Original Article

Development of an instructional module in mathematics in the modern world utilizing design thinking approach

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ABSTRACT

The development of instructional materials (IMs) has reached the pinnacle of what innovation can bring to classroom instruction. By thoroughly examining students' learning difficulties in mathematics in the modern world, the creation of these IMs has explored all possible avenues for improvement. Utilizing a methodical investigation, specifically a sequential design. This study analyzed the results from the research tools administered to 134 students and 10 mathematics instructors at a certain university in the Philippines, applying this in the discovery stage of the design thinking model adapted from IDEO. The learning needs for teaching the topic "problem-solving strategies" were identified during the interpretation stage. During the ideate stage, a module was proposed. The gathered information, along with crucial data from relevant studies, was organized into a detailed plan for module development during the experimentation stage. Finally, the evolution stage confirmed the module's content validity. Furthermore, the study recommends that the developed instructional module be subjected to Phase 2 validation and utilized by students to assess its effectiveness.

Keywords: instructional materials, learning difficulties, mathematics education, teaching-learning experiences

INTRODUCTION

Change and innovation have always been the focus of educational advancement, especially in light of global interconnectivity, rapid advancements in technology, and diversity in the classroom (OECD 2018; Revano and Garcia 2020; Ang 2021). These demands require a transformation on how educational content is delivered and experienced by students. In the Philippines, this drive for educational reform is supported by national directives, including Senate Bill No. 1162, which mandates that all public and private schools be equipped with

updated learning resources and technology to ensure the country's competitiveness in the global economy (Senate of the Philippines 2010). Complementing this, the Commission on Higher Education (CHED) issued CMO No. 20, s. 2013 introducing the mathematics in the modern world (MMW) in the general education curriculum, presenting mathematics in broader and more practical contexts (CHED 2013). Also, CHED reiterated through CMO No. 4, s. 2020, the need to produce learner-centered, inclusive, and outcomes-based instructional materials aligned with 21st-century learning goals and global standards (CHED 2020).

Despite these directives, challenges persist in many higher education institutions, including the locale of this study. Students' feedback highlights the difficulties they face in learning mathematics due to its abstractness and associated psychosomatic impacts (Bangalan and Hipona 2020; Verdeflor and Pacadaljen 2021). This perception is often worsened by conventional pedagogy that focus on procedural tasks and rely heavily on textbooks, thereby limiting learning engagement (Noreen and Rana 2019; Ariaso 2020). Additionally, the availability of updated, relevant, and engaging learning materials for the MMW course remains limited at the locale. This issue has been acknowledged in institutional reviews. This finding is consistent with those from the Second Congressional Commission on Education (EDCOM II 2024), which noted persistent gaps in instructional resources across tertiary institutions.

To address these concerns, this study adopted the design thinking (DT) approach in developing a localized instructional module for MMW. This approach provides a human-centered, iterative framework that encourages educators to empathize with learners, define core problems, brainstorm innovative solutions, build prototypes, and refine them through testing (Carlgren 2013; IDEO 2013). Its application in higher education has proven beneficial in supporting curriculum development, enhancing student engagement, and accommodating diverse learning needs (Lor 2017; Beligatamulla et al. 2019; Panke 2019; Quintos 2022). The DT process aligns with MMW's goals, which include enhancing mathematical appreciation and demonstrating the relevance of mathematics in various real-world contexts. Using the IDEO DT for educators' model, this study followed the phases of empathizing with students, identifying their learning difficulties, designing appropriate instructional materials, building a prototype, and validating it with MMW instructors.

By integrating the objectives of the MMW curriculum with the DT process, this study aimed to bridge the gap between students' prior mathematics learning and their learning needs. Given the critical need for additional instructional materials (IMs) to teach the MMW course at the study's locale, the DT model provided a valuable framework. The primary objective of this study was to develop instructional materials using the IDEO: DT for Educators model for teaching mathematics to college students. Specifically, this study aimed to empathize

by gathering and analyzing students' learning experiences in the MMW classroom; define by clearly articulating the learning difficulties based on the students' needs; ideate by brainstorming and selecting innovative IM to teach MMW; prototype by designing and developing a draft version of the selected IM; and test and refine by validating and improving the IM based on feedback from MMW instructors.

In essence, the development of this instructional module responds both to CHED's calls for more educational resources and to local classroom challenges. Integrating the DT into the creation of the MMW module presents an opportunity to enhance students' attitudes toward mathematics, enrich their learning experience, and ensure the course remains relevant and engaging in a rapidly changing educational landscape.

