POLARIS GLOBAL JOURNAL OF SCHOLARLY RESEARCH AND TRENDS

Research Article

Development and validation of self-paced learning digital module in Mathematics 10

Arselyn M. Bustoba[1], Maria Crisella A. Dela Cruz[2]
[1]*Holy Angel University, PHILIPPINES*
ambustoba@hau.edu.ph
[2]*Pampanga State Agricultural University, PHILIPPINES*
kreezdelacruz@psau.edu.ph

ARTICLEINFO

Received
7/11/2022
Revised
8/15/2022
Accepted
9/13/2022

KEYWORDS
distance education, google classroom, learning management system, open and distance e-learning, self-paced learning digital module

E-ISSN: 2961-3809

ABSTRACT

The study used the design and development analysis method to provide an empirical foundation for instructional design and to systematically analyze the data on the development and validation of Self–Paced Learning Digital Module (SPLDM) in Mathematics 10 of the K-12 curriculum. Specifically, it addressed the following questions: 1) how can the Self–Paced Learning Digital Module in Mathematics 10 be developed? 2) how can the Self–Paced Learning Digital Module in Mathematics 10. The experts validated the SPLDM in terms of a) *Content Quality*; b) *Design/Format*; c) *Technical/Technological Quality*, and; d) *Pedagogical Quality*. The module underwent three phases: *preparation*, *development*, and *validation*. Using the evaluation instrument for topics to be included in the DE/ODel Module, 10 subject matter experts in mathematics 10 selected the essential and non-essential learning competencies. Lawshe's content validity ratio (CVR) found 38 of the subject's 50 learning competencies as essential. The 9 experts utilized the evaluation rating sheet for DE and ODeL Modules to assess the content, format, technical/technological, and pedagogy elements of the created SPLDM. The results of the validation of the developed SPLDM were found acceptable in terms of its content, design/format, technical/technological, and pedagogical after undergoing evaluation and full approval of the evaluators. As a result of this research, the generated SPLDM can be used as a learning material in the classroom when teaching Mathematics 10.

How to cite:
Bustoba, A.M. & Dela Cruz, M.C.A. (2022). Development and validation of self-paced learning digital module in Mathematics 10. *Polaris Global Journal of Scholarly Research and Trends*, 1(1), 12-28.

INTRODUCTION

Mathematics is one of the subjects that students study. It could be a language that represents a collection of major theoretical perspectives. To begin with, all branches of science require Mathematics to raise science's predictability and control significantly. Mathematics is a tool for extrapolating using a specific mentality (Cabrera, 2014). Also, it is clear that Mathematics is fundamental to teach, cultivate, and master in the field of education because if students learn mathematics lessons in class properly during the learning process, it will result in lifelong learning (Muhktar et al., 2017).

The mathematics curriculum is one of the most effective tools today's teachers can use to guide students toward the country's development, modernization, and industrialization goals. The goal of increasing productivity, sustainable development, and global competitiveness is to provide opportunities for all Filipinos to grow and develop (Melad, 2016). Furthermore, teachers play an important role in the innovation of mathematics education. Education institutions are concerned about a global initiative to promote quality education to produce qualified graduates, as well as a continuous search for and testing of new teaching approaches. The notion that the educational system is not sufficiently preparing students for the future and jobs in the twenty-first century has led people all over the country to look at alternative educational approaches (Dela Fuente, 2021; Caguimbal, 2013). In 2018, the Philippines joined the Organization for Economic Cooperation and Development's (OECD) Programme for International Student Assessment (PISA) as part of the standard Basic Education amendment plan and an effort to globalize Philippine Education standards. The findings showed that the Philippines students' mathematical performance is deficient, ranking second to last among the seventy-nine (79) countries that took part in the study (Department of Education, 2019). Filipino students excel at knowledge acquisition but perform poorly in lessons that require higher-order thinking skills (Dela Fuente, 2019; Dinglasan & Patena, 2013; Ganal & Guiab, 2014). According to Kaushar (2013), most students nowadays spend less time studying, a large percentage of them do not keep a calendar, and they are unaware of executive time plans, which adds to the difficulties they face when studying Mathematics.

The role of modules in Mathematics education

Several aspects of learning have an impact on achieving learning objectives. Learning materials are an essential part of education. According to Ballado and Espinar (2017), learning materials come in a variety of shapes and sizes, including learning materials used in the independent learning approach, also known as modules. The module helps students learn independently because it contains the entire learning content. It has self-explanatory power and grows under the characteristics of the learners. It has the potential to capture students' attention and increase their involvement in mathematics learning. Furthermore, modules are learning materials aligned with a specific curriculum, packed into the smallest learning unit, and enable students to check individually under a certain amount of time (Berondo & Dela Fuente, 2021; Columbano, 2019). A module is a comparatively short, self-contained, independent instruction unit designed to realize a limited set of specific and well-defined educational objectives (Meyer, 2014). It usually encompasses a tangible format as a collection or kit of coordinated and highly produced materials involving a spread of media. Likewise, a module may or might not be designed for individual self-paced learning and will employ a span of teaching techniques. In addition, the utilization of modules also motivates independent study. It manages students to apply rehearsed information (Nardo, 2017).

