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Future-Proofing mathematics education: Challenges from the pandemic to coping mechanisms and action planning

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ABSTRACT

This study examines the resilience and adaptability of mathematics education during the COVID-19 pandemic, focusing on the challenges faced by teachers and the coping mechanisms they employed during the abrupt transition to new learning modalities in secondary schools in Baganga, Davao Oriental, Philippines. Employing a qualitative research design with a phenomenological approach, five respondents participated in in-depth interviews selected through purposive sampling. The research highlights three primary challenges: adapting to new teaching modality; efficiency of learning materials' distribution and retrieval; and validating students' learning. To address these challenges, teachers implemented several coping mechanisms, including the contextualization and adaptation of learning materials; adaption of digital platforms and educational apps; and the conduct of home visits. These strategies not only facilitated the continuation of mathematics education under constrained conditions but also offer insights into future-proofing educational practices. Aligned with Sustainable Development Goal (SDG) No. 4, Quality Education , this study underscores the need for strategic action planning to enhance the resilience and flexibility of mathematics education systems, ensuring they are better prepared for any future disruptions.

Keywords: Future-proofing education, educational resilience, teaching modalities, coping mechanisms

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INTRODUCTION

Mathematics education is crucial as it enhances critical thinking and problem-solving skills (Bucu, 2022), which are fundamental for STEM disciplines. It not only promotes active involvement in scientific and engineering endeavors but also addresses social justice issues (Appelbaum, 2023). In the Philippines, mathematics education faces significant challenges and shows considerable room for improvement, especially in high school performance. Filipino students have consistently underperformed in international assessments like PISA and TIMSS, demonstrating concerning weaknesses in mathematics (OECD, 2023).

The COVID-19 pandemic has exacerbated these issues. It has affected educational systems worldwide, significantly impacting mathematics education, highlighting various challenges and coping mechanisms among teachers. Globally, educators faced obstacles such as learning losses (Marquez, et al., 2020), limited resources, communication barriers, and the need to adapt to online platforms (Tuxtashevna, 2022). In the Philippines, these challenges were adressed through the Basic Education Learning Continuity Plan (BE-LCP), a framework incorporating various educational nterventions to mitigate the effects of COVID-19 on learning continuity (DepEd Order No. 12, 2020). Like many other schools in the Philippines, high schools in Baganga, Davao Oriental encountered challenges with modular learning during the pandemic.

To safeguard the health, safety, and well-being of students, teachers, and staff, the department has adopted alternative learning delivery methods such as modular, television-based, radio-based education, blended learning, and online learning (Rodriguez, 2022; Anzaldo, 2021). These adaptations have necessitated a shift in the role of instructional delivery within the teaching and learning process. Subjects are now taught through diverse methods including inquiry, hands-on learning, social engagement, and constructivism. However, these pedagogies are challenging to implement in a remote learning environment, and many teachers feel unprepared and incapable of teaching effectively at a distance (Lichoro, 2015).

Teachers reported challenges in assessing student performance and engaging learners effectively, leading to increased anxiety around mathematics (Brijlall and Ivasen, 2022), a subject already perceived as difficult. With its structured content and often abstract concepts, it presents unique teaching and learning difficulties in remote settings (Velez et al., 2023).

The lack of direct interaction, difficulties in engaging students, and the digital divide have exacerbated existing educational challenges, making effective instruction and learning more arduous (Ferri et al., 2020). The broader stress and trauma of the pandemic can exacerbate students' existing math anxiety, potentially multiplying stress during math classes, whether onsite, online, or in a blended teaching-learning environment (Sawchuk and Sparks, 2020). Parents, meanwhile, have taken on the role of teachers and tutors for their children's home learning tasks, often without the necessary preparation to assist in math, at a time when their support is crucial to student success (Sawchuk and Sparks, 2020). These challenges have not only hindered the learning process but have also raised concerns about long-term educational outcomes and equity in access to quality education (Paul, 2022).

Coping strategies included problem-focused approaches, emphasizing the need for mental and emotional support alongside technological resources (Wottrich et al., 2023). Furthermore, innovative pedagogies like the flipped classroom emerged as potential solutions, promoting hybrid learning environments that could enhance student engagement in mathematics (Cevikbas and Kaiser, 2022). The adoption of tools such as virtual whiteboards, simulation software, and collaborative

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platforms has transformed the traditional mathematics classroom, allowing for a more interactive and engaging learning experience (Engelbrecht et al., 2024).

Looking beyond immediate responses, this research focuses on sustainable strategies to future-proof mathematics education. This involves not only enhancing technological infrastructure but also fostering resilience in educational practices that can adapt to various teaching and learning conditions. Future-proofing strategies emphasize the importance of continuous professional development, robust support systems for students and teachers, and policies that ensure equitable access to educational resources (Helliwell and Ng, 2022).

This study aims to analyze the lessons learned during the recent educational disruptions and to propose a framework that can help educators, policymakers and stakeholders prepare for future challenges in mathematics education. Specifically, it aimed to answer the following questions:

1. What are the primary challenges faced by mathematics teachers in adapting to new learning modalities?
2. What coping mechanisms have proved effective in managing these challenges?
3. How can mathematics education be future-proofed to ensure resilience and adaptability in facing potential disruptions.

METHODOLOGY

Research design

This phenomenological study focused on exploring the varied lived experiences of teachers within the alternative delivery modes of teaching and learning mathematics. The research was designed to not only capture the essence of their immediate responses to COVID-19 pandemic but also gather insights into strategic actions for future-proofing mathematics education against similar disruptions.

Participants

The study involved five participants selected through purposive sampling to ensure a comprehensive exploration of experiences. Participants included mathematics teachers from high schools in Baganga, Davao Oriental Division, with a minimum of two years of teaching experience, who underwent the rapid transition in teaching modalities. This selection was expanded to include participants likely to provide insights into both the coping mechanisms during the pandemic and thoughts on proactive strategies for future educational challenges.

