inspired to do my best, understand my own learning (metacognition), experience challenges in reading the lessons, exercise critical thinking while studying, learn without relying on sophisticated gadgets, have difficulty understanding the lessons, have feedback on my progress/performance, be confident in my performance, exercise creativity in my learning, be anxious while studying, communicate for help when the need arises (and extend help when warranted), and appreciate calculus and its use in the real world. An open-ended question is given at the end: write your comments/suggestion on the use of modules for flexible learning.

Focus Group Discussion. Towards the end of the semester, a select group of 8 students were gathered for a focus group discussion which was done virtually via Google Meet. The questions asked during the FGD were as follows: state your name and the school you graduated from; what is your understanding of a module; what is your understanding of a modular instruction; what are your practices during asynchronous classes, what are the opportunities and challenges encountered during the fully modular form of instruction in the calculus class? Each of them, in random order, was called to answer one question at a time until everyone has given their answer before proceeding to the next question. The students were allowed to answer in Tagalog.

3. Results and Discussion

Reflective journals. The journals reflected the students' individual stories of struggles and success as they use the modules. The narratives were analyzed by serious reading and identifying words and ideas which appeared more often than others; emerging themes were subsequently captured. The reflections revealed the difficulty of the students in reading the modules because they were not trained in reading for instruction but were used to listening to lectures from teachers. Several times they doubted their own understanding and their own solution, thus, they needed group meetings so they could share among the members their own difficulty and accomplishments. They thought that if they share the same solution with a classmate for example, then, most probably, they got the solution right and they were able to give the correct answer. The reflective journal proved to be a rich source of data as students were free to express their views, experiences, struggles, and even suggestions. This was supported by the

study of Ahmed (2019) where reflective journals were used to promote students' learning and gather research data. Journaling, along with other writing activities was seen to be an effective supplement to traditional lecture mathematics for it complements the critical and logical identity of mathematics and this blend creates a unique learning culture (Domingo, 2019). Maintaining a journal improves the quality of data collection besides providing opportunities to deal with one's emotions (Annink, 2016).

Survey questionnaire. Accomplished questionnaires were collected, and the ratings were tabulated, and frequency was noted. Descriptive interpretation was given in terms of percentage. About 97% of the students often or always experienced being able to: have access to the module anytime, exercise creativity in learning, communicate help when needed, and appreciate calculus better. Forty-seven percent sometimes have difficulty understanding the lessons while 57% often experienced the same. A number of participants, at 70% were often anxious while studying. It was noted that 57% were graduates of public senior high school. The survey is a flexible research approach used to investigate a wide range of topics (Mathers et al., 2009). The tabulated result of the accomplished survey was in consonance with the findings of Goldschmid & Goldschmid (1972) that modular learning offers flexibility and cooperation which was manifested with the need for group studies among the learners.

Focus Group Discussion (FGD). Focus group discussions are commonly conducted as group interviews which aim to explore the participants' experiences, beliefs, and attitudes by using group processes to stimulate responses and gain insights through participants exchanging views, and questioning and challenging each other (Scheelbeek et al., 2020). The recorded FGD was transcribed and put in Excel for ease of analysis (**Figure 3**). The more than one-hour virtual question and answer activity on 8 randomly selected students produced

	A	B
5	Prof. Lea	ay oo! Parang lahat naman. Parang ako din ganun hinahanap... parang natatandadaan ko "dito kjo sinulat yun banda ehh" ganun so... understandable naman yun! What about you Trisha? Anong opportunity?
7	Trisha	Ganun din po! Pwede po talaga syang balikan kasi hawak hawak nyo na po yung module and pwede mo syang ulit ulitin basahin para mas m aintindihan mo pa sya ng maigi yun inexplain sa module.
8	Prof. Lea	Okay! Precious?
9	Precious	Yun po! Since yung mga module po natin sa calculus is downlodable pwede po syang ano... available po sya offline. Kung baga nagkakaroon po... yung opportunity po na ma-manage... mas ma-manage po namin ng tama yung oras... ganun kasi po! Since ayun nga available naman sya all the time... kumbaga mas flexible syang isingit sa mga activities po namin. ganun...
10	Prof. Lea	Okay! So sayo... flexibility no... ang opportunity na na-provide. What abouit you Zack? Parang gustong - gusto ng sumagot ni Zack!
11	Zack	Yung sa ano lng po maam... yung sa pag momodule na practice po yung indepence... yung pagiging independent po sa pagsasagot like explain mop sa sarili mo kung paano mo sya na gets. Tapos, tsaka mo lang... Tsaka ka lang hihingi ng tulong sa classmate mo kapag medyo hindi mo na talaga maintindihan at maipaliwanag sa sarili mo.
12	Prof. Lea	Aaaa! So sayo independent learning. So you find it a positive attribute. Okay! Thank you! What about you Neil?