Different perspectives on self–paced instruction and modules

Self-paced instruction is a discipline that proceeds based on the learners' ability and responses to instructional and pedagogical interventions. It is intended to allow students to progress from one subject or section to the next academic level (Dick et al., 2014). Furthermore, it will enable the learner to monitor the rate of their exposure to learning experiences that have a nonadjacent dependence on the instructor (Dela Fuente, 2021; Farmer et al., 2013). Aptly, self-paced learning aligns with the pursuit of life-long learning. As a result, it enters a game described as organized learning. Participants have access to learning materials and content and can study when, where, and how they want. This pursuit supplements and complements the traditional educational system and satisfies the demand for life-long learners. This guidance guarantees quality learning when correctly executed through the academic mentor's enforced diligence (Anderson et al., 2015). A self-paced learning module is an orderly set of instructions designed to facilitate the learner's mastery of a body of knowledge or a procedure. When combined with other modules, learners can master an extensive body of information or a complex process (Dela Fuente, 2021; Calucag, 2013). Furthermore, a self-paced learning module can be in digital or print form. For example, the digital modules or lessons offered via a school's Learning Management System (LMS) are examples of self-paced learning modules (Cooper & Maile, 2018).

Current situation in education: A paradigm shift

Due to Covid -19 Pandemic, higher education institutions are shifting to online learning or distance education programs. Online Learning or Distance Education Program lets students learn at their convenience since it does not require attending training centers and universities. This enormous shift to online instruction prevents and controls the spread of the virus, for it does not need face-to-face interaction or the conventional educational process (Toquero, 2020). Rapid advances in information and communication technology (ICT) have resulted in significant improvements in distance education since the mid-1990s. Open, and distance e-learning (ODeL) describes the latest online or Web-based DE style. ODeL stands for education provision that uses contemporary technologies to allow various synchronous and asynchronous communications among learners and educators (Alfonso & Garcia, 2015). Providing teachers with appropriate training courses will help them execute this efficiently through electronic delivery and eliminate obstacles. They need to learn online-driven competencies in preparing, implementing, and evaluating their students' results. Teachers can access and promote learning for students with diverse educational needs through devices with innovative tools. The necessary and significant factors needed for successfully providing lessons in an online environment are technological devices, program design, instructors' choices, amenable curriculum, and corroborative stakeholders (Dela Fuente & Biñas, 2020; Barr & Miller, 2013). Teachers assessed their ability to teach Grade 10 mathematics material. (1) Sequences, (2) Polynomials and polynomial equations, (3) Polynomial functions, (4) Circles, (5) Plane coordinate geometry, (6) Permutations and combinations, (7) Probability of compound occurrences, and (8) Measures of the location were among the various topics in the material (Ferrer, 2017).

As the educational system struggles with the endeavors expressed in traditional teaching, technology integration in education is rapidly increasing in the modern era. Several studies have shown that incorporating digital technology into teaching strategies and instructional materials improved students' achievement in various subjects and tasks, particularly mathematics. According to student respondents, the implementation of a Learning Management System (LMS) to serve as a virtual extension of the classroom for both students and teachers was found to be generally acceptable and effective (Dellosa et al., 2012; Brioso, 2017; Garcia, 2017; Marcial, 2018). An LMS can be a repository of instructional material, a tool for administrative purposes, or both, depending on how it is used, or even become a virtual classroom.

Google classroom as an LMS

Google Classroom is an unlimited access service that connects teachers and students online. This service is available to anyone who has a Google account. Teachers can create and manage online classes, upload study materials, design, and grade assignments, and share feedback and grades. Students can use this service to access and use educational materials, interact with teachers and other students, submit assignments, and receive feedback and grades. Administrators can create multiple classes in their domain, assign teachers and students to these classes, and track the work in these classes. According to Iftakhar (2016), Google Classroom has the following advantages: 1) A centralized location for discussion threads and assigned work; 2) A centralized program for storing all student work in a paperless format; 3) A mechanism for identifying students who are struggling with assigned tasks; 4) Grading features have been simplified; 5) Google Classroom is an easily accessible resource for teachers who want to use a blended learning approach in their teaching because it is free and available to anyone with a Google account.

Objectives

The researcher was inspired to improve and innovate the teaching method by the current state of mathematics education in the Philippines. The goal of this study is to test a novel approach to teaching mathematics by combining two teaching methods – modular and self-paced learning – into a single teaching principle – modular self-paced learning instruction – and discover new teaching concepts. This study necessitates the creation of instructional materials to assist student researchers in connecting the role of Mathematics in the production of high-quality research and modern technology. In response to the evolving situations caused by the pandemic, the researcher investigated the possibility of developing a self-paced learning digital module for Grade 10 Mathematics in an Open and Distance e-Learning (ODeL) format via a Learning Management System, as well as an investigation into the efficacy of modular self-paced learning to teach Mathematics (LMS). The researcher conducted this study for this specific reason.

METHODS

The current study used the design and development analysis methodology to provide an empirical foundation for instructional design and systematically analyze data on the development and validation of a Self–Paced Learning Digital Module (SPLDM) in Mathematics 10. Descriptive research was also employed. Data collection, organization, analysis, and interpretation are all part of the process.

Validators

The researcher identified the validators using purposive sampling. Subject Matter Experts (SMEs) and validators of the Self–Paced Learning Digital Module (SPLDM) in Mathematics 10 were divided into two (2) groups of 20 experts in their respective fields. The study's initial batch of SMEs comprised ten (10) non-affiliated Grade 10 Mathematics Teachers from selected schools in the Division of Pampanga who are experts in the curriculum of Mathematics 10 and who verified the SPLDM's contents as essential or non-essential topics. The second set of validators consisted of ten (10) experts in their respective fields who validated the SPLDM in terms of content, format, design, technical/technological, and pedagogical. It included one (1) mathematics coordinator, who is an expert in terms of topics and content in mathematics across all year levels in the Junior Basic Education Department and who is updated on new trends and strategies in teaching mathematics, three (3) ICT Experts, who are experts in multimedia and integrating technology into instructional materials, five (5) Mathematics 10 Teachers, who are Master Teachers and experts in the topics and content of mathematics 10, and one (1) English Critique, who will also correct conceptual, factual, and grammatical errors in the module's content.