Data collection

Phenomenology was chosen for its effectiveness in analyzing a small number of subjects, enabling an in-depth qualitative understanding of their experiences (Creswell, 2014). Data were collected through in-depth interviews, focusing on participants' experiences during the pandemic and their views on strategies for future educational resilience. Interviews were scheduled at a mutually agreed time and location, and participants were briefed on the study's purpose, methods, risks, benefits, and confidentiality, as outlined in the consent letter. Floating prompts and open-ended grand-tour questions were used to guide the interviews, targeting the study's main themes. Though questions were pre-scripted, the researcher allowed flexibility to explore each participant's unique perspective.

Data analysis

Data were analyzed using the descriptive phenomenological method by Morrow et al, (2015) which involves seven steps: familiarization with the data, identifying significant statements, formulating meanings, clustering themes, developing a detailed description, establishing the fundamental structure, and

seeking verification of the fundamental structure (Morrow et al., 2015). This rigorous analysis helped in identifying not only the immediate coping mechanisms but also the perceived needs and strategies for strengthening future educational practices.

Trustworthiness

Trustworthiness was ensured by adhering to the criteria of credibility, dependability, transferability, and confirmability as defined by Golafshani, (2003). This involved consistent methods in data collection and analysis, stability and recurrence in participant reports, and rigorous checks for accuracy in the capture and representation of data. The research process was designed to allow the findings to be applicable in similar contexts, enhancing the study's value across broader educational settings.

Ethical considerations

Ethical considerations were meticulously followed, with respect for persons, beneficence, and justice guiding the conduct of the study (Barrow et al., 2020). Efforts were made to maximize the benefits of the research while minimizing potential harm to participants. This included ensuring informed consent, confidentiality, and the right to withdraw from the study at any time without penalty.

RESULTS

Challenges encountered by math teachers

These are the various challenges encountered by mathematics teachers at Baganga National High School, Davao Oriental, Philippines during the COVID-19 pandemic and their coping mechanisms.

Theme 1: Adapting to new teaching modality

Table 1 below shows a summary of participants' responses to the first theme, Adapting to New Modality, focusing on the main challenges and perspectives shared by teachers regarding the use of Self-Learning Modules (SLMs) in modular distance learning.

Table 1. Participants' responses to theme 1: Adapting to new teaching modality.

Theme 1: Adapting to new teaching modality	Participant	Key points / Challenges	Quotes / Insights
Teacher challenges in implementing SLMs	IDI_Teach_003	Teachers find delivering modular distance learning challenging, particularly in adapting methods to suit students' needs. Preparation requires stepping into students' perspectives to determine if they can understand and engage with the material.	*"The real challenge is deciding what method to impose in the self-learning because it is difficult. We need to assume that we are in the students' shoes... We need to centralize our preparation from the students' perspective to determine if they can comprehend and engage with the material or not..."*

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	IDI_Teach_005	Despite available references, teachers struggle with organizing and presenting material in a way that makes it comprehensible for students. Modular learning is particularly difficult since even face-to-face learning poses comprehension challenges for students.	*"It's difficult because even with references, it's confusing how to organize and present the material... Even when I understand the lesson well, how can I make it comprehensible to my students when, even face-to-face, they struggle to understand?"*
Role of parental support and its limitations	IDI_Teach_004	Teachers observe that students with minimal parental supervision struggle significantly. Parents often lack the knowledge to support module learning, which affects students' ability to complete work effectively. Additionally, distractions, such as cellphones, further reduce students' focus on assignments.	*"Because they are just working through the module on their own... they have a hard time, especially when they juggle many subjects without anyone to supervise or guide them... Consequently, they often get distracted by their cellphones, and some end up submitting incomplete modules."*

Table 1 outlines key challenges teachers face in implementing modular distance learning. Although printed self-learning modules (SLMs) are preferred by students and parents, teachers struggle to adapt teaching methods to ensure student comprehension. Limited training in modular strategies and the lack of parental support further hinder effective learning, with students often facing distractions and incomplete guidance at home. These challenges collectively impact students' understanding, particularly in subjects like math, highlighting the need for improved resources and training for modular learning success.

Theme 2: Efficiency of learning materials' distribution and retrieval

Table 2 below presents the summary of participants' responses to the second theme, Efficicency of Learning Materials' Distribution and Retrieval, with a focus on the key challenges and actions taken by teachers in ensuring that learning materials reach students in a timely manner.

Table 2. Participants' responses to theme 2: Efficiency of learning materials' distribution and retrieval.

Theme 2: Efficiency of learning materials' distribution and retrieval	**Participant**	**Key points / Challenges**	**Quotes / Insights**
Student and parent barriers to timely module retrieval	IDI_Teach_001	Many students in remote areas are unable to collect modules on time due to travel costs and distances.	*"During distribution, some students get their modules on time while some are late because they are from far-flung areas and have no fare for a ride."*

Technical and equipment issues	IDI_Teach_002	Malfunctions in reproduction equipment, such as printing machines, cause delays in the production and release of modules.	*"There were times that we cannot reproduce the needed number of modules because our machine is not working well. So, we have to postpone the releasing of modules as well as the retrieval."*
Urgency of task completion and logistical challenges	IDI_Teach_005	Teachers face tight schedules to staple and organize SLMs for distribution, often needing to expedite processes to meet weekly deadlines. Additionally, they face shortages of materials like bond paper and ink, delays in receiving master copies, and high workloads.	*"Our task is to organize SLMs urgently in order to catch up for next week's distribution."*
Challenges for students in remote areas	IDI_Teach_002	Students in remote areas struggle with access, often facing high travel costs (up to 500-1000 PHP round trip) to retrieve and submit modules.	*"I find that the students who are living far from our school are really having a hard time to get and or to submit their modules especially they have to pay a fare of five hundred or one thousand, back and forth."*
Proactive steps taken by teachers to support distribution	IDI_Teach_005	Teachers have adopted strategies like delivering modules directly to students' residences, coordinating with barangay officials, and leaving modules at community centers for easier student access.	*"We left the modules in the barangay so others who were not able to get them during our visit can get there and we retrieve them after a week."*

