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PRINCIPAL COMPONENTS OF STUDENTS' DIFFICULTIES IN MATHEMATICS IN THE PURVIEW OF FLEXIBLE LEARNING

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HIGHLIGHTS

This policy brief underscores the difficulties experienced by college students in mathematics under the purview of flexible learning. Using Principal Component Analysis, seven (7) factors were identified as the emerging students' difficulties. These factors are further classified as teacher-, student-, and technology-related. It also appears that some of these difficulties are particularly severe for students taking advanced mathematics courses. These intertwined difficulties generally stem from a lack of planning and preparation, as well as the complex, abstract, and notational nature of mathematics.

INTRODUCTION

The COVID-19 pandemic has forced academic institutions to migrate from traditional face-to-face classes to flexible learning. With flexible learning, the majority of students were allowed to have their classes online (synchronous or asynchronous, or a combination of both) in the comfort of their homes. This abrupt migration has undoubtedly resulted in students' difficulties specifically in their mathematics classes because **(a)** there are students who belong at the bottom of the digital divide (Department of Information and Communications Technology, 2019; World Bank, 2020) or the gap between students' opportunities to use information and communication technology, and the internet; **(b)** mathematics is difficult to communicate online-it is complex, abstract, and uses notations and symbols (Hodds, 2020; Johns & Mills, 2021); and **(c)** learning disruptions are likely to happen when students learn at home (Dutta & Smita, 2020; Tasso et al., 2021).

These identified difficulties may serve as the basis for curricular revisions, new policies, and identification of effective teaching strategies. It may also help improve the present state of mathematics online education, and will open the door to offering a stable and regular online academic program in the future.

METHODOLOGY

This study is quantitative-exploratory since it identifies the students' emerging difficulties in mathematics under flexible learning. It involves 273 BSU students who were enrolled in mathematics courses during the first semester of the school year 2021-2022.The data was gathered using Students' Difficulties in Mathematics Flexible Learning (SDMFL)-questionnaire developed by the researchers.

The components were identified via a dimension-reduction analysis called Principal Component Analysis. Also, the degree of seriousness of the difficulties among students enrolled in mathematics courses in varying difficulties were compared using Analysis of Variance (ANOVA).

FINDINGS

Principal Components of Students' Difficulties in Mathematics Flexible Learning

The statistical analyses of data led to the extraction of seven components. A qualitative analysis was further conducted to provide a thematic name for each component (Figure 1). Component 1 includes ten items from the SDMFL questionnaire. These items contain the phrases "there are too few examples in the module", "instructions and explanations in the module are not clear", "modules lack information", "teacher does not provide real-time feedback", etc., all describing the quality of learning materials and support provided by the teacher. Similarly, all five items under component 2 relates to students struggles in time management and procrastination so that this component is named "struggles in time-management". There are five (5) items that load under component 3, which all describe the inadequate internet connection and devices of students. Moreover, three (3) items comprising component 4 indicate that submitting the requirements on-time is challenging. Another set of items loads under component 5, all relating to students' low self-efficacy in learning mathematics and using technology, while four (4) more items describing students' health-related challenges load under component 6. Finally, three (3) item statements comprised component 7, all relating to students' difficulties in communicating with their teachers and peers online.

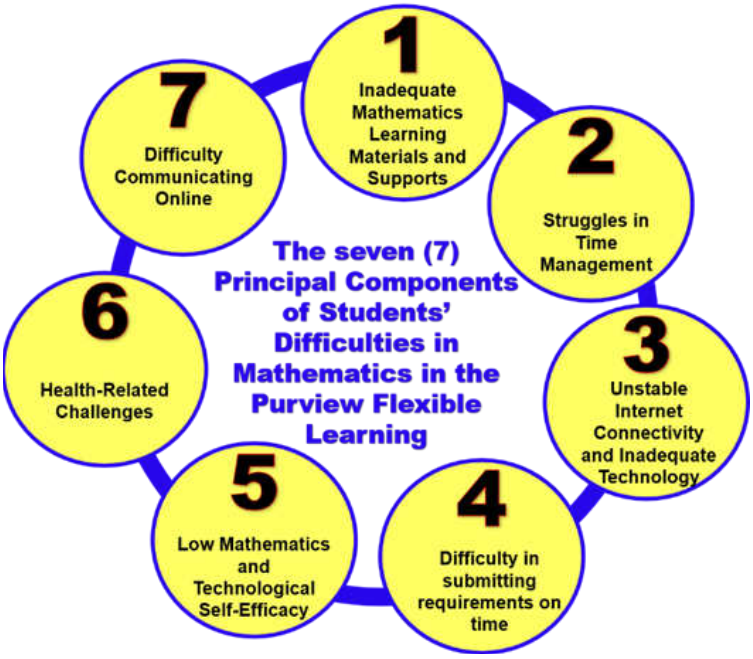

Figure 1. The Seven-component Students' Difficulties in Mathematics in the Purview of Flexible Learning

The emerging students' difficulties in flexible mathematics learning are generally classified as teacher-related (component 1), student-related (components 2, 4, 5, 6), and technology-related (components 3, 7). These difficulties appear to be the by-product of the abrupt migration to flexible learning. Moreover, these difficulties may have been intensified by the nature of mathematics. That is, because mathematics is a language of symbols and notations that represent advanced, complex, and abstract ideas, communicating them online is a massive challenge.