Instrument

The researcher used Evaluation Instrument for Topics to be included in the DE/ ODeL Module, the Evaluation Rating Sheet for DE &ODeL Modules, and the SPLDM to conduct the study. The College of Education of Pampanga State Agricultural University provided the Evaluation Instrument for Topics to be included in the DE/ODeL Module and the Evaluation Rating Sheet for DE and ODeL Modules (PSAU). The Essential and Non-essential Learning Competencies in Mathematics 10 were determined using the Evaluation Instrument for Topics to be included in the DE/ODeL Module. These learning competencies were identified using the Department of Education Curriculum Guide. The validators used the Evaluation Rating Sheet for DE and ODeL Modules to validate the SPLDM in four evaluation categories: Content Quality; Design/Format; Technical/Technological Quality; and Pedagogical Quality which provide a conceptual understanding of the requirements and features of DE and ODeL Modules. Yes or No was used to define the criteria. The researcher created the Self-Paced Learning Digital Module (SPLDM) as digital content based on the essential learning abilities in mathematics 10. It is a self-contained and self-sufficient instructional unit that enables a student to achieve a set of objectives within a specific and realistic time frame. The SPLDM was created using Google Classroom, a student-friendly, and open-access Learning Management System.

Procedures

The researcher took the following steps to get the information needed for this study:

Preparation phase

The preparation phase was the first step in creating the SPLDM. To carry out the study, the researcher prepared two letters of approval. The first was a letter to the Dean of the College of Education at Pampanga State Agricultural University requesting permission to use the Evaluation Instrument and the Evaluation Rating Sheet. The second is a letter of authorization to conduct the study, which was sent to the involved specialists and requested permission to collect the necessary data and information from them. The researcher then used purposive sampling to identify experts to validate and evaluate the self-paced learning digital module. Finally, the researcher selected all of the mathematics 10 learning competencies and gathered all of the necessary resources, such as textbooks, e-books, and websites, to aid in the development of the module.

Development phase

The development phase was the second step in creating the SPLDM. The Evaluation Instrument for topics expected to be included in the DE/ODeL module was used to assess the essential and non-essential learning competencies in the mathematics 10 curriculum and was given to ten (10) Subject Matter Experts (SME) selected by purposive sampling. Lawshe's Table of Minimum Values for CVR was used to determine the essential and non-essential learning competencies. The content and design of the proposed SPLDM in Mathematics 10 were based on the essential learning competencies. The researchers organized each learning competency based on the nature of the topics after identifying the essential learning competencies. The researcher created the material, images, exercises, and assessments for each topic. The topics were divided into nine sections: what I need to know, what I know, what's in, what's new, what's more, what I have learned, what I can do, and lastly, the assessment. What I Need to Know is the first section, and it will give the student an idea of the skills or competencies they should gain in the module. The next segment is What I Know, which comprises an activity aimed at what the learner already knows about the upcoming session. Then there's what's in, a short drill or review to assist the learner in connecting the present and previous lessons. To introduce the new lesson in what's new, a story, a song, a poem, a problem opener, an action, or a circumstance will be used. What Is It is the next section, which discusses the task? This is intended to assist the learner in discovering and comprehending new concepts and abilities. Furthermore, create practice exercises to improve the learner's understanding and skills in each area. What I Have Learned contains open-ended questions to help learners absorb what they've learned in class. What I can do supplies a problem-solving, mini-task, or performance challenge that will assist the learner in transferring the skill they learned in the topic to real-life situations. The Assessment section is the last section of each lesson and is used to evaluate the learner's level of competence in completing the learning competency. SPLDM is focused on Google Classroom, an easy-to-use, open-access Learning Management System (LMS) for Open Distance Electronic Learning.

Validators phase

The validation phase was the final stage of the SPLDM's development. The validity and utility of the phase were determined. During the initial validation, ten (10) experts in their respective fields, one (1) Mathematics Coordinator, three (3) Instructional Media Coordinators (ICT

Experts), five (5) Mathematics 10 Teachers, and one (1) English Critique, were given access to the Google Classroom for the SPLDM link and their copy of The Evaluation Rating Sheet for DE and ODeL Modules. The content, design/format, technical/ technology, and pedagogical aspects of the DE and ODeL modules were appraised. Following the submission of the validation results, the nominal data (Yes/No) were tallied to determine which experts provided comments. During the initial phase, the SPLDM was revised based on expert ideas and recommendations. After the SPLDM's final validation was completed, all indicators on the DE and ODeL Evaluation Sheets were marked "Yes," indicating that the SPLDM can be considered an adequate instructional resource in teaching Mathematics 10. The nominal data collected in the DE and ODeL Evaluation Sheets were tallied, and their frequencies were used as indicators for whether each criterion in the evaluation sheet should be accepted or rejected.

