

Modularization: An Inclusive and Sustainable Approach to the Teaching of Differential Calculus

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Abstract: The nature of calculus allows students to thrive in a traditional classroom setting where face-to-face interaction is observed. However, the global health pandemic in 2020 abruptly changed the educational landscape by cancelling in-person classes. To date, frequent suspensions of classes are experienced due to various reasons including high heat index, inclement weather, and transport strike which pose serious problems on instruction delivery on any subject including calculus. To address the task of instruction and as a direct response to the challenge of SDG #4, quality education, self-contained learning modules (SLM) in differential calculus were developed following the Community of Inquiry (CoI) framework and were provided as learning resource. The CoI espouses a deep, meaningful learning experience through the development of three primary elements namely cognitive presence, social presence, and teaching presence. This 4-cycle action research employing the plan-do-study-act (PDSA) model explored the learning experience of an intact class of BSE Math students ($n = 22$, AY 2023-2024) in a modularized approach. The students' experiences were determined through reflective journal, survey questionnaire, and focus group discussions while calculus performance was ascertained through pretest and post test scores. Descriptive and thematic analyses were utilized where results revealed that modularization offered flexibility, accessibility, better time management and enhanced metacognition underpinning opportunities for self-regulated learning encouraging creativity and critical thinking. The use of English and Filipino in the SLMs and in reflective journals allowed better students' participation and involvement. Using a two-tailed paired t -test at $\alpha = 0.05$, a significant difference exists between the pretest and posttest scores which can largely be attributed to the use of the modules ($p < 0.001, d = 8.57, \bar{x} = 147.4, T_s = 160$). Despite the nature of calculus as a discipline, carefully written self-contained learning modules featuring translanguaging offers inclusive and sustainable learning material for calculus agency.

Key Words: modularization, translanguaging, community of inquiry, inclusivity, sustainability, calculus agency

1. INTRODUCTION

Frequent suspension of classes due to various reasons including high heat index, inclement weather, and transport strike among others,

pose a serious problem to instruction delivery. In light of this, self-contained learning modules appear to be a helpful learning resource. A module is considered to be a set of learning opportunities organized around a

well-defined topic which contains elements of instruction, specific objectives, learning activities and self-assessment and evaluation using criteria-referenced measurement (Ibyatova et al., 2018). According to Juceviciene (as cited by Lapp, 2012), the modular approach is an information block which include logically complete unit of learning material, program of actions determined by a specific purpose, and guidance for didactic objectives to be achieved. A module, simply put is a complete learning package and the modular instruction seem to be a potent mode of instruction delivery in either remote learning or in person classes or both. However, a full English text modules exposed reading literacy problem (Domingo, 2023) and thus, self-contained learning modules in differential calculus were developed where translanguaging is employed. Pedagogical translanguaging aims at reinforcing the learning processes by using the whole linguistic repertoire and can be used in language and content classes (Cenoz & Gorter, 2020). Translanguaging is also believed to provide crucial emotional support for emergent bilingual students for language, identity, and emotion are deeply intertwined (deFalco, 2023). Linguistic and cultural backgrounds are believed to be at the heart of the teaching-learning process in a translanguaging pedagogy (Driouch, 2022). Translanguaging allows students with varied linguistic background the opportunity to benefit from their linguistic resources. Research shows that when students are allowed to use all their linguistic repertoire, they tend to have more control over their learning and they learn more easily (Helot,

2012). They become empowered to be fully engaged participants, both at school and the community (Garcia & Flores, 2012).

This study sheds light to the question: will the teacher-researcher's implementation of modularization in differential calculus which adopted translanguaging provide a positive learning experience to student users? It is geared towards evaluation of ones' own practice through the views and experiences of the students. It is imperative to find out how modularization which adopted translanguaging provided learning experiences in calculus. An action research design was employed following the Community of Inquiry (CoI) framework overarching the plan-do-study-act (PDSA) model. The CoI framework was developed by Garrison et al. (2009) and represents a process of creating deep and meaningful learning experience through the integration of three core elements: teaching presence, cognitive presence, and social presence. Social presence was defined in terms of affective expression, open communication and group cohesion (Akyol & Garrison, 2008) as students actively get involve in discussions. The two defined cognitive presence by the practical inquiry model and consisted of the phases—triggering event, exploration, integration, and resolution while teaching presence was defined in terms of design, facilitation and direct instruction. Central to this study is the integration of the aforementioned three core elements.

2. METHODOLOGY

This action research followed the CoI framework and used the PDSA model (Fig. 1)

and was implemented in a hybrid calculus class composed of 22 BSE major in mathematics students during the 2nd semester of academic year 2023-2024 (Feb.-June 2024).

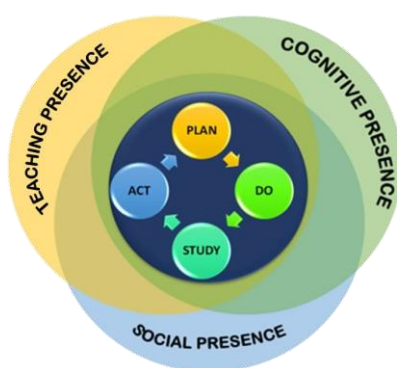


Figure 1. The Community of Inquiry framework was adopted throughout the PDSA cycle

The PLAN part is to integrate Tagalog sidenotes in the self-learning modules after the feedback from the first users of the modules came and their reading difficulty with the all English text modules were exposed. 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. The STUDY part included ways to determine the experiences of the students with the translanguaged self-contained calculus modules. The teacher-researcher used survey questionnaire, reflective journal, and focus group discussion. Frequency count, percentages, and thematic analysis were utilized to determine the students' views and experiences and subsequently make appropriate decision of whether to continue

or discontinue the use of the modules which is the ACT part.