Comparison of Students' Rating on the Difficulties According to the Level of Mathematics Course

The degree of seriousness of students' difficulties was compared according to whether a student is enrolled in a basic, advanced, or major mathematics course. The results of ANOVA and Duncan's Multiple Range Test revealed that students enrolled in advanced and major mathematics courses have indicated a higher degree of seriousness only in two difficulties (components), namely (a) inadequate mathematics learning materials and supports and (b) difficulty in submitting requirements on time (Figure 2).

Results reflect the fact that advanced and more abstract mathematics courses require a higher level of visualization during the teaching-learning process. This in turn requires some knowledge of media platforms and tools appropriate for communicating online, as well as some digital proficiency to translate mathematical topics into self-sufficient learning materials (e.g., modules). Also, advanced and abstract courses are more difficult to communicate because topics are more complex and therefore require more elaborate explanations and examples, especially in cases where technology is insufficient and time is a constraint. Many authors have in fact agreed that depending on the nature of mathematics, the manner in which it is taught and the technological support that aide teachers should be reconsidered (Artigue, 2010; Freiman et al., 2017; Pierce & Ball, 2009).

Students enrolled in advanced and major courses have a higher level of difficulty in terms of submitting their requirements on time. The amount of time needed to finish a task is reasonably dependent on whether the student has sufficiently understood a topic, either through synchronous or asynchronous learning. If the teaching-learning process is hampered and understanding slows down because communicating mathematical content is a struggle between the teacher and students, it follows that students are unable to provide the output that is expected of them. Teachers' inexperience with online learning may also have accounted for this difficulty. It is possible that the time given to finish a task is appropriate for traditional face-to-face classes and not for online or flexible classes. This means that teachers are unable to adjust assessment practices that are appropriate and practical for flexible learning.

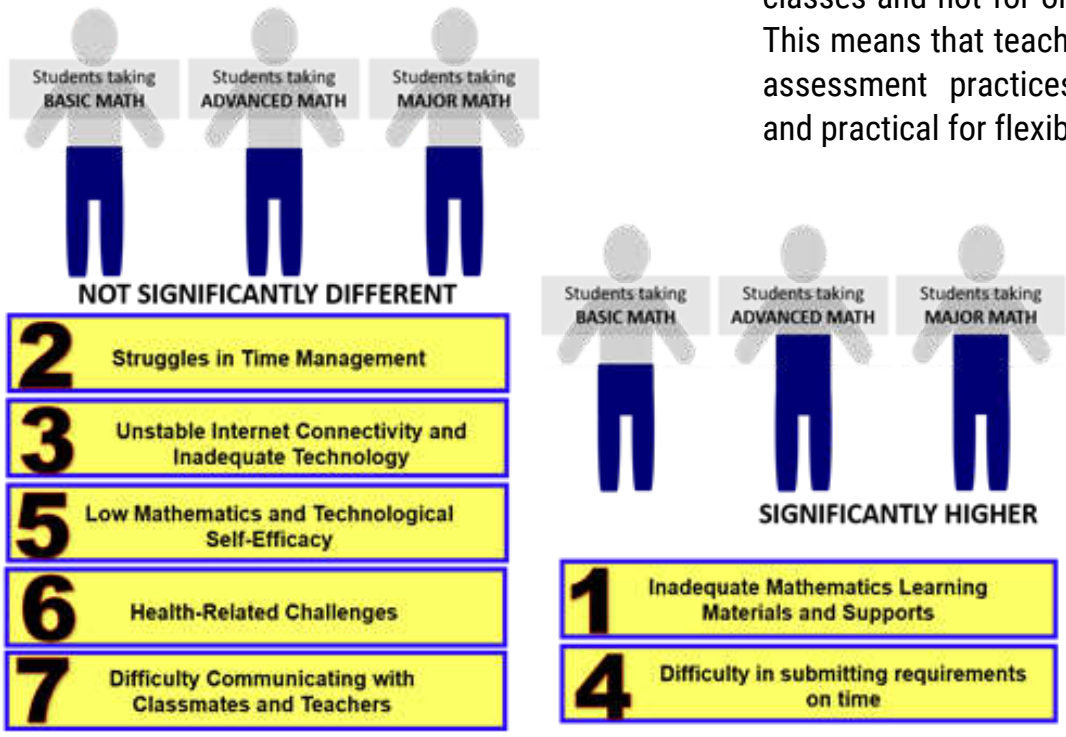

Figure 2. Comparison of Students' Difficulties According to the Level of Mathematics

CALL TO ACTION

- The seven-component students' difficulties may serve as a model for teachers, students, and administrators towards attaining more successful mathematics teaching and learning in a flexible setting.

- ✓ On the part of the teachers, improving the communication and delivery of the learning content may be prioritized. For example, trainings and workshops may be conducted to familiarize oneself of existing applications and technology that aid in the development of effective learning materials, master teaching tools and platforms that facilitate online learning (e.g. integrating GeoGebra in online classes), and ignite conversations that aim to identify teaching strategies that are appropriate to the delivery and assessment of specific mathematics courses. Also, students' self-efficacy maybe improved by promoting real-time feedback and encouragement, monitoring, and acknowledging students' achievements and best practices.

- ✓ For advance and more abstract courses, teachers may invest in strengthening the communication of learning content and the provision of technology-laden learning materials and supports.

- ✓ Teachers are encourage to remind their students of the importance of time management and strategies to manage disruptions during flexible classes. Relevant programs like seminars on self-learning strategies and maintaining healthy lifestyle may be initiated.

- For future studies, one may investigate the relationship among the identified difficulties to provide evidence-based results on how these factors interact with each other.

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ABOUT THE MATERIAL

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