METHODS

Research Design

This study utilized a sequential research design (both exploratory and explanatory), which is a specific type of mixed-methods research design. While the DT approach follows a series of stages in a specific sequence, quantitative and qualitative methods were applied in a complementary manner. In the discovery and interpretation stages, a sequential explanatory procedure was employed. Quantitative data were gathered through surveys, and the findings were validated through qualitative data obtained from interviews. The ideate stage utilized a sequential exploratory process, beginning with qualitative data collected through a brainstorming session for idea development. In the experimentation stage, a sequential explanatory process was used, where quantitative and qualitative data from surveys, interviews, and brain storming session guided the development of a prototype for the selected IM. Finally, the evolution stage employed a sequential exploratory procedure, beginning with qualitative consultations involving research panel members and instructors, followed by the quantitative and qualitative validation of the final draft of the module by course experts.

Research Participants

The research was conducted at Kalinga State University (KSU) having three campuses located in the municipalities of Rizal and Tabuk City (Bulanao and Dagupan) in Kalinga province. A total of 134 student respondents (Table 1) were identified using G*Power software (version 3.1.9.7). To generate this sample, the study considered a medium effect size (0.3), two-sided testing, an alpha level of 0.05, and a power of 0.95, using both the exact test family and the standard statistical test. These elements were considered to optimize the identification and correction of an impact, thereby increasing the likelihood that a false positive would not occur in the study's findings. Additionally, a stratified random sampling with an equal allocation of samples was used to select 12 participants from each college, with 13 participants chosen from the two largest colleges.

Table 1. Samples of the study (Note: N = 3622, n = 134).

Program	Program Population	Sample size	Percent
Bachelor of Public Administration	541	12	8.9
Bachelor of Secondary Education	403	12	8.9
Bachelor of Science in Accountancy	122	12	8.9
Bachelor of Science in Agriculture	316	12	8.9
Bachelor of Science in Agroforestry	108	12	8.9
Bachelor of Science in Biology	266	12	8.9
Bachelor of Science in Civil Engineering	466	13	10
Bachelor of Science in Criminology	616	13	10
Bachelor of Science in Forestry	168	12	8.9
Bachelor of Science in Hospitality Management	272	12	8.9
Bachelor of Science in Social Work	344	12	8.9

The teacher participants were limited to the 10 mathematics instructors who voluntarily participated in this study. From these instructors, the majority had completed their Master's degree (80%), one had completed a doctoral degree (10%), and one chose not to disclose his/her highest educational attainment. The majority of them had a Bachelor's degree in Secondary Education, with a major in Mathematics Education (60%), some have a Bachelor's degree in Mathematics (30%), and one holds a Bachelor's degree in Elementary Education (10%).

Data Collection and Analysis

Ethical considerations such as conflict of interest, confidentiality, data protection, risk-benefit ratio, informed consent, and terms of reference were all taken into account. Following the Data Privacy Act of 2012, respondents were required to complete a consent form before participating, which highlighted the anonymity and confidentiality of the information gathered. The participants were oriented about the goals of the study before administration. After that, they were instructed to study the instructions and answer each question honestly and carefully. The survey was conducted in person during the middle of the second semester (SY 2023–2024). Three consecutive weeks of data collection were conducted for students' data, instructors' data, and a day of brainstorming sessions.

Frequency counts and percentage distributions were used to organize and present the demographic profiles of students and instructors. Means and standard deviations were used to determine the most challenging topic, preferred IMs and their features, and experts' ratings for the developed IM. Additionally, inductive thematic coding analysis was employed to interpret and analyze the instructors' responses from the brainstorming session. This session utilized various templates to organize additional information required for each stage of the design thinking process. These templates were patterned after Dam and Teo (2020a), the ones used in a workshop for training design thinkers by Cordovilla (2020). During the discovery stage, the instructors used the empathy mapping template (Dam and Teo 2020b) to empathize with students. The interpretation stage identified the

learning difficulty using the POV insight template (Dam and Teo 2020c). For the ideation stage, the instructors identified the appropriate IM that would address the learning difficulty by using a brainstorming sheet (Dam and Teo 2020d). For the experimentation stage, additional information for the prototype of the IM uses a mind-mapping template (Dam and Teo 2020e). Finally, validation was conducted for the developed IM, which was analyzed using inter-rater reliability. Eight invited faculty members validated the developed module – three holding a PhD degree, two pursuing a PhD degree, and the rest holding an MST degree. All experts (five from KSU and three from other universities) have taught MMW and are recognized for their contributions to the development of learning materials across several mathematics courses.