The responses highlight the key challenges teachers face in adhering to the Weekly Home Learning Plan (WHLP) schedules. Major obstacles include student and parent delays in retrieving modules due to transportation costs, technical issues with reproduction equipment, and shortages of essential materials like bond paper. Teachers have implemented strategies such as delivering modules directly to remote areas and collaborating with local barangays to make materials more accessible. Despite these efforts, communication barriers and resource limitations continue to impact the timely distribution and retrieval of learning materials.

Theme 3: Validating student's learning

The responses to the third theme, Validating Student Learning are summarized in Table 3 below. It focuses on the challenges teachers face in assessing students' progress through modular learning and the actions taken to address these issues. The summary outlines the difficulties teachers face in assessing students' genuine learning progress in a modular format. Issues such as incomplete submissions, copied answers, and over-reliance on answer keys hinder the validation of students' understanding. Teachers highlighted that subjects like math, which benefit from face-to-face

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explanations, are especially challenging to assess through modules alone. Despite these obstacles, teachers strive to follow flexible assessment guidelines, balancing fairness with the integrity of grading practices during the pandemic.

Table 3. Participants' responses to theme 3: Validating students' learning.

Theme 3: Validating student learning	Participant	Key points / Challenges	Quotes / Insights
Challenges in ensuring authentic learning	IDI_Teach_001	Teachers observe that many students lack focus and understanding, leading them to copy answers from classmates rather than engage with the material. This diminishes the validity of learning assessment.	*"The disadvantage is that students have not learned enough because they lack focus, hence they resort to copying answers from their classmates."*
Frequent submission of incomplete or copied work	IDI_Teach_001	Students frequently submit incomplete modules with copied or repeated answers, which complicate the validation of learning.	*"Every time modules are passed, I check them immediately... some students have the same answers, some have repeating answers while others have answers in the front of the paper but empty at the back."*
	IDI_Teach_002, IDI_Teach_003	Incomplete submissions, missing solutions, or no answers at all are common, particularly in subjects like math where steps are crucial.	*"The challenge is that the answers are lacking solutions, and worst, there is no answer at all."*
Over-Reliance on answer keys	IDI_Teach_005	Some students bypass learning by directly copying from the answer keys provided at the back of modules, hindering authentic assessment of their understanding.	*"Some students just go directly to the back [answer keys]."*
Need for face-to-face interaction for effective learning	IDI_Teach_004	Teachers emphasize that subjects like math require face-to-face interaction for effective comprehension. The modular setup prevents teachers from ensuring that students understand the material or genuinely answer on their own.	*"The challenge especially in math is that it requires face-to-face classes for the students to understand... When we receive modules that are unanswered, we return them to students and require them to fill out the missing parts."*
Grading and assessment difficulties	IDI_Teach_004	Teachers struggle with grading due to incomplete submissions, late submissions, and lack of evidence that students genuinely understand the material.	*"My job of checking repeats endlessly because some submitted late, some don't pass. I am confused as to what grade to put because some didn't submit."*

Skepticism about student engagement with material	IDI_Teach_002, IDI_Teach_003	Teachers doubt whether students who complete modules truly understand the lessons or if they simply copy answers, as patterns in copied work become evident.	*"I do not have the one-hundred percent guarantee that they were able to read or to understand the lessons... or they're just copying the answers at the back of the module."*

Coping mechanisms of mathematics teachers in their challenging experiences

Theme 1: Contextualization and adaptation of learning materials

The summary of the responses to Theme 1: Contextualization and Adaptation of Learning Materials, is shown in Table 4. This highlights teachers' efforts to adapt and contextualize learning materials to fit students' abilities and the challenges encountered in doing so.

Table 4. Participants' responses to coping mechanisms related to theme 1.

Theme 1: Contextualization and adaptation of learning materials	**Participant**	**Key points / Challenges**	**Quotes / Insights**
Use of supplemental activities for validation	IDI_Teach_001	Teachers use additional activity sheets to verify student learning and prevent copying among students.	*"The answers of my students seemed to have been copied from others. For me to be sure, I give another activity sheet for my students."*
Tailoring instructions and assessments to student abilities	IDI_Teach_002	Teachers adapt instructions and assessments to match students' comprehension levels, ensuring tasks can be completed independently within the allotted time.	*"I will prepare my instructions... to make sure the assessment tools can be answered by the students on their own."*
Concise and accessible learning materials	IDI_Teach_005	Teachers create additional, concise materials and supplemental activities to simplify essential content, especially when faced with technical or printing issues.	*"We send supplemental activities aside from the module."*
Developing alternatives for technical issues	IDI_Teach_002	In response to printing and reproduction challenges, teachers produce alternative worksheets aligned with the module content to ensure continuity in learning.	*"Since we have printers per year level... we produce alternatives such as worksheets, to be used by students for the meantime."*