RESULTS AND DISCUSSION

Table 1. Phases of the development of a self-paced learning digital module in Mathematics 10

Phases	Activities/Descriptions
Preparation Phase	• Securing authorization to utilize the instrument for content validity and the rating sheet through a permission letter. • Identification of experts needed to verify and assess the Self–Paced Learning Digital Module. • Seeking permission from subject matter experts and validators through request letters. • Identifying learning competencies according to the Department of Education Curriculum Guide • Accessing relevant sources, such as textbooks, e-books, and websites, to aid the development of the module.
Development Phase	• Identification of essential and non-essential topics through the Evaluation Instrument for topics to be included in DE and ODeL Modules with the help of Mathematics 10 SMEs. • Verification of the content of the SPLDM through Lawshe Table of Minimum Values for CVR. • Identification of the format to be used in constructing SPLDM, which is dividedinto nine (9) sections. • Creation of the first draft of the digital module in a Learning Management System (LMS) using Google Classroom (GC)
Validation Phase	• Initial validation of the content, design, and format, technical/technological, and pedagogical aspects of the Self-Paced Learning Digital Module (SPLDM) in Mathematics 10 by the experts through the Evaluation Rating Sheet for DE and ODeL Modules. • Accumulation of the nominal data and frequencies for the Statistical Treatment of the findings in the initial validation of the SPLDM. • Integration of comments and

suggestions of the experts in the initial validation.

- Final validation of the content, design, and format, technical/technological, and pedagogical aspects of the Self-Paced Learning Digital Module (SPLDM) in Mathematics 10 by the experts through the Evaluation Rating Sheet for DE and ODeL Modules.
- Integration of comments and suggestions of the experts in the final validation.
- The Developed Self–Paced Learning Digital Module in Mathematics 10.

The preparation, development, and validation phases are shown in Table 1 as part of creating a Self-Paced Learning Digital Module in Mathematics 10. During the preparation phase, a letter of authorization was sent to the College of Education Dean's Office, requesting permission to use the college's DE/ODeL questionnaire. Following the approval of the questionnaire, the request letters were distributed to the two groups of validators, who were in charge of determining the essential and non-essential topics, as well as evaluating the SPLDM's content, format, design, technical/technological, and pedagogical aspects. During the development phase, subject matter experts (SMEs) in Mathematics 10 used The Evaluation Rating Sheet for DE and ODeL Modules to validate the essential and non-essential topics. As there are ten (10) SMEs involved, a learning competency must have a CVR of at least 0.62 to be included as a topic in the construction of the SPLDM, according to Lawshe's Table for Minimum Values of Content Validity Ratio. Then, the essential learning competencies were classified according to the topics' nature. The researcher's preferred Learning Management System, Google Classroom, was then used to create the first draft of the SPLDM. During the validation phase, the experts are given access to the Google classroom for the SPLDM link, as well as a copy of the Evaluation Rating Sheet for DE and ODeL Modules, which includes content, design and format, technical/ technological, and pedagogical aspects of the Self-Paced Learning Digital Module in Mathematics 10. Experts scrutinize the created SPLDM for the presence of each criterion for each factor. The results of the SPLDM's initial validation are statistically described by tallying the nominal data. Expert comments and recommendations resulted in additional adjustments to a criterion in a specific factor marked "no" by an expert. The feedback and suggestions were incorporated into the module until all indicators in each aspect were marked "yes" as the final validation. In the final validation, another round of description of the outcomes is recorded by tallying the nominal data and their frequencies as statistical treatment. This implies that the digital module was created in a logical order, with preparation, development, and validation phases. This is consistent with Verano and Alonzo's (2019) study, in which their developed module went through the same phases.

Table 1.1. First-quarter learning competencies in Mathematics 10

Learning Competencies	Essential (f)	Not Essential (f)	CVR*	Interpretation
1. Generates patterns	10	0	1.00	Retained
2. Illustrates an arithmetic sequence.	10	0	1.00	Retained
3. Determines arithmetic means and nth term of an arithmetic sequence.	10	0	1.00	Retained
4. Finds the sum of the terms of a given arithmetic sequence.	10	0	1.00	Retained
5. Illustrates a geometric sequence.	10	0	1.00	Retained

6. Differentiates a geometric sequence from an arithmetic sequence.	9	1	0.80	Retained
7. Differentiates a finite geometric sequence from an infinite geometric sequence.	7	3	0.40	Rejected
8. Determines geometric means and nth term of a geometric sequence.	10	0	1.00	Retained
9. Finds the sum of the terms of a given finite or infinite geometric sequence.	8	2	0.60	Rejected
10. Illustrates other types of sequences (e.g., harmonic, Fibonacci)	8	2	0.60	Rejected
11. Solves problems involving sequences.	10	0	1.00	Retained
12. Performs division of polynomials using long division and synthetic division.	10	0	1.00	Retained
13. Proves the Remainder Theorem and the Factor Theorem.	7	3	0.40	Rejected
14. Factors polynomials.	10	0	1.00	Retained
15. Illustrates polynomial equations.	10	0	1.00	Retained
16. Proves Rational Root Theorem.	7	3	0.40	Rejected
17. Solves polynomial equations.	10	0	1.00	Retained
18. Solves problems involving polynomials and polynomial equations.	9	1	0.80	Retained

** A learning competency must have a minimum CVR value of 0.62 to be retained*

The essential and non-essential topics in mathematics 10 for the first quarter are shown in Table 1.1. According to the table, 13 of the 18 learning competencies were essential (72.22 %). The content validity ratio, which requires a minimum value of 0.62 for topics to be regarded essential as stressed in Lawshe's Content Validity Ratio with the opinion of ten (10) subject matter experts, was used to confirm the results. The following were the essential learning competencies and associated CVRs: generates patterns (1.00); illustrates an arithmetic sequence (1.00); determines arithmetic means and nth term of an arithmetic sequence (1.00); illustrates a geometric sequence (1.00); finds the sum of the terms of a given arithmetic sequence (1.00); differentiates a geometric sequence from an arithmetic sequence (0.80); determines geometric means and nth term of a geometric sequence (1.00); solves problems involving sequences (1.00); performs division of polynomials using long division and synthetic division (1.00); factors polynomials (1.00); illustrates polynomial equations (1.00); solves polynomial equations (1.00), and, solves problems involving polynomials and polynomial equations (0.80). The results conform with Obara(2018), stating that "Pattern recognition is a vital curriculum area that students at all grade levels should study — from detecting simple patterns to understanding algebraic expressions — because Patterns are so fundamental in mathematics."