RESULTS

Empathize: Understanding Learning Experiences in the MMW

The empathize stage (discovery phase), of the DT approach aimed to identify students' impressions of the course and their perceived difficulty with MMW topics. Thematic analysis of interview responses revealed five distinct themes, with frequencies of "difficult" (62), "fascinating" (27), "worthwhile" (27), "nervous" (3), and "did not answer" (15). These reflected varied students' impressions, negative (46.27%), positive (20.15%), and neutral (11.19%).

Most of the students (62 out of 134) expressed negative impressions of the course, describing it as complex or confusing. Sample responses include:

"My impression of the subject is very hard because I cannot understand how to solve the equations." – Bob

"It is difficult because there are so many variables and numbers to memorize." – Ron

Meanwhile, a smaller group indicated positive impressions, describing the course as interesting, engaging, or intellectually stimulating. Others provided neutral views, expressing uncertainty or withholding judgment until they gained more experience with the course.

These impressions were supported by gathered data from the interviews, the brainstorming session, and the assessment of both students and teachers. The prevalence of negative perceptions intensified the need to address students' concerns through the design and content of IMs. For instance, the inclusion of challenging problems embedded in comic strips support the balance of rigor with engagement, thereby fostering a more positive learning experience.

This highlighted the importance of empathizing with learners to ensure that their struggles and expectations were acknowledged and addressed early in the design process. Table 2 presents a comparison of

students' and teachers' evaluations of MMW topics, further validating these impressions and guiding improvements in content.

Table 2. Students' assessment and teachers' evaluation of the MMW topics' difficulty level [Note: 1-1.49 (Not Taken-NT), 1.50-2.49 (Very Difficult-VD), 2.50-3.49 (Difficult-D), 3.50-4.49 (Average-A), 4.50-5.49 (Easy-E), 5.50-6 (Very Easy-VE)].

Topics	Students' Assessment			Teachers' Evaluation		
	Mean	Rank	Qualitative Description	Mean	Rank	Qualitative Description
Non-negotiable Topics						
Mathematics in our World	3.68	11	A	4.25	12	A
Mathematical Language and symbols	3.76	12	A	3.97	10	A
Problem-Solving and Reasoning	3.67	10	A	3.87	9	A
Data Management	3.6	9	A	3.63	7	A
Elective Topics						
Geometric Designs	3.18	8	D	2.64	6	D
Codes	2.55	3	D	2.19	2	VD
Linear Programming	2.79	5	D	1.93	1	VD
Mathematics of Finance	3.07	7	D	3.78	8	A
Apportionment and Voting	2.39	1	VD	2.37	4	VD
Logic	2.9	6	D	4.06	11	A
Mathematics of Graphs	2.47	2	VD	2.45	5	VD
Mathematical Systems	2.77	4	D	2.33	3	VD
OVERALL	3.15	N/A	D	3.25	N/A	D

In a follow-up interview, students identified their three most difficult topics as: problem-solving strategies, the Fibonacci sequence, and conditional, bi-conditional, and related statements. Similarly, during the brainstorming session with the instructors, the following topics were identified as most challenging to teach and learn: problem solving and reasoning, specifically, problem-solving strategies (cited by 7 out of 10 instructors), and data management. The insights gathered in this empathize phase laid the foundation for the next stage – define, where learning difficulties and instructional gaps were further examined based on the expressed needs of students and observations of instructors.

Define: Identifying Learning Difficulties in MMW

The define stage (interpretation phase) focuses on synthesizing data from student impressions, complex topics, and teacher observations to clearly articulate the learning difficulties in the course. Data gathered from piloted questionnaires and student interviews were consolidated and presented during the brainstorming session with the instructors. Results revealed that 100% of the instructors observed a need for a strong mathematical foundation and emphasized the importance of prerequisite concepts to help learners connect their foundational knowledge to higher-level mathematics. This was followed by the observation that learners find it challenging to solve problems (70%) and that the students need to have a strong critical thinking ability with good comprehension (40%). Finally, at the end of the point of view (POV) insight activity, the following key problem statements were identified: 1) How might we strategize the teaching of MMW topics to ensure effectiveness? 2) How might we

help learners appreciate MMW as both a course and a part of daily life? 3) How might we simplify MMW discussions to ensure clarity and relevance? 4) How might we design activities and tasks in MMW that are engaging and enjoyable? Lastly, 4) how might we encourage students to value and apply their learning in mathematics? These insights served as the foundation for the next stage of the design thinking process.