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Enhancing teaching methods for complex subjects	IDI_Teach_003	Teachers employ additional resources, like videos and reading materials, to better explain complex subjects (e.g., Grade 11 Mathematics), using relatable examples to simplify abstract concepts.	*"I narrow it down... for example, in GenMath, rational functions."*
Localization and use of mother tongue-based learning	IDI_Teach_005	Teachers use local dialects in notes and explanations to enhance student comprehension, in alignment with the Mother Tongue-Based Multilingual Education (MTB-MLE) principles outlined in the Enhanced Basic Education Act.	*"So, what will I do if they don't understand? I provided notes written in their dialect."*
Resourcefulness in adapting curriculum content	IDI_Teach_003	Teachers read journals and watch videos to gather additional teaching methods for subjects like math, allowing them to contextualize lessons with relevant examples and simplify complex topics.	*"All of my coping mechanism is to read and to watch videos about how to apply methods especially in mathematics."*

Table 4 illustrates teachers' proactive efforts to make learning materials accessible and understandable for students. Strategies include using additional activity sheets to validate learning, tailoring instructions and assessments to students' abilities, and creating supplemental activities to simplify content. Teachers also localize explanations in the students' dialects and utilize multimedia resources to enhance complex subjects like mathematics. Despite technical challenges, these approaches support the goal of providing a contextualized and inclusive learning experience.

Theme 2: Use of social media and educational apps

Table 5 highlights how teachers have integrated digital tools into their teaching practice during the pandemic and the challenges faced.

Table 5. Participants' responses to coping mechanism related to theme 2.

Theme 2: Use of social media and educational apps	Participant	Key points / Challenges	Quotes / Insights
Digital platforms for student queries and support	IDI_Teach_001	Social media and chat platforms like messenger and facebook have been used effectively for students to ask questions and receive help with assignments, allowing for continuous student-teacher communication.	*"Students are allowed to ask questions through chat via messenger... we also utilize other apps to cater to all of their queries."*

Group chats for lesson clarifications	IDI_Teach_003	Teachers set up group chats to provide students a platform for clarifying lesson content and raising questions when in-person visits are not feasible, ensuring consistent access to support.	*"We have a group chat with the students... they can contact us to cater to their queries."*
Teacher accessibility through multiple channels	IDI_Teach_004	Teachers make themselves available through various means, including text, calls, and messenger, to ensure students can reach them whenever they need assistance, enhancing the support provided to students.	*"We are available anytime that if ever they need to con*tact us, they can through text, call or messenger."
Skill development and creativity with technology	IDI_Teach_002	Teachers have gained new technology skills through blended learning, allowing them to integrate apps and other digital resources creatively to enhance lesson delivery.	*"Modular and blended learning help us teachers learn new skills with technology."*
Innovative teaching through learning apps	IDI_Teach_002	Engaging with learning apps and exploring new technology tools has enabled teachers to develop innovative methods of instruction, improving their capacity to support students' learning experiences remotely.	*"I engage myself in learning apps or exploring technology so I could help students with an innovative way of teaching."*
Value of online platforms in 21st-century learning	IDI_Teach_001	While traditional classrooms are preferred, teachers recognize that platforms like Zoom and Google Meet provide valuable experience with 21st-century learning tools, which can enhance future educational experiences.	*"Even in normal classes, we still have the Zoom classes, the Google Meet classes for the students to experience what the 21st century is like."*

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It is shown in Table 5 the teachers' reliance on digital platforms like messenger, facebook, and google meet to maintain communication and support student learning during the pandemic. Group chats and other online tools have facilitated real-time responses to student questions, while also encouraging teachers to develop new skills in technology and innovate their teaching methods. However, limited internet access and device-sharing challenges hinder some students' engagement. Teachers appreciate these tools for offering a glimpse into 21st-century learning, even while expressing a desire to return to traditional classrooms.

Theme 3: Conduct of home visitation

Theme 3 which is conduct of home visitation is based on the responses as displayed in Table 6, emphasizing teachers' insights on the benefits and challenges of home visits to support student learning and engagement.

Table 6. Participants' responses to coping mechanism related to theme 3.

Theme 3: Conduct of home visitation	Participant	Key points / Challenges	Quotes / Insights
Preparation for home visits	IDI_Teach_002	Teachers prepare by gathering students' contact information and addresses to assess if the home environment supports learning, and engage parents in the students' education, especially to verify if children are working independently on modules.	*"I asked the numbers or the address of the students... to check if their environment is conducive for learning."*
Support for struggling students in remote areas	IDI_Teach_002	Teachers focus on visiting low-performing students, especially in remote areas, to ensure they understand basic concepts, addressing challenges with complex subjects such as math.	*"I visited those who are performing poorly in math, especially those in remote areas... I make sure they were able to learn the basic concepts at least."*
Logistical challenges and teacher efforts	IDI_Teach_004	Visiting students in remote areas is challenging, but teachers remain committed, using a checklist to track students in each barangay to ensure no student is left unvisited.	*"Of course, it's very hassle... we reached out to students in their barangays with a checklist at hand."*
Importance of maintaining student engagement	IDI_Teach_004	Teachers find that without home visits, students may neglect their studies. Regular visits help mitigate issues with grading by ensuring students remain engaged and accountable.	*"If you don't reach out to the students, they will just ignore it. So, I conduct home visits."*

School directive for home visitation	IDI_Teach_001	The school administration encourages home visits, especially for students struggling in math, advising teachers to visit not only low-performing students but all students, to foster better learning outcomes.	*"Our principal instructed us to visit not just the struggling students, but all students in my class advisory at their homes to help them."*

The table revealed the positive impact of home visits on student learning and engagement, with teachers emphasizing their value in supporting struggling students, especially in remote areas. Although logistical challenges exist, teachers view these visits as essential for fostering accountability and bridging the gap between school and home, following school directives to help all students improve academically. These visits also allow teachers to connect with parents and ensure a conducive learning environment at home.

Action plan

Table 1. Future-proof mathematics education action plan matrix with SWOT analysis.

