Utilization of Digital Module for Asynchronous Online Independent Learning in Advanced Mathematics Education

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Abstract: *The exponential increase in the number of cases and number of affected countries of the novel coronavirus disease 2019 (COVID-19) brought significant change in the mode of instruction from face-to-face to distance learning among the different levels of education around the world. This descriptive-developmental method of study adopted the ADDIE (Analysis, Design, Develop, Implement, Evaluate) model of instructional system design (ISD) framework in the development and evaluation of digital learning module intended for asynchronous online independent learning among students at the advanced mathematics education level. The adopted instructional materials evaluation instrument and the 10 items open-ended teacher-made test were used to describe the learning outcomes of the 13 enrolled graduate mathematics education students (4Male, 9Female) during the COVID-19 pandemic period in Sorsogon, Philippines. Findings of the study revealed that the designed digital learning modules covering the required content topics of modern algebra arranged in increasing complexity and ensuring the presence of the basic elements of discussions, definition, examples, and practice drills (worksheets) provide a significant learning experience among the students in times of pandemic as exhibited by their very satisfactory level of evaluation (Mean=4.42±2.58) on its characteristics. The utilization of the digital module available for asynchronous online independent learning maximizes learning outcomes which showed an increase in the mean score of 8.10 equivalent to 53.97 percentage score indicating a highly significant improvement ($t=5.034$, $p<0.05$) in the level of students' understanding of the content topics. Investment in strong internet connectivity is necessary to strengthen the asynchronous learning experiences of the students with the use of digital modules through the regular conduct of virtual conferences for monitoring and immediate feedbacking.*

Keywords: *Digital Module, Asynchronous Online Learning, Independent Learning, Advanced Mathematics Education, Instructional System Design*

INTRODUCTION

The pandemic phenomenon as declared by the World Health Organization (WHO) on March 11, 2020, due to an exponential increase in the number of cases and number of affected countries of the novel coronavirus disease 2019 (COVID-19) (Cucinotta & Vanelli, 2020; Ducharme, 2020) showed a significant impact not only in the health sectors (Xiong et. al, 2020; Giusti et. al., 2020; Berardi, Antonini, Genie, Cotugno, Lanteri, Melia & Paolucci, 2020) but also in the socio-economic activities (Nicola et. al., 2020; Martin, Markhvida, Hallegatte & Walsh,

2020; Iacus, Natale, Santamaria, Spyratos & Vespe, 2020; Sharifi & Khavarian-Garmsir, 2020) including the education sectors (Chandasiri, 2020; Marinoni, Van't Land & Jensen, 2020) around the world. Similarly, in the Philippines, the Proclamation No. 929 declaring the state of calamity throughout the country due to the COVID-19 outbreak (Gita-Carlos, 2020; Merez, 2020; Kabiling, 2020; Vallejo & Ong, 2020) brought drastic changes in the mode of instruction at a different level of education (Tria, 2020; Toquero & Talidong,2020; Reimers & Schleicher, 2020).

The restriction of face-to-face interaction paved the way towards the adoption of online learning among the basic, higher, and advanced levels of education in the Philippines. One of the most salient features of the educational delivery during the pandemic period was the implementation of synchronous and asynchronous online learning which requires stronger internet connectivity among the teachers and learners. Each educational leader including classroom teachers was engaged in the creation of the best instructional mode either print or non-print for learners' utilization.

The introduction of this new mode of instruction became a challenging task for most of the teachers in bringing active participation and involvement among the students. Swan (2001) found out that the clarity of design, interaction with instructors, and active discussion among course participants significantly influenced students' satisfaction from asynchronous online learning. Moreover, the task of designing appropriate instructional material is necessary to support the needs of the students and thus they will become more engaged in asynchronous online learning (Alrajeh & Shindel, 2020). The students in advanced education level (or graduate students) have different learning styles that need to be supported with suitable teaching approaches and strategies. Graduate students who are generally independent learners desired more of a mentoring relationship with faculty where they could seek guidance and information about their professional development.

Holzweiss, Joyner, Fuller, Henderson & Young (2014) reveals in their investigation that the best learning experiences of graduate students in an online class are the activities that allowed for the creation and/or sharing of knowledge such as problem-solving assignments, research, writing, journal reflection, discussion forums, video lesson creation and virtual conferencing. In addition, students enrolled in online education demonstrate strong preferences for asynchronous mode of learning because of convenience and favored individual assignments (Butler & Pinto-Zipp, 2005). Swan, Shen, and Hiltz (2006) explored collaborative activities such as discussion, small group sessions, and collaborative exams as a form of assessing students' learning in an online class which can be possibly made by an explicit learning goal with an explicit evaluation criterion available at the beginning of the course.