Table 1.2. Second-quarter learning competencies in Mathematics 10

Learning Competencies	Essential (f)	Not Essential (f)	CVR *	Interpretation
1. Illustrates polynomial functions.	10	0	1.00	Retained
2. Graphs polynomial functions.	10	0	1.00	Retained
3. Solves problems involving polynomial functions.	10	0	1.00	Retained
4. Derives inductively the relations among chords, arcs, central angles, and inscribed angles.	8	2	0.60	Rejected
5. Proves theorems related to chords, arcs, central angles, and inscribed angles.	9	1	0.80	Retained
6. Illustrates secants, tangents, segments, and sectors of a circle.	10	0	1.00	Retained
7. Proves theorems on secants, tangents, and segments.	9	1	0.80	Retained
8. Solves problems on circles.	10	0	1.00	Retained
9. Derives the distance formula.	9	1	0.80	Retained
10. Applies the distance formula to prove some geometric properties.	9	1	0.80	Retained
11. Illustrates the center-radius form of the equation of a circle.	10	0	1.00	Retained
12. Determines the center and radius of a circle given its equation and vice versa.	10	0	1.00	Retained
13. Graphs a circle and other geometric figures on the coordinate plane.	8	2	0.60	Rejected
14. Solves problems involving geometric figures on the coordinate plane.	8	2	0.60	Rejected

** A learning competency must have a minimum CVR value of 0.62 to be retained*

The essential and non-essential topics in mathematics 10 for the second quarter are shown in Table 1.2. According to the table, 11 of the 14 learning competencies (78.57%) were essential. The following were the essential learning competencies and associated CVRs: illustrates polynomial functions (1.00); graphs polynomial functions (1.00); solves problems involving polynomial functions (1.00); proves theorems related to chords, arcs, central angles, and inscribed angles (0.80); illustrates secants, tangents, segments, and sectors of a circle (1.00); proves theorems on secants, tangents, and segments (0.80); solves problems on circles (1.00); derives the distance formula (0.80); determines the center and radius of a circle given its equation and vice versa (1.00), and, illustrates the center-radius form of the equation of a circle (1.00). The result shows that topics in geometry and plane coordinate geometry are essential to the Grade 10 curriculum, as supported in the study of Abunda (2020). Geometry, in particular, helps students develop visualization, critical thinking, intuition, perspective, problem-solving, conjecturing, deductive reasoning, logical argument, and proof, all need to be cultivated in secondary mathematics.

Table 1.3. Third - quarter learning competencies in Mathematics 10

Learning Competencies	Essential (f)	Not Essential (f)	CVR*	Interpretation
1. Illustrates the permutation of objects.	10	0	1.00	Retained
2. Derives the formula for finding the number of permutations of n objects taken r at a time.	7	3	0.40	Rejected
3. Solves problems involving permutations.	9	1	0.80	Retained
4. Illustrates the combination of objects.	10	0	1.00	Retained
5. Differentiates permutation from combination of n objects taken r at a time.	10	0	1.00	Retained
6. Derives the formula for finding the number of combinations of n objects taken r at a time.	8	2	0.60	Rejected
7. Solves problems involving permutations and combinations.	10	0	1.00	Retained
8. Illustrates events, and union and intersection of events.	10	0	1.00	Retained
9. Illustrates the probability of a union of two events.	10	0	1.00	Retained
10. Finds the probability of (A U B).	9	1	0.80	Retained
11. Illustrates mutually exclusive events.	10	0	1.00	Retained
12. Solves problems involving probability.	10	0	1.00	Retained

** A learning competency must have a minimum CVR value of 0.62 to be retained*

The essential and non-essential topics in mathematics 10 for the third quarter are shown in Table1.3. According to the table, 10 of the 12 learning competencies (83.33%) were essential. The following were the essential learning competencies and associated CVRs: illustrates the permutation of objects (1.00); solves problems involving permutations (0.80); illustrates the combination of objects (1.00); differentiates permutation from a combination of n objects taken r at a time (1.00); solves problems involving permutations and combinations (1.00); illustrates events, and union and the intersection of events (1.00); illustrates the probability of a union of two events (1.00); finds the probability of (A U B) (0.80); illustrates mutually exclusive events (1.00), and, solves problems involving probability (1.00). Most of the topics identified as essential are under probability. In the study of Dinc et al. (2019), it is critical to include Probability in secondary mathematics education curricula.

Table 1.4. Fourth-quarter learning competencies in Mathematics 10

Learning Competencies	Essential (f)	Not Essential (f)	CVR*	Interpretation
1. Illustrates the following measures of position: quartiles, deciles and percentiles.	10	0	1.00	Retained
2. Calculates a specified measure of position (e.g. 90th percentile) of a set of data.	10	0	1.00	Retained
3. Interprets measures of position.	10	0	1.00	Retained
4. Solves problems involving measures of position.	10	0	1.00	Retained
5. Formulates statistical mini-research.	6	4	0.20	Rejected
6. Uses appropriate measures of position and other statistical methods in analyzing and interpreting research data.	6	4	0.20	Rejected

** A learning competency must have a minimum CVR value of 0.62 to be retained*

The essential and non-essential topics in mathematics 10 for the fourth quarter are shown in Table 1.4. According to the table, 4 out of 6 learning competencies (66.67 percent) were essential. The following were the essential learning competencies and associated CVRs: illustrates the following measures of position: quartiles, deciles, and percentiles (1.00); calculates a specified measure of position (e.g., 90th percentile) of a set of data (1.00); interprets measures of position (1.00), and solves problems involving measures of position (1.00). The essential topics identified in the fourth quarter are under statistics. According to Oliveira et al. (2018), statistics is becoming increasingly important in higher education. Education institutions respond to the current demand for people who can help handle massive amounts of data quickly and master analysis techniques that aid decision-making based on sample data inference. Generally, the mathematics 10 curriculum includes 50 learning criteria in total. After the content evaluation, however, only 38 (76%) were deemed essential. These fundamental learning competencies were arranged into 19 modules based on the nature of the topics.