Objective	Action	Responsibility	Metrics for success	SWOT
Integrate technology in learning	Implement digital tools and platforms (e.g., adaptive learning software, virtual reality)	Math department heads, IT staff	Increased student engagement; improvement in math proficiency scores	**Strengths:** Current tech-savvy faculty; Weaknesses: Budget constraints for ongoing technology updates; **Opportunities:** Emerging tech like AI and VR; **Threats:** Rapid technological obsolescence
Enhance teacher training	Provide ongoing professional development on new math teaching methods and technologies	Professional development coordinators	Teacher satisfaction and competency in new methodologies measured annually	**Strengths:** Established training programs; **Weaknesses:** Resistance to change among staff; **Opportunities:** Access to global training resources; **Threats:** Inadequate funding for training

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Foster collaboration	Promote collaborative projects and peer learning in math classes	Math teachers	Positive student feedback; observed increase in collaborative skills	**Strengths:** Collaborative culture in schools; **Weaknesses:** Limited physical spaces for group work; **Opportunities:** New collaborative technologies; **Threats:** Diverse student needs complicating group dynamics
Address diverse learning needs	Tailor math instruction to meet various learning styles and needs	Special education coordinators, math teachers	Reduction in dropout rates; improved grades among previously underperforming students	**Strengths:** Dedicated special education staff; **Weaknesses:** Varied educational backgrounds of students; **Opportunities:** Customized digital learning tools; **Threats:** Funding limitations for specialized resources

This action plan has been meticulously designed based on insights gathered from teachers about the challenges they faced and the coping mechanisms they employed during the abrupt transition to new teaching modalities. It aims to systematically address these challenges and bolster mathematics education by integrating effective strategies and tailored interventions. The plan focuses on four key objectives: integrating technology in learning, enhancing teacher training, fostering collaboration, and addressing diverse learning needs.

Integrating technology in learning

The first objective of this plan is to integrate advanced technology into the learning environment, which is crucial as highlighted by teachers who faced significant challenges with traditional teaching methods during the pandemic. The effectiveness of this integration will be measured by increased student engagement and improvements in math proficiency scores. Despite potential budget constraints and the rapid pace of technological obsolescence, the existing tech-savvy faculty will provide a strong foundation for this integration.

Enhancing teacher training

Another critical area identified from teacher feedback is the need for enhanced professional development, particularly in new mathematical teaching methods and technologies. This objective addresses the challenge of teachers feeling unprepared and ill-equipped to handle remote teaching scenarios. The success of this initiative will be assessed through annual surveys measuring teacher satisfaction and competency in applying new methodologies. While resistance to change and inadequate funding present potential barriers, the existing robust training programs offer a solid basis for these enhancements.

Fostering collaboration

Teachers also emphasized the importance of collaboration for effective learning. In response, this plan promotes collaborative projects and peer learning within math classes. The aim is to cultivate a more interactive and cooperative learning environment, which will be evaluated through positive student feedback and an observed increase in collaborative skills. Challenges such as limited physical spaces and diverse student needs might complicate group dynamics, but the school's collaborative culture and new collaborative technologies are expected to mitigate these issues.

Addressing diverse learning needs

The necessity to cater to diverse learning needs was another significant challenge that emerged from discussions with teachers. Tailoring math instruction to accommodate various learning styles and needs will be a continuous effort, assessed at the end of each term. Special education coordinators and math teachers will collaborate to ensure that instructional strategies are inclusive and effective. Success in this area will be indicated by reductions in dropout rates and improved grades among previously underperforming students. Although varied educational backgrounds and funding limitations pose challenges, the dedication of the special education staff and the potential of customized digital learning tools are promising factors that will support this objective.

DISCUSSIONS

Challenges

Theme 1: Adapting to new teaching modality

The alternative delivery mode most preferred by students and parents is the printed self-learning modules, or SLM. The study of Dapa and Valdez (2021), revealed that students in Tagugpo National High School in Davao Oriental, Philippines preferred modules printed in booklet form, distributed within their barangays on Mondays, and collection at the end of each quarter. Despite their preference, teachers have faced substantial challenges both before and during their implementation, especially concerning their capability to deliver effective modular distance learning. The strain of SLMs is both mental and physical, compounded by their novelty to educators. For instance, IDI_Teach_003 highlighted the difficulty in determining the most effective method for self-learning, stating, *"The real challenge lies in choosing which method to implement in self-learning."*. Similarly, IDI_Teach_005 expressed concerns about comprehension: *"How can I make it comprehensible to my students when, even face-to-face, they struggle to understand?*

Mathematics, which typically depends on dynamic and repetitive learning interactions, poses distinct challenges when delivered via Self-Learning Modules (SLMs). During both the preparation and implementation stages of modular distance learning, teachers have encountered significant hurdles that are both logistical and instructional (Ferri et al., 2020).

Supporting this, Nardo (2017), observed that in modular learning, students often study alone, which decreases their ability to effectively deconstruct the content due to the absence of face-to-face interaction. This isolation can hinder students' understanding and retention of the material, exacerbating the challenges faced by teachers who lack comprehensive training in self-learning teaching strategies. As a result, the quality of instruction suffers, and both students and teachers struggle to navigate the complexities of modular distance learning effectively (Rodriguez, 2022).

Another significant obstacle is the lack of parental guidance and familiarity with the module's contents. IDI_Teach_004 noted the difficulties students face working independently: "Because they are

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just working through the module on their own, they have a hard time, especially when they juggle many subjects without anyone to supervise or guide them." Dangle and Sumaoang (2020) emphasized that effective implementation of modular learning is compromised when parents are not well-equipped to assist their children. This lack of support at home, combined with teachers' unpreparedness for this new modality, leads to significant challenges in completing tasks and effectively learning, particularly in subjects like math. which demands high levels of discipline and intrinsic motivation that younger students, in particular, may not yet have developed (Torres, 2022).