The digital learning module has been recognized as one of the common instructional deliveries being utilized in the implementation of asynchronous online independent learning at the advanced education level during the pandemic period. The development of the digital module requires time to plan out the learning activities appropriate to the learners covering the course objectives aligned to the program goal and performance indicators as reflected in the course syllabus. The digital module shall be designed to capture advanced education students' independence in learning mathematics concepts (Setiyani, Ferdianto & Fauji, 2020).

OBJECTIVES

This study evaluated the utilization of the designed digital module in an asynchronous online independent learning at the advanced mathematics education level amid the COVID-19 pandemic period. The following were the specific objectives: (1) design a digital module for asynchronous online learning, (2) describe the learning experiences of the students in the utilization of the digital module, and (3) test the effectiveness of the developed digital module in student's understanding of the subject content topics.

METHODOLOGY

The study utilized a descriptive-developmental method of research combined with a qualitative approach to analysis. The developmental nature of this study adopted the ADDIE model of instructional system design (ISD) framework which is composed of the five phases: Analysis, Design, Develop, Implement, and Evaluate.

Analysis. This phase involved the review of the set program standards including the instructional objectives for the Master of Arts in Education (MAEd) major in Mathematics. The analysis of the approved course syllabus for the semester focusing on the content and coverage, course objectives, and the performance standards was executed to define and meet the needs of the advanced education mathematics students in the course during the COVID-19 pandemic period.

Design. This phase involved the logical arrangements of content topics of the course with due consideration to the prior knowledge and needs of the enrolled graduate education students. The listed topics were based on the previous coverage of the course subjects as reflected in the approved course syllabus. The learning module for each of the identified topics contains the following elements: discussions, definition, example, and practice drills to check their understanding. The learning modules were designed in a manner that will be available in digital format to be utilized by the students in an asynchronous online independent learning.

Development. This phase involved the creation of the learning modules for each of the identified topics to be covered in the course. The content and discussions of each topic came from different sources both print and non-print materials. Each learning module contains the worksheet as drill exercises to check the student's understanding of the topic using the developed learning materials. The developed worksheets ensure their alignment to the content and examples provided in the learning modules. There was a total of 22 learning modules developed with the corresponding worksheets to be accomplished by the students before the semester ends.

Implement. This phase involved the utilization of the developed learning modules. Before its utilization, general directions were provided to the whole class which includes the manner of weekly distribution of each learning module virtually as well as the submission of the worksheets. The accomplishment of the worksheets was designed on weekly basis. The synchronous learning feature of the course was made through virtual discussion of the learning modules once a week to

follow up students' understanding of the content. Students are free to ask any questions regarding the topic coverage specific for the week as reflected in the digital learning module during the virtual discussion. The weekly format of implementation in the course follows: Digital module distribution, utilization (asynchronous independent learning), accomplishments of worksheets, submission of worksheets, and virtual discussions for feedbacking and deepening of skills.

Evaluate. This phase was an integral component of each stage of development from the Analysis phase involving the two faculty members of mathematics education of the institution to ensure alignment of the module content with the set program standards. This phase guarantees the accuracy and reliability of the developed digital learning module appropriate for graduate education mathematics students. The evaluation in terms of the content and coverage, theoretical considerations, appearance/visual appeal, and language of the materials by the students who utilized the digital module in an asynchronous online independent learning were also executed. The evaluation phase includes the qualitative approach to the analysis of students' experiences with the use of a digital learning module in an asynchronous online independent learning.

Moreover, the evaluation phase of the current study also involved the test for the effectiveness of the digital learning module in understanding the learning content of the course through a one-group pre-test post-test design. The study involved 13 officially enrolled students of the regular class (4 Males, 9 Females) under the Master of Arts in Education (MAEd) major in Mathematics during the First Semester (August – December) of AY 2020-2021 in Sorsogon, Philippines.

Instrument

The Board of Trustees (BOT) approved Instructional Materials Evaluation instrument of the institution was used in the assessment of the developed digital learning module. The study made use of the interview guide focusing on their learning experiences in the asynchronous online independent learning with the use of a digital module. The questions include: How is your experience with this subject? How does the digital module help you in meeting your learning needs with this subject course?