Data Collection:

Qualitative data to determine students' experience, and affordances and constraints of the modular instruction were collected through reflective journals, survey questionnaires, and focus group discussions, while quantitative data to determine calculus performance used the pretest-posttest scores.

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 Translanguaging in Self-contained Differential Calculus Assessment was given to the students at the end of the semester using Google form. There were 6 questions: 5 open-ended and 1 close-ended one. The survey aimed at determining the views and experiences of the students with the self-learning modules where translanguaging is employed.

Focus Group Discussion. Towards the end of the semester, a select group of 8 students were gathered for a focus group discussion (FGD) 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.

Pretest/Posttest. Each of the 15 self-learning modules has pretest and posttest which the students need to perform and accomplish. Everything is self-check and the learner just needs to compare their score to scores presented in the table in each module to determine what to do next. The scores in the pretest and posttest will be used in a two-tailed paired-sample t-test at $\alpha = 0.05$ to determine the students' calculus performance.

Data Analysis:

Frequency count and percentages were employed to interpret data collected from the survey. Braun and Clarks' six-phase framework for thematic analysis was utilized for the reflective journal and FGD, to describe the students' experience in the modular instruction. A two-tailed paired-sample t-test at $\alpha = 0.05$ was used for the pretest and posttest to determine calculus performance while Cohen's d was used for effect size.

3. RESULTS AND DISCUSSION

Qualitative and quantitative data collected and analyzed revealed the results presented below.

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 positive experience of the students when Tagalog sidenotes were incorporated in the modules. Every student believed that they are better able to understand the lessons because of the Tagalog explanations which they found very helpful.

Survey questionnaire. The Google form rendered ease to the survey conducted (Fig. 2). Accomplished questionnaires were collected and the ratings were automatically tabulated, and frequency were noted. Descriptive interpretation was given in terms of percentage. About 92% of the students think the self-contained learning modules which employed translanguaging were very helpful in their study of calculus. About 97% 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.

Focus Group Discussion (FGD). The recorded FGD was transcribed and put in Excel for ease of analysis. The more than one-hour virtual question and answer activity on 8 randomly selected students produced 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.

Calculus Performance. Using a two-tailed paired sample t-test, the pretest and posttest scores were compared. The table shows a

significant increase in the posttest scores and a significant decrease in the standard deviation which infers that students are more homogenous in their performance after the lessons and activities in the modules were accomplished. The significant difference between the pretest and posttest scores can largely be attributed to the use of the modules as shown by the test of effect size.

		\bar{x} ($N=160$)	σ	α = 0.05	Cohen's d	Remarks
2023 - 2024 (n=22)	Pre test	69.3	11.2	$p < 0.001$	8.57	Significant difference exists (highly attributed to the use of SLM)
	Post test	147.4	6.39			

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 in 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).

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 Goldschimid & Goldschimid (1972)

that modular learning offers flexibility and cooperation which was manifested with the need for group studies among the learners.

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). 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 Narda (2017) which espoused that MI encourages independent learning and learners develop better self-study and learning skills.

Teacher-researcher Reflection

Module-writing is a challenging task. It involves ensuring that whatever should be given in in-person lectures are put into texts. The need for careful planning is crucial for the teacher provides the direction of the learning activity required in the module. It is also possible that though the teacher exercise prudence in writing the module, mistakes cannot be avoided, and thus, module writing should be collaborative to ensure that mistakes are limited if not totally eliminated. This is supported by the study of DeWitt and Siraj (2020) where they espoused the collaborative nature of module writing. Expert validation and student validation are important aspects of ensuring cognitive presence is observed and unintentional mistakes are corrected. Question and answer activities after each module should be conducted among the teacher and students for the latter need validation of their understanding of concepts. The students feel they are on the right track if they hear validation from their teacher not trivializing the validation they get from their peers during group studies.

The modular instruction provides an opportunity for teaching-learning despite many class suspensions. The availability of the modules anytime keeps the instruction delivery continuous and thus sustaining the needs for learning materials. The additional feature on translanguaging which was aimed at supporting students who are struggling with understanding English written modules seem to really helped

the students better understand the lessons and ultimately improve their calculus performance. This is supported by the study of Perez-Fernandez (2024) that translanguaging practices promotes educational inclusivity through the integration of students' home languages into the learning environments. Overall, though, module writing is challenging, the benefits from a sustainable modularized classroom far outweighs the difficulty encountered while developing the modules. Moreso, translanguaging enhanced the positive teaching-learning experience by creating a more inclusive learning environment for calculus learning.

4. CONCLUSIONS

The results of the action research highlighted the following:

1. Module writing should be a collaborative effort between and among colleagues of the same discipline to ensure content validity. It should also involve students for the necessary student validation.
2. The modular instruction provided positive learning experiences which encourages self-regulated learning and improved calculus agency without trivializing the teacher's presence.
3. Translanguaging provided support for a more inclusive learning environment and significantly helped the students to better understand the lessons.
4. Modularization and translanguaging are agents of sustainability and inclusivity in a learning environment.

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