Theme 2: Efficiency of learning materials' distribution and retrieval

The Weekly Home Learning Plan (WHLP), designed to help students achieve the Most Essential Learning Competencies (MELCs), faces substantial logistical hurdles in the timely distribution and retrieval of learning materials across the Philippines. Teachers encounter numerous difficulties due to the geographical dispersion of students and technical issues with reproduction equipment (Cajurao et al., 2023). For example, IDI_Teach_001 noted that *students from remote areas often struggle with transportation costs, which delay their collection of modules*. Additionally, the scarcity of resources such as bond papers and ink further delays module preparation (Cajurao et al., 2023). Despite the Department of Education's (DepEd) efforts to outline clear guidelines and provide funding, teachers like IDI_Teach_005 emphasized the constant battle with deadlines due to these logistical challenges (COVID-19 Pandemic and Teaching and Learning: A Literature Review, 2023).

Moreover, technical malfunctions within the reproduction teams exacerbate these issues. IDI_Teach_002 shared, "*There were times we could not reproduce the needed number of modules because our machine was not working well. So, we had to postpone the releasing and retrieval of modules*." The pressure to adhere to the WHLP's weekly schedules is intense, as IDI_Teach_005 expressed, "*Our task is to organize SLMs urgently to catch up for next week's distribution*."

Logistical challenges are compounded by the late distribution of master copies and the demanding schedules of teachers, which hinder timely module creation and distribution. These factors significantly restrict students' access to education and impact the quality of learning. DepEd has issued guidelines and allocated funds to aid the printing and delivery of learning materials (DepEd Order No. 18, s.2020), which has alleviated some of the burden. However, resource shortages often require teachers to double their efforts in preparing and distributing modules efficiently.

The situation is particularly dire for students living in remote areas. Some teachers have resorted to direct deliveries to students' residences, although they often face challenges such as inaccurate addresses and the unavailability of students or parents at the time of delivery. IDI_Teach_005 described an adaptive strategy: "We left the modules at the barangay so others who were not able to get them during our visit can pick them up, and we retrieve them after a week." Communication barriers also persist, with issues like inactive students in group chats and lack of proper contact information complicating the distribution efforts (Dangle and Sumaoang, 2020). Their study highlights that many students and parents lack the necessary resources for effective communication, exacerbating the challenges of timely module distribution and retrieval. Despite these substantial obstacles, teachers continue to strive to meet the demands of the WHLP, underscoring the need for increased community support and resource availability to ensure educational continuity during these unprecedented times.

Theme 3: Validating student's learning

Validating students' learning poses significant challenges for teachers, especially when students depend heavily on independent study modules. The reliance on such modules often results in issues such as incomplete submissions, copied answers, and overall lack of engagement, all of which hinder effective assessment practices. According to Holden et al., (2021), many students submit modules that lack solutions or exhibit evidence of copying from peers or readily available answer keys, complicating the validation process. For example, IDI_Teach_001 *observed that students frequently lack focus, which leads to repeated or incomplete answers.*

Moreover, the absence of face-to-face interaction, which is critical for subjects requiring problem-solving skills like mathematics, exacerbates these challenges. IDI_Teach_004 emphasized the importance of direct engagement to ensure that students comprehend the material. Despite these obstacles, teachers are adapting their assessment methods, guided by policies such as DepEd Order No. 31, which permits leniency in grading during the pandemic to accommodate these unprecedented educational disruptions (Gesta et al., 2023).

Al Mamun and Lawrie (2023), found that students showed reluctance to engage deeply with open-ended questions, completing tasks with less effort. The absence of instructional guidance contributed to lower engagement and potentially superficial learning outcomes in the independent online learning modules. This disengagement is evident on how students complete and submit their modules. IDI_Teach_001 *expressed frustration over the lack of deep learning, noting the prevalence of copied answers and incomplete tasks.* Other educators echoed similar concerns; IDI_Teach_002 and IDI_Teach_003 reported *frequent instances of incomplete modules, while IDI_Teach_005 observed that some students resort to copying answers from answer keys provided at the end of the modules.*

IDI_Teach_004 shared strategies for managing incomplete submissions and reiterated the critical need for interactive learning experiences to enhance understanding, particularly in technical subjects. The challenge is compounded by the endless cycle of reviewing and returning incomplete modules, leaving educators uncertain about appropriate grading practices.

Despite these significant hurdles, teachers continue to make commendable efforts to adapt and fairly assess students, as directed by DepEd Order No. 31, series of 2020. This policy under the Basic Education-Learning Continuity Plan (BE-LCP) provides guidelines for flexible assessment and grading to address the challenges posed by the pandemic, maintaining the integrity of the assessment process while accommodating the unique difficulties of this period.

Coping mechanisms of mathematics teachers in their challenging experiences

The implementation of the Basic Education Learning Continuity Plan (BE-LCP) has posed operational challenges. To address these, teachers have developed coping mechanisms tailored to the context of modular distance learning and other alternative delivery modes.

Theme 1: Contextualization and adaptation of learning materials

The Enhanced Basic Education Act of 2013 mandates a curriculum that is both contextualized and global. During the pandemic, this mandate has proven essential as teachers have heavily relied on it to ensure continuity of quality learning. For instance, IDI_Teach_001 *has implemented measures to deter plagiarism by redistributing activity sheets to students caught copying answers.* This reflects an adaptive measure to maintain academic integrity in remote learning settings IDI_Teach_002 *has tailored instruction to accommodate diverse student capabilities, ensuring that materials fit the allocated*

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class time and that assessments can be completed independently by students. This approach not only addresses educational needs but also mitigates the extended workload and technical issues encountered by school reproduction units (Ferri et al., 2020). Additionally, the act of supplementing the main modules with extra activities as done by IDI_Teach_005 illustrates a proactive approach to reinforce math skills and help bridge the gap between standard expectations and the actual capabilities of students learning remotely (Panoy et al., 2022).