Moreover, the teacher-made test for the pre-test and post-test was used in the assessment of students' understanding of the content topics in the subject offered during the semester. The test is an open-ended test question that requires a graduate student who is pursuing the MAEd degree major in mathematics to show solutions and/or explanations to justify their answer in a particular item. The 10-item teacher-made open-ended test item requires a substantial response expected from a graduate mathematics education student to get a maximum score of 15 points. This type of test item will ensure assessment of student attainment of the performance standards and program outcomes required for a graduate education student.

Data Collection Procedures

The data were collected through virtual/online surveys and interviews. The teacher-made test was conducted before (pretest) and after (posttest) utilization of the digital module to test

students' conceptual understanding. The test was conducted virtually with a specific time allotment of submission within the day. The students were explicitly provided with the learning goals, targets, and performance indicators that they need to accomplish in the course which is made available through the distribution of the course syllabus at the beginning of the semester. This was made to ensure clarity of the students' tasks and deliverables before the study implementation.

Data Analysis Procedures

Descriptive statistical measures such as frequency count, mean, and standard deviation were used in the evaluation of the digital learning module. Cronbach's alpha (α) was also used in the assessment of the consistency of students' evaluation of the digital module. This was supported with a qualitative approach to the analysis of the textual responses and information from the respondent's learning experiences in the utilization of the digital module. Coding of responses was used to evolve the themes or categories of the experiences in the asynchronous online independent learning.

The t-test was used to test the effectiveness of the digital learning module in students' understanding of the required mathematics content topics after its utilization in asynchronous online independent learning. Test of normality of scores in the pretest ($D = 0.265$, $p=0.541$) and posttest ($D= 0.217$, $p = 0.506$) were confirmed through the Kolmogorov-Smirnov (K-S) test statistic (D). Both the pre-test and post-test scores of the students were translated into percentage scores (PS) to show the difference in students' level of understanding of the required content before and after utilization of the digital module. The responses of the students in the pretest and posttest were analyzed to further show evidence of learning of the identified content topics.

RESULTS AND DISCUSSIONS

The Designed Digital Module in Learning Mathematics Course for Graduate Students

The Modern Algebra course, also known as Abstract Algebra, has been identified by the mathematics education major students as one of the most challenging subjects because of its symbolic features and structures which made its concept foreign to study (Ko & Knuth, 2013; Mowahed, Song, Xinrong, & Changgen, 2019). The course intends to enhance logical and analytical reasoning and symbolic thinking of the students in the appreciation of basic algebraic structures: groups, semigroups, and rings. The *New Normal* phenomenon made the teaching and learning of the subject more challenging because of the absence of the usual face-to-face classroom interaction among the higher education institutions (HEIs) worldwide. The digital learning module on selected 22 primer topics in modern algebra has been conceived as one of the self-learning materials intended for the mathematics major students of the Teacher Education Institutions (TEIs) in response to the *New Normal* teaching and learning approach brought by the pandemic due to the Corona Virus Disease (COVID -19).

The primary reason for designing the digital module is to make possible the attainment of the set of educational objectives for a one-semester modern algebra (abstract algebra) course. Students were assumed that they have learned the most essential foundational topics and concepts of the set theory, linear algebra, number theory, and probability theory to better understand the content of this course materials. They are expected to exert time and effort to learn every topic which were arranged in a manner that prerequisites are considered first. The material hopes to help students learn the salient and essential topics of the subject, both in synchronous and asynchronous blended teaching-learning approach.