Table 2. Validation of the SPLDM as to Content

Content	Initial Validation		
	Yes	No	DR
1. The topics/lessons included in the module are very relevant to the main goal of the course and greatly contribute to the achievement of the specific lesson objectives.	6	0	Yes
2. The module provides information that are very important and useful to the students who will be utilizing it.	6	0	Yes
3. Adequate information is being provided in every lesson with links and references included to guide students for further research activities.	6	0	Yes

4.	The content is presented clearly using language that is understandable and suited to the level of the target learners.	6	0	Yes
5.	The knowledge and ideas being presented in every unit are accurate, recent, and free from errors using terminologies that suit the distinct characteristics of the target learners.	6	0	Yes
		n = 6		

The content validation of the SPLDM is highlighted in Table 2 Based on the findings of the initial validation, all validators (6 out of 6) agreed that the SPLDM met all five criteria in the content factor. The module was praised for how well the divisions of each topic are presented, as well as the interactions within each part, allowing the learner to absorb each lesson quickly. As a result, the SPLDM contains lessons that correspond to the Department of Education's learning competencies in Mathematics 10. The SPLDM contains vital, functional, and relevant information. Furthermore, the SPLDM presents information in a clear, accurate, and error-free manner. The importance of content knowledge is linked to student learning. Teachers with solid content knowledge are more likely to help students construct knowledge by asking appropriate questions, suggesting alternate answers, and offering additional research (Telaumbanua, 2017).

Table 2.1 Validation of the SPLDM as to design and format

	Design and Format	Initial Validation			Final Validation		
		Yes	No	DR	Yes	No	DR
1.	Textual information is presented clearly with appropriate choice of font size and style including other formatting features that could enhance the appearance of the texts (e.g., italics, boldface, underline, etc.)	6	0	Yes	-	-	-
2.	Proper spacing is observed in between texts, sentences, and paragraphs including margin and indention to avoid congested page.	6	0	Yes	-	-	-
3.	The graphics used and other media elements utilized (audio, video, animation etc.) are motivating and very relevant to the topics presented.	4	2	No	6	0	Yes
4.	Main topics, subtopics, specific discussions, and other important parts of the module are properly labeled for easy recognition.	6	0	Yes	-	-	-
5.	The module is properly organized and packaged in such a way that all the parts compliment with one another and each part contains clear directions for students to follow.	6	0	Yes	-	-	-
			n = 6				

Table 2.1 displays the design and format validation of the SPLDM. All validators (6 out of 6) agreed that the SPLDM met criteria 1,2,4, and 5 in the design and format factor, but only 4 out of 6 validators agreed that the SPLDM met criterion 3. One validator, who was dissatisfied with criterion number 3 of the generated module, suggested making the graphics more engaging and visible. As a result, the researcher changed the graphics such that the banners and information visuals used in

the SPLDM meet the validator's requirements. Another validator recommended using Bitmoji, an app that allows you to build an avatar that looks exactly like you and then add it to the SPLDM visuals. The researcher then enhanced the SPLDM's aesthetics with Bitmojis. Criterion 3 was met during the final validation. Based on the final validation results, all validators (6 out of 6) agreed that the SPLDM met the design and format criteria. The results show that the generated SPLDM's textual data is presented clearly and distinctly. The information graphics in the SPLDM are brief and relevant, and they can easily capture students' attention, motivating them to correctly understand and answer the module's topic. Finally, the SPLDM produced is appropriately labeled and organized, including themes, subtopics, and discourse. According to Torreffanca (2017), the instructional design ensures that students achieve specific learning goals or educational objectives as outlined in the curriculum and deliver relevant instructions appropriate for various learning situations through systematically developing instructional materials and activities. Also, modules can be viewed as a single source of learning systematically organized in a language based on its design and format that students can understand based on their level of ability with minimal teacher guidance (Wiesenfarth et al., 2018)

Table 2.2. Validation of the SPLDM as to technical/technological

	Technical/Technological	Initial Validation		
		Yes	No	DR
1.	Use of the module does not require equipment or applications beyond what is typically available to the students (e.g. operating systems, browsers, application software)	3	0	Yes
2.	The module can be accessed by students either through the internet (online) or offline by providing them both hard and electronic copy (from CD, flash drive and other modes of transferring files)	3	0	Yes
3.	The module can be embedded or fully integrated into a Learning Management System for wide dissemination and accessibility	3	0	Yes
4.	The module has a user-friendly interface and navigational tools that even novice users can easily follow	3	0	Yes
5.	The module provides students opportunity to interact with the teacher and other students through various communication tools provided such as email, messenger, video- conferencing etc.	3	0	Yes
		n = 3		

Table 2.2 demonstrates the validation in terms of technical/technological factors. This component was validated by a separate team of validators comprised of three ICT professionals. According to the final validation results, all three validators agreed that the SPLDM met all of the technical/technological criteria. According to the results, learners can easily access the generated module using commonly available applications. Furthermore, the module is available online, allowing students to virtually communicate with the teacher and other students through comments and private messages. Finally, the SPLDM was fully integrated into the Google Classroom Learning Management System, allowing online distance learning. As a result, SPLDM is a critical tool for distance learning (Oronce & Manalo, 2021).