In response to technical challenges, such as printer malfunctions, teachers have produced alternative resources like worksheets that align with the weekly modules, as discussed by IDI_Teach_003. According to Patel and Gomez (2024), mathematics educators have complemented these efforts by teachers' personal development, as they enhance their methods by engaging with educational content, including videos and journals that introduce new teaching approaches, especially in mathematics.

Republic Act 10533 also emphasizes the Mother Tongue-Based Multilingual Education (MTB-MLE) framework, which requires starting instruction in a language familiar to students and progressively introducing new concepts. IDI_Teach_005 addressed language barriers by providing notes written in students' dialects, thereby enhancing comprehension and engagement.

Ajibade et al., (2024), argued that when learning materials are contextualized, showing their relevance and utility, student motivation increases. This is supported by Jimenez (2020), who noted that contextualized materials not only boost motivation but also improve academic performance. Hattie and Donoghue (2016), further reinforced this by highlighting that making learning relatable significantly enhances student engagement and motivation.

The adaptation of learning materials is critical in meeting diverse student needs, particularly in remote learning settings. Suson et al., (2020) stresses the importance of differentiated instruction to cater to these varied needs. By customizing and simplifying materials, teachers create a more inclusive educational experience that promotes student success.

The use of technology has been pivotal in adapting learning materials during the pandemic. According to Gisy (2023), technology facilitates personalized learning experiences, enabling teachers to tailor their instruction to individual student needs. Teachers have reported using social media and educational apps to support students effectively, aligning with findings from Almarzooq et al., (2020) that technology can provide innovative solutions for assessment and feedback.

The theme of contextualization and adaptation of learning materials is a critical coping mechanism for mathematics teachers navigating the challenges of remote learning. By connecting content to students' real-life experiences, personalizing instructional materials, and leveraging technology, educators enhance student engagement and success. This strategy not only addresses immediate challenges posed by remote learning but also aligns with broader educational theories and practices that emphasize the importance of relevance and adaptability in teaching. The study's findings from Baganga, Davao Oriental, reflect these broader educational trends, underscoring the ongoing need for innovation in mathematics education.

Theme 2: Adaption of digital platforms and educational apps

With the onset of the COVID-19 pandemic in 2020, the shift to online learning has become a predominant mode of education, leveraging digital platforms like Facebook, Messenger, Google Meet, Zoom, and Kahoot! to maintain student-teacher connectivity. Teachers have recognized the effectiveness of these tools in sustaining engagement and addressing student queries. IDI_Teach_001 described the process: "We

give them assignments to answer, and if they don't understand, we discuss them online. Students are encouraged to ask questions through chat via messenger, and we utilize other apps to cater to all their queries."

IDI_Teach_003 highlighted the essential role of group chats for facilitating communication, stating, "*We have a group chat with the students, and I told them if they don't understand our module or have questions regarding the lesson, they can contact us to address their queries*." This method has become a supplementary support to traditional modular learning, especially for students who struggle with assignments.

IDI_Teach_004 noted the enhanced accessibility of teachers, saying, "*We are available anytime so that if they need to contact us, they can do so through text, call, or Messenger*." Meanwhile, IDI_Teach_002 shared how integrating technology has not only enhanced their teaching capabilities but also enabled the adoption of new skills. She explained, "*Modular and blended learning help us teachers learn new skills with technology. I engage myself in learning apps or exploring technology so I could help students with an innovative way of teaching*."

Despite the benefits, challenges remain, particularly due to limited internet access among students, which restricts their full engagement with e-learning platforms. Cleofas and Rocha (2021), highlighted that low-income students often share devices, which hampers their ability to participate in online classes consistently. Furthermore, IDI_Teach_001 expressed a longing for a return to traditional classroom settings but recognized the value of online platforms in providing a glimpse into 21st-century education: "*It's difficult to teach students through modular learning. I hope and pray that this pandemic will end and we can return to normal classes. However, to encounter what it is like to be in the 21st century, we utilize online classes via Zoom or Google Meet.*"

Research by Manca and Ranieri (2016) indicates that social media enhances communication and collaboration among students and teachers, providing a space for sharing resources and ideas. This aligns with the use of group chats that help maintain communication and foster a supportive learning environment. Additionally, Khulkar et al., (2023) noted that educational apps provide interactive and engaging experiences, catering to diverse learning styles. This has allowed teachers to present mathematical concepts in innovative ways, enhancing student learning and engagement.

Bharti (2023), suggested that gamification elements in educational apps can significantly motivate students and increase participation in learning activities, making education more enjoyable. Also, GeoGebra's integration into mathematics curricula has shown to improve student competencies, engagement, and understanding of mathematical concepts, particularly in trigonometry (Picaza et al., 2024). The collaborative use of social media and educational apps fosters a learning community where students are encouraged to ask questions and collaborate, aligning with Vygotsky's social constructivist theory that views learning as a social process enhanced through interaction.

Utilizing digital platforms, social media, and educational apps is a critical coping mechanism for teachers navigating the challenges of remote learning. These tools have not only facilitated learning and community building but also allowed educators to meet the diverse needs of students in an evolving educational landscape. The experiences from Baganga, Davao Oriental, alongside broader educational research, underscore the need for continued innovation in mathematics education to adapt effectively to future challenges.

Theme 3: Conduct of home visitation

The Department of Education strongly advocates for home visits as a critical strategy to re-engage students who are at risk of falling behind. IDI_Teach_002 prepared for her visits by gathering essential contact

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information and addresses, ensuring she could effectively reach students in their home environments. She noted, "*Before I conducted the home visitation, I collected the phone numbers or the addresses of the students so I could visit them to check if their environment is conducive to learning*." During these visits, she also engaged with parents to discuss their involvement in their children's education.