Ideate: Identifying the Appropriate IM to Teach MMW

The ideate phase focused on proposing potential solutions to address the specific problems identified from the define stage. One of the most optimistic solutions that emerged was the development of IM tailored to the needs of learners. This phase also involved gathering and analyzing diverse perspectives from both students and instructors to determine the most appropriate IM format.

Students were asked to select their preferred type of IM through a questionnaire. Findings revealed that teacher-made videos were the top choice (32.09%), followed by activity sheets (28.36%) and gamified PowerPoint presentations (21.64%). Other options, such as infographics (12.69%) and blogging (5.22%), received less vote, indicating that most students favored instructional tools that are interactive, visual, and easy to follow.

Instructors, on the other hand, provided their recommendations during a brainstorming session. Their suggestions emphasized the use of practical, structured, and self-paced resources. Among the most frequently recommended materials were activity sheets, modules, and workbooks or worksheets (all 40%). Other tools, such as lecture notes (30%), manipulatives and infographics (both 20%), and digital platforms like Google Forms and supplemental videos (each 10–20%) were also suggested, but to a lesser extent.

The combination of student preferences for multimedia and engaging content, and instructor recommendations for content-rich, structured materials, led to a consensus that a module is the most appropriate IM to be developed for the MMW course. For instance, the module was designed to reflect both the challenging and enjoyable aspects of the course. Moreover, this module will incorporate elements from both groups' suggestions, such as embedded videos, activity sheets, and interactive components, ensuring that the resource is adequate, relevant, and aligned with the diverse learning needs of students.

Prototype: Designing and Developing Draft IM for MMW

Pertinent to the experimentation stage, a prototype of the chosen IM was drafted. Considering the topic "problem-solving strategies" identified from the discovery or empathize stage, how to teach it effectively (determined from the interpretation or define stage), and the identified IM from the ideate stage, which is "module", this phase created a draft of the material. Table 3 also presents some important themes, features, and components considered.

206 **Table 3.** Parts of the developed module.

Parts of the Module	Frequency	Percent
Theme		
Nature and Scenery	2	66.67
Numbers/Symbols	1	33.33
Feature		
Pre-Test and Post-Test for evaluation	1	33.33
SMART (specific, reasonable, attainable, realistic, time-bound, and applicable to real-life)	1	33.33
Detailed illustrations	1	33.33
Components		
Front Page–title/subheads	3	100
Table of Contents	1	33.33
Pre-Test	1	33.33
Introduction	2	66.66
Discussion and illustration	3	100
Examples	2	66.66
Activities/Quiz/Tests	2	66.66
References	1	33.33

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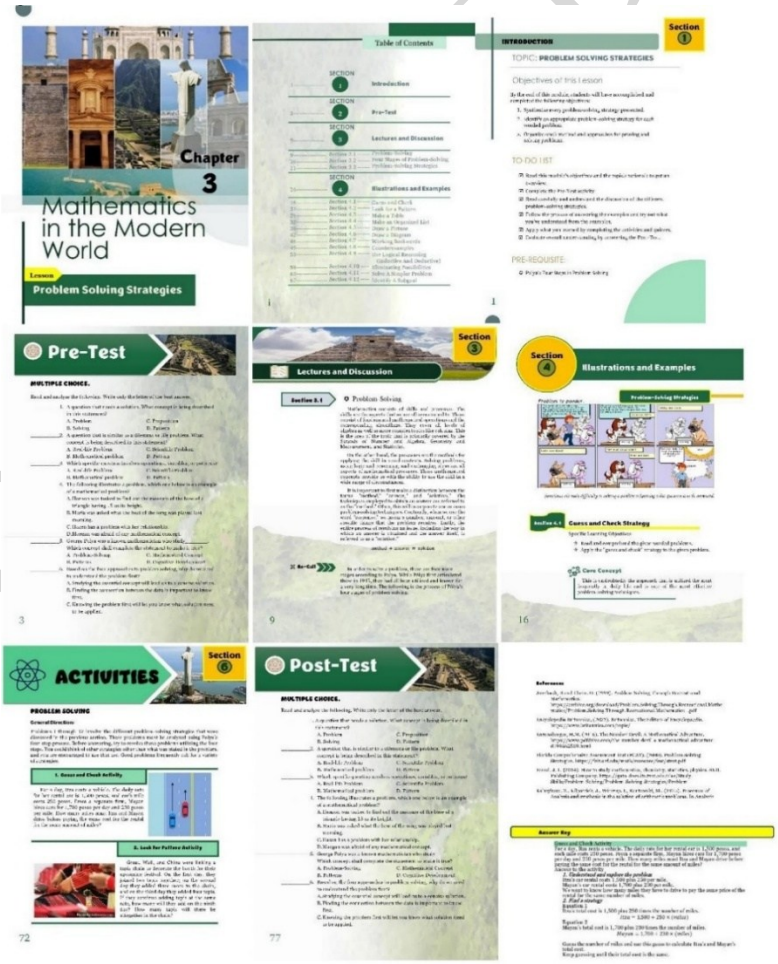
208 The final prototype of the module was then created using the conceptualized plan. Also, various checking