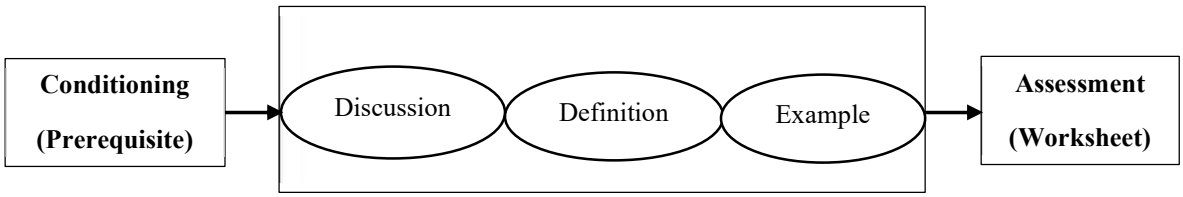
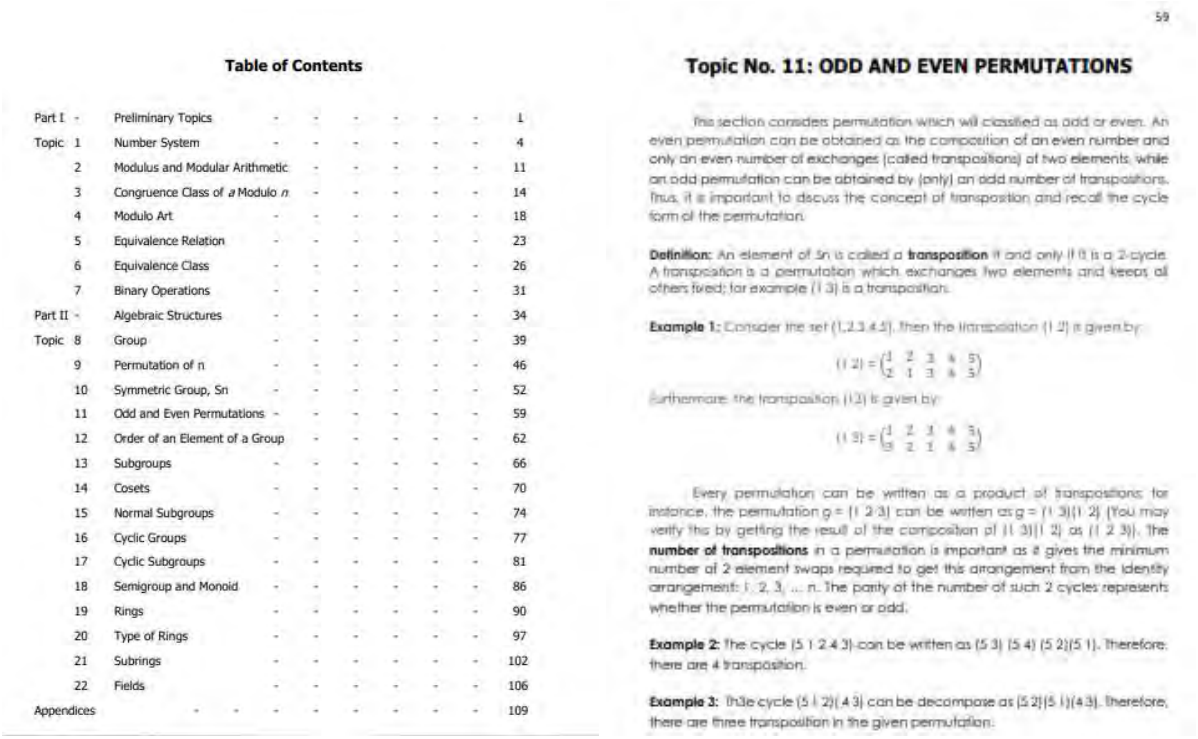


Figure 1. Manner of Utilization of the Digital Module in Asynchronous Learning

The learning modules were designed in a manner that will be available in digital format to be utilized by the students in an asynchronous online independent learning. With the intent of ensuring that the material would cater to independent learning, topics were arranged from simple to increasing complexity so as prerequisites are discussed first and deepened through an integrative approach between and among content topics as shown in Figure 1. The user of the module is encouraged to have some review of the topics on properties of real numbers, properties involving equations, and inequalities to have a better understanding of the course. These topics can be found in the appendices (Appendices A to C) of the compiled format of the module for easy reference which was distributed at the beginning of the semester. Each module corresponds to a specific identified topic of Modern Algebra provided to students every week with a corresponding assigned task to be accomplished and to be returned in the succeeding week. The topics included are divided into two main parts; part I deals with the preliminary topics intended for those students who have a little background, if none, in Abstract Algebra, Number Theory, and Probability Theory. On other hand, part II deals with the basics of algebraic structures which will lead students to deepen their understanding of group theory and ring theory as illustrated in Figure 2.

The learning module for each of the identified topics contains the following basic elements: discussions, definition, example, and practice drills (worksheets) to check their understanding. The *discussion* component of the module contains the basic concepts and ideas about the topic being introduced in the module. This serves as the backgrounder leading towards the understanding of the content topic and how it is related to their prior and acquired knowledge and skills in the previous lessons to connect with the new lesson. The *definition* component of the module will strengthen student understanding of the new mathematics concepts introduced in the lesson.

Essential mathematics concepts which bear significance in students' understanding of the new concepts are defined in the lesson.