Particularly for students struggling with mathematics, home visits provide an opportunity to address educational gaps directly. IDI_Teach_002 emphasized the importance of these visits for students in remote areas, stating, "*I visited those who are performing poorly, especially those in distant locations, to ensure they at least grasp the basic concepts, even if not the more complex ones.*" However, logistical challenges often complicate these efforts. IDI_Teach_004 described the difficulties of reaching students in remote areas: "*Of course, it's very challenging. We have to reach out to students who live far away... since we trace where our students are in various barangays, each assigned teacher has a checklist to manage the outreach.*"

The school's directive supports the notion of home visitation not just for struggling students but for all, to enhance overall learning outcomes. IDI_Teach_001 principal instructed: "*to visit all students I am advising, especially those who are significantly struggling with mathematics, to offer them assistance.*"

In addition to addressing academic needs, home visits provide teachers an opportunity to inform parents about available educational resources and support systems, enhancing parental involvement in the educational process. This aligns with findings by Ilhan et al., (2019) who observed that home visits help bridge communication gaps between schools and families, offering teachers insights into potential barriers to learning that students face at home.

Home visits have been recognized as a powerful strategy for enhancing students' academic progress and fostering meaningful teacher-student relationships. Research conducted by Wright et al., (2018) confirms that home visits significantly improve students' academic performance and strengthen teacher-student connections. Lin and Bates (2022) highlighted the role of home visits in providing teachers with a firsthand understanding of their students' diverse backgrounds, effectively bridging the gap between school and home environments. Additionally, Stetson et al., (2012) noted that home visits not only lead to substantial progress in students' academic work but also positively affect their attitudes towards school.

Action plan

In light of the findings from the study on the challenges and coping mechanisms of mathematics teachers during the transition to new learning modalities, an action plan was developed to enhance the resilience and effectiveness of mathematics education. This plan focuses on addressing the identified challenges and leveraging the coping strategies that emerged from the research. To ensure a comprehensive strategy for future-proofing mathematics education, a SWOT analysis was integrated within the action plan matrix. Several case studies have demonstrated the effectiveness of incorporating SWOT analysis into the strategic planning of math education programs. Chusniyah et al., (2023) emphasized that SWOT analysis is a valuable tool for assessing internal and external factors affecting educational quality, which can be applied to various subjects, including mathematics, to enhance overall educational strategies and performance.

By implementing the action plan, mathematics education can be future-proofed against potential disruptions, ensuring that both teachers and students are equipped to navigate challenges effectively. The insights gained from the study underscore the importance of adaptability, community engagement, and resource accessibility in fostering a resilient

educational environment. Gallagher et al., (2020) emphasized adaptability as a key trait for educators, particularly in mathematics, where evolving methodologies and technologies continually reshape the landscape. Furthermore, Casey et al., (2022) demonstrated how community-driven initiatives in math education have successfully mitigated the effects of educational disruptions by providing students with real-world applications and external support. Lastly, Guerra et al., (2022) emphasized that effective accessibility enhances the adaptability of educational resources, enabling tailored learning experiences for diverse student needs. This adaptability strengthens educational systems, ensuring they are better equipped to meet future challenges in virtual education.

IMPLICATIONS AND RECOMMENDATIONS

The study highlights significant challenges in adapting to remote learning, impacting student engagement and educational outcomes. Addressing these challenges effectively requires a multifaceted approach that includes enhancing instructional strategies, improving logistical support, and fostering better community involvement. By implementing the following recommendations, educational institutions can better support both teachers and students, ensuring that learning continues effectively, regardless of external circumstances.

Enhancing support for Self-Directed Learning (SDL)

Educators need comprehensive training programs designed to equip them with effective strategies for facilitating self-directed learning. Alyani and Ramadhina (2022) suggested that educational policies should promote the integration of SDL strategies into math curricula to support students during disruptions like pandemics. This includes developing resources that facilitate SDL and training teachers to guide students in setting realistic learning goals and applying mathematical thinking independently. To assess the impact of these training programs, future studies should investigate the relationship between specific training strategies and teacher effectiveness in delivering self-directed learning. This research could help identify the most impactful aspects of teacher training and lead to more tailored professional development offerings.

Strengthening assessment methods

Adopting continuous and formative assessment techniques that utilize technology to provide immediate feedback can enhance the understanding and retention of course material. Future studies should examine the outcomes of various assessment strategies on student performance, particularly in a remote learning context. Such research could determine the effectiveness of different technological tools in improving assessment methods and ultimately student learning outcomes.

Community and parental involvement

Enhancing communication channels between schools and parents and conducting regular home visits can strengthen community ties and parental involvement, which are crucial for student success. Future research should assess the impact of increased parental involvement and community engagement on student learning outcomes and emotional well-being. This could help quantify the benefits of such engagement and identify best practices for schools to implement.

Leveraging technology and digital tools

Digital tools and platforms have been identified as crucial in enhancing engagement and deepening understanding of mathematical concepts (Gamit, 2023). According to Hussein et al., (2021), Digital Game-Based Learning (DGBL) is effective in promoting knowledge acquisition, cognitive skills, and motivation, thus supporting the notion that interactive

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technologies enhance dynamic, hands-on learning experiences in math. Future research should evaluate the long-term effects of these technologies on teaching efficiency and student learning gains. Such studies could help optimize the use of technology in education, ensuring it effectively complements traditional teaching methods.

The Education Commission (EdComm) Report 2 also supports these initiatives by emphasizing the critical need for adaptability and innovation in educational strategies, particularly in math education. It underscores the importance of technological integration and the development of resilient educational frameworks that can withstand future disruptions. The recommendations from the EdComm Report align with the proposed actions, reinforcing the strategic direction for enhancing math education in the new normal.

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