Table 2.3. Validation as to pedagogy

	Pedagogy	Initial Validation		
		Yes	No	DR
1.	Objectives are well-formulated giving clear direction and establish a sense of expectancy among students).	6	0	Yes
2.	Prior knowledge of students is properly assessed to bridge the gap between what they already know and what they must know.	6	0	Yes
3.	Various motivational and cognitive strategies are properly embedded in every lesson/unit to keep students on track.	6	0	Yes
4.	Tasks or activities required in the module are very relevant to the main objectives of the course and lessons and must be realistic considering the resources available (e.g., time, materials, equipment, etc.).	6	0	Yes
5.	The module provides provision for individual differences by supporting diverse learners with different learning styles, preferences, interests, and experiences.	6	0	Yes
6.	Assessment tools included ensure the development of higher-order thinking skills such as critical and creative thinking.	6	0	Yes
7.	The module also provides good feedback mechanism so learners can regularly receive formative feedback on learning (i.e., they can track their performance, monitor their improvement, test their knowledge).	6	0	Yes
		n = 6		

The confirmation of the pedagogical component is shown in Table 2.3. Based on the initial validation findings, all validators (6 out of 6) agreed that the SPLDM met all of the pedagogical requirements. One of the validators raised a concern about the assurance that students will complete the last activity before answering the next and proposed allocating time to complete the module. The researchers explained the function of the “required button" in the Google form. Each topic’s inclusion of a temporal frame was also considered. The outcome suggests that the SPLDM's lesson objectives are well-formulated and provide insight into what the learners intended to learn during that session. Furthermore, each module's what I know portion assesses the learner’s past knowledge to bridge the gap between what they already know about the topic and what they must know as the course progresses. In addition, each module contains several incentive tactics to assist students in achieving desired results. Assessment, the final component of each module in the created SPLDM, is responsible for the learners’ critical and higher-order thinking skills, particularly important in mathematics. Finally, the built SPLDM shows how to follow their development and check correct answers as feedback to measure their improvement. This finding is consistent with the discussion of Nepomuceno cited by Vergara (2017), who described the modules as follows: It is essentially self-teaching. It focuses on a specific, different skill or set of skills or outcomes other than skills; it is relatively brief so that students can make the most of their study time.

CONCLUSION AND RECOMMENDATION

The following conclusions are drawn from the study's findings: (1) The Self-Paced Learning Digital Module in Mathematics 10 was created using a Learning Management System called Google Classroom and went through design, development, and validation phases. (2) The module's contents were identified and selected by taking into consideration the essential learning competencies evaluated by 10 subject matter experts using Lawshe's content validity ratio (CVR) and was further validated by 9 experts in terms of content, format, and design, technical/technological, and pedagogical aspects, which received approval from all experts based on the DE/ODeL rating sheets they used, satisfying the Self-Learning requirement. As a result of this study, the generated SPLDM can be used as a learning material in the classroom when teaching Mathematics 10. Based on the study's findings, the researcher suggests the following: (1) The developed learning modules can be used as a supplement to the mathematics curriculum in a variety of topic areas and courses to encourage students to use technology in their learning through an Alternative Delivery Model. (2) More research is recommended as part of this project to expand the findings regarding the application and efficacy through experimental design.

REFERENCES

Alfonso, G. & Garcia P. (2015). Open and Distance eLearning: New Dimensions in Teaching, Learning, Research, and Extension for Higher Education Institutions. *International Journal on Open and Distance eLearning*, 1,(1 & 2).

Anderson, T., Dron, J., Malone J., Poelhuber, B., & Upton, L. (2015). Social Interaction in Self-Paced Distance Education. *International Council for Open and Distance Education*.

Arinto, P. (2016). Issues and Challenges in Open and Distance e-Learning: Perspectives from the Philippines. *International Review of Research in Open and Distributed Learning*, 17(2).

Ballado, R. &Espinar, M. (2017). Content Validity and Acceptability of a Developed Work text in Basic Mathematics 2. *Asia Pacific Journal of Multidisciplinary Research*, 5(1).

Barr, B.A. & Miller, S.F. (2013). Higher Education: The Online Teaching and Learning Experience. Phoenix, AZ: University of Phoenix Faculty School of Advanced Studies.

Bautista, R. (2015). Optimizing Classroom Instruction through Self-Paced Learning Prototype. *Journal of Technology and Science Education*.

Berondo, R.G. & Dela Fuente, J.A. (2021). Technology Exposure: Its Relationship to the Study Habits and Academic Performance of Students. *Utamax : Journal of Ultimate Research and Trends in Education*, *3*(3), 125-141. https://doi.org/10.31849/utamax.v3i3.7280

Bersoto, L. (2014). Status of implementation and usefulness of outcomes-based education in the engineering department of an ASEAN University. *International Journal of Multidisciplinary Academic Research*, 2(4).

Cabrera, F. (2014). Modular Cooperative Learning: A Designed Mathematics Instruction for 21st Century Education. *UNP Research Journal*.

Caguimbal, D. (2013). Level of awareness of the maritime students on the outcomes-base-education. *Educational Research International*, 2(1).

Calucag, L. (2013). Self- Paced Instruction and Mathematics Achievement. *Journal of Education and Practice*, 4(17).

Columbano, M. (2019). Development and Validation of Modules in Basic Mathematics to Enhance Students' Mathematics Performance. *International Journal of Innovative Technology and Exploring Engineering*, 8(12).