209 and drafting were done (Figure 1).



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211 **Figure 1.** Module draft of final prototype.

Test and Refine: Validating the Developed IM by the Instructors of MMW

After finalizing the module draft, the material underwent content validation during the evolution stage. The evaluation of the eight experts yielded a percentage agreement of 84.44% for the inter-rater reliability of the developed module. Table 4 shows an overall mean (3.92) and standard deviation (0.19), indicating that the experts are very satisfied with the fulfillment of all the factors for the module. Also, this suggests that they were very satisfied with the outcome of the developed module.

Table 4. Experts' ratings of the factors of the developed module [Note: 1:00-1.49 (Not Satisfactory-NS); 1:50-2:49 (Poor-P); 2:50-3:49 (Satisfactory-S); 3:50-4:00(Very Satisfactory-VS)].

Factors	Mean	Standard Deviation	Qualitative Descriptions
Factor 1: Content	3.91	0.19	VS
Factor 2: Format	3.86	0.31	VS
1. Prints	3.85	0.34	VS
2. Illustrations	3.97	0.08	VS
3. Design and Layout	3.90	0.23	VS
4. Paper and Binding	3.80	0.45	VS
5. Size and Weight of Resource	3.80	0.45	VS
Factor 3: Presentation and Organization	3.92	0.18	VS
Factor 4: Accuracy and Up-to-datedness of Information	4.00	0.00	VS
Overall	**3.92**	**0.19**	**VS**

DISCUSSION

Empathize: Understanding Learning Experiences in the MMW

At the top of the list of interviews and the brainstorming session data for mathematics perception and complex topics, students found the course hard to understand due to its nature. According to Verdeflor (2024), it has been a widespread observation that college students have difficulty understanding MMW because the course causes them to feel dread and anxiety. As presented by the CHED (2016) and adapted by KSU (2020), MMW encompasses a range of topics that need to be covered within a semester. The components are relatively important, but students might have been overwhelmed.

Concerning this, the study found that problem-solving strategies was considered a difficult topic. Consistently, problem-solving strategies under the main topic of problem-solving and reasoning were found to be one of the most challenging major topics for first-year students, as stated in Remo's (2019) study. Additionally, Bangalan and Hipona's (2020) study revealed that the lesson was among the most liked topics of students, ranking in the bottom third. This notion might be attributed to the students' difficulty in completing exercises and exams that required them to solve problems (Roman and Villanueva 2019; Pentang et al. 2024). Verdeflor (2024) supported this finding by pointing out that most students struggle to recall mathematical formulae and equations, which causes them to become perplexed while trying to solve mathematical problems.

To properly understand these learning difficulties, the interpretation stage identifies the specific problem. To define the problem in the next section, the findings from this section were utilized.

Define: Identifying Learning Difficulties in MMW

The findings suggest that teachers have noticed their students struggle to complete written problems and lengthy calculations; as a result, there was a need to reinforce their foundation in the fundamentals of mathematics and to inspire and equip them with critical thinking skills. According to Lima et al. (2019), math learning challenges have their roots in basic mathematics, which students were first introduced to in elementary school, long before they entered college. They claimed that two different types of issues can typically explain this learning difficulty: the first is related to the child's cognitive development, and the second is related to issues outside the child or to another specific issue. Thus, their research proposed the development of several teaching methods for fundamental mathematics. The same recommendation was made by Remo (2019) that mathematics teacher evaluate their teaching strategies to be appropriate for the different topics in the MMW course. Once this is achieved, there is an increase in comprehension, application, analysis, and mastery of mathematical knowledge (Moreno-Guerrero et al. 2020; Roman and Villanueva 2019).