Figure 3. Sample transcription from the FGD.

305 individual rows of transcription of varying width. Checking of common and similar words or answers and presenting them collectively under the same theme was done. This checking and collective presentation was done twice so that the number of themes were narrowed down for analysis and interpretation to be easier. Finally, a generalized theme for every question was developed. Most students' notion of a module is something printed which contains everything about the lesson provided as specific topics as well as activities to be done and problems to be answered. They also believed that the use of modules would entail self-study and that they will have to do everything by themselves. The common practice is to set aside sometime for module reading (about 20 - 30 minutes) and do this several times.

They all experienced being able to retrieve the module and use it whenever they feel like or whenever they forgot something about the lesson. They were all in consonance that the module was very accessible and provided flexibility on their learning. Some were able to practice their reading and time-management skills, but they all agreed that the modular form of instruction enhanced their independent learning skills. Sometimes, they had difficulty reading the module primarily because they would prefer actual lecture from the instructor besides most of them do not like reading in the first place. Another challenge that they experienced were mistakes found in the module. There were typographical errors, error in grammar, and some mistakes in the presented solution. In a nutshell, the FGD revealed that the modular form of instruction is beneficial yet challenging. The results were supported by the study of Nardo (2017) which espoused that MI encourages independent study and learners develop better self-study and learning skills.

Act

The experiences of the students in a modular instruction provided affordances and challenges (**Figure 4**). The opportunities encountered by the students on a

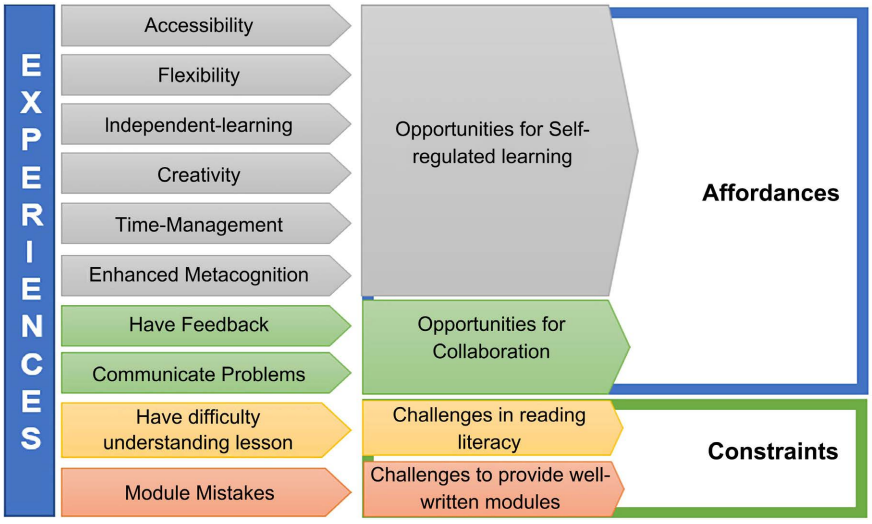

Figure 4. Affordances and constraints in a modular calculus class.

fully modular calculus class enhanced self-regulated learning and collaboration. Self-regulated learning refers to one's ability to understand and control one's learning environment (Shuy, 2010) and these abilities include goal setting, self-monitoring, and self-reinforcement. The modular instruction also enhances collaboration for there is a need for group studies where students can discuss their strength and weakness manifested by the items, they found easy to solve and those where they had difficulty with. Collaboration, as practiced by the group members, is a philosophy of interaction where individuals are responsible for their actions, including learning and respect the abilities and contributions of their peers (Laal et al., 2012). The modular approach helps to maximize the chances of students' participation to fulfill the given tasks at the spot, so the students feel free to learn in their own style (Sadiq and Zamir, 2014). Though collaboration is manifested by the group study, the use of self-learning modules allows learners to work independently and without faculty supervision and is beneficial in self-directed learning (Tohidi et al., 2019). While opportunities for learning are provided by MI, challenges were also encountered which included challenges in reading literacy defined as the understanding, using, evaluating, reflecting on and engaging with texts in order to achieve one's goals, to develop one's knowledge and potential to participate in society (OECD, 2019) and the task for the teacher-researcher to provide well-written modules, free from typographical and grammatical mistakes and which cater to reading readiness of the students.

With all these considerations, the inclination to continue using the modular instruction is apparent.

4. Conclusion and Implication

The fully modular instruction (MI) in a calculus class provided students with opportunities for self-regulated learning and collaboration but exposed their reading difficulties. Overall, the MI is a viable form of calculus instruction delivery with the various positive learning experiences it provides. Well-written modules free from mistakes and errors using language suitable to reading skills of the users should be provided though.

Conflicts of Interest

The author declares no conflicts of interest regarding the publication of this paper.

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