Cooper, M. & Maile, C. (2018). The CIMC Guide to Developing a Self – Paced Learning Module. Curriculum and Instructional Materials Center.

Dela Fuente, J.A. (2021). Contributing factors to the performance of pre-service physical science teachers in the Licensure Examination for Teachers (LET) in the Philippines. *Journal of Educational Research in Developing Areas*, *2*(2), 141-152. https://doi.org/10.47434/JEREDA.2.2.2021.141

Dela Fuente, J.A. & Biñas, L.C. (2020). Teachers' competence in information and communications technology (ICT) as an educational tool in teaching: An empirical analysis for program intervention. *Journal of Research in Education, Science and Technology*, 5(2), 61-76.

Dela Fuente, J.A. (2019). Driving Forces of Students' Choice in specializing science: a science education context in the Philippines Perspective. *The Normal Lights*, 13(2), 225-250.

Dela Fuente, J.A. (2021). Facebook messenger as an educational platform to scaffold deaf students' conceptual understanding in environmental science subject: A single group quasi-experimental study. *International Journal of Education*, 14(1), 19-29. doi:10.17509/ije.v14i1.31386

Dela Fuente, J.A. (2021). Implementing inclusive education in the Philippines. College teacher experiences with deaf students. *Issues in Educational Research*, 31(1), 94-110. http://www.iier.org.au/iier31/dela-fuente.pdf

Dellosa, R.M., Prospero, M.R., & Rodriguez, J.L. (2012). Learning Management System for LPU-Laguna. *Lyceum of the Philippines–Laguna Research Journal*, 2(1).

Dick, W., Carey, L., & Carey, J. (2014). The Systematic Design of Instruction (8th edition). Pearson Publishing.

Dinglasan, B.L. &Patena, A. (2013). *Students Performance on Departmental Examination: Basis for Math Intervention Program*. University of Alberta School of Business Research Paper, (2013–1308).

Farmer, T.A., Fine, A.B., Jaeger, T.F., & Qian, T. (2013). Rapid expectation adaptation during syntactic comprehension. *PLoS ONE*, 8, e77661. htp://dx.doi.org/10.1371/journal.pone.0077661

Ferrer, I.M.C. (2017). Competency Level of Grade 10 Mathematics Teachers in Pangasinan Philippines. *Pangasinan State University Journal of Education, Management and Social Sciences*, 12–15.

Ganal, N.N. & Guiab, M.R. (2014). Problems and difficulties encountered by students towards mastering learning competencies in mathematics. *Researchers World*, 5(4), 25.

Iftakhar, S. (2016). Google Classroom: What works and how? *Journal of Education and Social Sciences,* 3, 12-18.

Jamal, H. & Shanaah, A. (2011). The Role of Learning Management Systems in Educational Environments: An Exploratory Case Study. Linnaeus University School of Computer Science, Physics and Mathematics.

Kaushar, M. (2013). Study of impact of time management on academic performance of college students. *Journal of Business and Management*, 9(6), 59-60. https://doi.org/10.9790/487X-0965960

Lim, E. (2016). Effectiveness of Modular Instruction in Word Problem Solving of BEED Students. *International Organization of Scientific Research Journal of Mathematics*, 12(5), 59-65.

Melad, A. (2016). Modular Approach in Teaching Mathematics: Quadratic Function. *Scholars Journal of Physics, Mathematics and Statistics*.

Meyer, K. (2014). Student Engagement in Online Learning: What Works and Why. Wiley Online Library. https://onlinelibrary.wiley.com/doi/abs/10.1002/aehe.20018

Mtebe, J. (2015). Learning Management System success: Increasing Learning Management System usage in higher education in sub-Saharan Africa. *International Journal of Education and Development using Information and Communication Technology*, 11(2), 51-64.

Muhktar, Sinaga, B., Surya, E., & Telaumbanua, Y. (2017). Development of Mathematics Module Based on Metacognitiupper-casey in Improving Students' Mathematical Problem-Solving Ability at High School. *Journal of Education and Practice*, 8(19).

Nardo, M.T. (2017). Modular Instruction Enhances Learner Autonomy. *American Journal of Educational Research*.

Oronce, J. & Manalo, D. (2021). Development and Validation of Flipbook in Earth and Life Science. *International Multidisciplinary Research Journal*, (3)1, 111-117.

PISA (2018). National Report of the Philippines.

Roman, A. (2013). Development and Validation of Statistics Module for Quality Educational Research. *International Journal of Science and Research*.

Telaumbanua, Y. (2017). Development of Mathematics Module Based on Metacognitive Strategy in Improving Students' Mathematical Problem-Solving Ability at High School. *Journal of Education and Practice,* 8(19).
Toquero, C. (2020). Challenges and Opportunities for Higher Education amid the COVID-19 Pandemic: The Philippine Context.
Torrefranca, E. (2017). Development and Validation of Instructional Modules on Rational Expressions and Variations. *The Normal Lights*, 11(1).
Verano, E. & Alonzo, M. (2019). Development and Evaluation of Business Mathematics Modules in Trece Martires City Senior High School. 4th Cavite Research Conference [Abstract].
Vergara, A. (2017). Development, Effectiveness and Acceptability of Module for the Problem Solving and Critical Thinking skills of Alternative Learning System in District of Tanay II.
Wiesenfarth, M., Gamisch, S., Jakob, P., Steiner, M., & Bett, A. (2018). Systematic design evaluation on the example of a photovoltaic concentrator module with mirror optics and passive heat dissipation. https://doi.org/10.1002/pip.3005