As the interview and brainstorming session thematically revealed, problem-solving strategies were identified as the most challenging topic. In connection with the crafted questions related to effectiveness, relevance, and enjoyability for teaching MMW, these issues may have been caused by several factors, including personal motivations or experiences with mathematics in general, the nature or complexity of the course, or the methods used by instructors to teach MMW. Substantially, the third cause is related to the objective of the present study.

This necessitates a need for a more ingenious way of introducing and teaching the course. Emphasizing that meaningful educational reform requires a holistic and integrated approach (Travero and Roble 2022; Susada 2025). According to Pagtalunan (2021), teachers should deliver MMW topics in more innovative ways because they are relatively new to the field. Pagtalunan (2021), along with Lobo (2023), recommended retooling MMW instructors by requiring them to attend seminars and conferences on the course and pedagogical approaches. Verdeflor and Pacadaljen (2021) also suggested that interventions such as bridging programs, teaching strategies, and curriculum be thoroughly reviewed to create an outcomes-based education that addresses the stigma associated with mathematics and promotes student learning.

These findings are relevant because they act as a roadmap for IM conceptualization in the following stage. The third stage of the design thinking process is the ideation stage, where researchers examine various instructional materials based on suggestions from students and teachers. To choose one and decide what would

be produced in conjunction with the results in the interpretation phase, the brainstorming session with the instructors was given emphasis.

Ideate: Identifying the Appropriate IM to Teach MMW

A remedy was implemented in the study, and one of the issues faced by the research locale was the instructional material for the MMW course. The maximization of the learning impact of IMs depends on the medium in which it is served and utilized. As Capuno et al. (2019) noted in their study, all facets of mathematics education were influenced by the effective and coordinated use of instructional media. The results in IM choice indicate that students preferred teacher-made videos, activity sheets, and gamified PowerPoint presentations most. According to Nabayra (2022), students' experiences using teacher-created videos to learn MMW online demonstrated that the films were thorough, adaptable, and student-friendly, suggested the teacher's virtual presence, and were tailored to the new normal of learning. The study of Johan et al. (2019) found that student activity sheets, combined with a scientific approach, could effectively improve students' skills to solve problems. Meanwhile, Lim (2021) noted that incorporating games or role plays into lessons was beneficial for specific mathematical topics.

Given careful consideration of the limitations of accessing IM, such as the need for stable internet connectivity for viewing teacher-made videos, gamified PowerPoint presentations, and blogs, the survey and brainstorming session findings indicated that a module must be developed to effectively address the identified problems. Accordingly, Cabral (2022) claimed that using a module was one of the most efficient strategies, particularly in areas with poor internet connections and when students cannot afford devices like laptops, PCs, or tablets for online classes. Some might argue that a module was not interactive or engaging; however, many studies have mentioned that it is one of the most flexible learning materials. A module possesses an adaptive nature, allowing it to be utilized for a specific period, and is designed to be user-friendly, which facilitates easier comprehension of the content by students (Ramdani et al. 2019). The study, as mentioned above, concluded that the module testing phases piqued students' interest. Additionally, by maximizing the utility of such modules, they can still be accessed through online mediums by converting them into an e-module. The study did not disregard students' choice of IM, since this module is not just an ordinary one; it was suggested by the instructors to incorporate elements that reflect all students' preferences. Mariano-Dolesh et al. (2022) support this move, as an online learning environment can improve students' conceptual understanding of problem-solving.

Essentially, the creation of this instructional module addresses local classroom issues seen at KSU as well as CHED's requests for more adaptable teaching materials. These results were subsequently utilized to plan

and develop the prototype of the IM in the next stage – the experimentation stage, the fourth stage in the design thinking process, wherein the researcher built the prototype of the module.

Prototype: Designing and Developing Draft IM for MMW

As problem-solving strategies were identified as the most challenging topic for students, the study then addressed questions about teaching the topic effectively, helping students appreciate it, simplifying conceptual discussions, and making activities engaging. For these problems, the result in the ideate stage suggested a module as a remedy, or at least it served as a medium to answer these questions. Following this, creating a prototype of the module is necessary.

The module's structure was based on the suggested themes of nature and scenery. The study considered various portrayals of nature and scenery. For instance, the seven wonders of the world and the natural scenery of Kalinga province, which is the Chico River. Meanwhile, the content included pre-test, post-test, illustrations, and SMART objectives as suggested features and components. The module consisted a series of discussions and problem-solving exercises based on the CHED-mandated curriculum. The study included word problems, which were subjected to reliability testing. Some of the developed problems were patterned after different studies and books, such as Stewart (2010), Averbach and Chein (2012), and Enzensberger (2000). For the illustrations included, it was created using MakeBeliefsComix.com. Additionally, the module incorporated links to teacher-made videos, blogs, gamified PowerPoint, infographics, and activity sheets as additional sources of information.

After completing the draft of the module, an initial review was conducted by the panel members. They assessed the structure and content of the module, and recommendations for improvement were provided. Additionally, the module was tested in Turnitin for a similarity check, and feedback was received, allowing revisions and achieving an acceptable similarity index. Finally, after incorporating the compilation of additional comments and suggestions from the research adviser, panels, and KSU instructors, the final draft was prepared for expert validation.

The final stage of the DT process is the evolution stage, during which the evaluation of experts was conducted.

Test and Refine: Validating the Developed IM by the Instructors of MMW

The validation results suggest a reasonable level of agreement among experts regarding the developed module. In particular, the module meets every requirement. The content factor received an acceptable rating, confirming that the module covers all necessary learning goals and aligns with curriculum objectives. The format factor rated very satisfactory, demonstrating good print quality, readable text, and an appealing color combination.

The presentation and organization factor was also rated very satisfactory which was attributed to the module's comprehensible and logical structure. Lastly, the findings showed that experts consistently rated the accuracy and timeliness of the material as very satisfactory. Similar evaluation factors should be considered for an MMW module, as noted in the studies by Calaminos (2024), Cadorna et al. (2023), and Cabral (2022), which report comparable findings. Based on these results, it can be inferred that the developed instructional module is both well-designed and well-developed.

Following the final revisions, the evaluation by eight experts recommended that the module be approved for potential use in public schools, as all the suggestions listed in their assessment forms have been addressed and accepted. However, the study also recognizes that prior to classroom implementation, the module should undergo a comprehensive validation process involving additional groups of experts and representatives of the stakeholders. According to Calaminos (2024), as part of this process, the module should be regularly reassessed and updated to ensure it remains relevant.

The implementation and testing phases, which provided opportunities to gain insights from other viewpoints and user feedback. These phases of validations contribute to refining solutions once the feedback has been analyzed (Palisoc et al. 2020). Due to time constraints, the implementation phase of the developed module was not included in this study; however, it is recommended for future research.

The study on improving teaching strategies for the MMW course, using the DT model, revealed key insights into students' learning experiences and challenges. The empathize phase showed that students struggled with abstract concepts and lacked engagement with existing IMs. Through the define and ideate phases, it highlighted significant learning gaps needed to be addressed. The selection of an IM, based on the needs of both students and instructors, was crucial in bridging these gaps. The prototype phase led to the development of a module that integrated the contents of problem-solving strategies and various features tailored to students' preferences. Finally, the testing phase highlighted the need for continuous refinement.

The study recommends that instructors regularly conduct feedback sessions with students to gain a deeper understanding of their learning experiences. This will support the identification of teaching strategies and learning materials to address students' needs while improving their engagement and retention. As implied by the findings of the define and ideate phases, a collaborative approach involving both students and instructors should be used to select the most effective IMs. The developed IM (module) during the prototype phase must be refined and tested continuously, ensuring that all stakeholders' feedback is considered.

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GENERATIVE AI STATEMENT

The authors declare that no AI- assisted tools were employed in generating the manuscript's content. All ideas, research design, procedures, analyses, findings, and discussions are original and derived from the authors' systematic conduct of the study. Meanwhile, Grammarly and QuillBot were used solely for proofreading, grammar correction, and language refinement to enhance clarity and accuracy.

ETHICAL CONSIDERATIONS

The study was conducted professionally to prevent conflicts of interest. Throughout this research, data security and confidentiality were preserved. Participants were not exposed to any known dangers and were not from vulnerable groups, as they were university students and instructors who were capable of handling research issues. Before data collection starts, respondents are asked for their consent.

DECLARATION OF COMPETING INTEREST

The authors declare that they have no competing interests.

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