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Topic No. 11: ODD AND EVEN PERMUTATIONS

This section consides permutation which will classified as odd or even. An even permutation can be obtained as the composition of an even number and only an even number of exchanges (called transpositions) of two elements, while an odd permutation can be obtained by (only) an odd number of transpositions. Thus, it is important to discuss the concept of transposition and recall the cycle form of the permutation.

Definition: An element of Sn is called a **transposition** if and only if it is a 2-cycle. A transposition is a permutation which exchanges two elements and keeps all others fixed; for example (1 3) is a transposition.

Example 1: Consider the set {1,2,3,4,5}, then the transposition (1 2) is given by:

$$(1\ 2) = \begin{pmatrix} 1 & 2 & 3 & 4 & 5 \\ 2 & 1 & 3 & 4 & 5 \end{pmatrix}$$

Furthermore, the transposition (1,3) is given by:

$$(1\ 3) = \begin{pmatrix} 1 & 2 & 3 & 4 & 5 \\ 3 & 2 & 1 & 4 & 5 \end{pmatrix}$$

Every permutation can be written as a product of transpositions; for instance, the permutation g = (1 2 3) can be written as g = (1 3)(1 2) (You may verify this by getting the result of the composition of (1 3)(1 2) as (1 2 3)). The **number of transpositions** in a permutation is important as it gives the minimum number of 2 element swaps required to get this arrangement from the identity arrangement: 1, 2, 3, ... n. The parity of the number of such 2 cycles represents whether the permutation is even or odd.

Example 2: The cycle (5 1 2 4 3) can be written as (5 3) (5 4) (5 2)(5 1). Therefore, there are 4 transposition.

Example 3: The cycle (5 1 2)(4 3) can be decompose as (5 2)(5 1)(4 3). Therefore, there are three transposition in the given permutation.

Figure 2. Screenshots of Some parts of the Digital Module

The *example* component of the module further elaborates the defined mathematics concepts through illustrations. This element of the module may contain computations, techniques, algorithms, approaches, among others which will expound the mathematics concepts and procedures to fully demonstrate understanding by the students. The students will see the pattern and the techniques in applying the definition on how certain mathematics expressions are converted in another form. The *definition* and *example* components are integral parts of the *discussion* component of the module which further explains and provides a concrete representation of the content topic being introduced.

Moreover, the *practice drills* component of the module will provide a venue for the student to further explore and test their understanding of the content topics being discussed. Each of the lessons (content topic) has a corresponding worksheet which serves as the practice drill. It contains several forms of assessment depending on the nature of the topic and the objectives of the lesson which may vary from multiple-choice, True or False, Short Answer test, Essay, and problem-solving. Answer key for each of the worksheets is provided to check their understanding of the lesson following the principle of independent learning. Further discussions and follow-up are held during the conduct of the virtual meeting via google meet, queries and questions from the students were entertained for clarification of the module content, see Figure 4.

Characteristics	Mean (Sd)	Description	Cronbach's Alpha (α)	Reliability
Content and Coverage	4.56 (1.66)	Outstanding	0.95	High
Theoretical Consideration	4.26 (1.27)	VS	0.81	High
Appearance/Visual Appeal	4.27 (1.48)	VS	0.96	High
Language	4.51(1.13)	Outstanding	0.87	High
Over-all	4.42 (2.58)	VS	0.95	High

Table 1. Users (n=13) Evaluation on the Characteristics of the Digital Module

Table 1 shows the results of the students' evaluation after a semester of the utilization of the digital module which illustrates the characteristics of the digital module along with content and coverage, theoretical consideration, appearance/visual appeal, and language used which represents the content validity and construct validity of the materials. The data reveals that the digital learning module has obtained an overall very satisfactory rating (Mean = 4.42 $\pm$ 2.58) from the students with a corresponding Cronbach's alpha (α) value of 0.95 which signifies a high internal consistency rating from among the student evaluators. An enrolled male graduate mathematics education student teaching in a private school at the basic education level expresses his appreciation in the utilization of the digital module, he stated that "*The provided instructional materials helped me greatly for the acquisition of learning even during the pandemic where we can learn anytime and anywhere*". This expression is supported by the statement from a female mathematics teacher of a public school who enrolled in the same course expounded that "*the provision of the digital module is an effective tool for continuous learning despite the pandemic since face-to-face is not possible at the moment*". This only means that the students are generally and consistently satisfied with the utilization of the digital learning module along with its characteristics.

Moreover, the students have an outstanding rating of the content and coverage (Mean = 4.56 $\pm$ 1.66) as well as the language (Mean = 4.51 $\pm$ 1.13) used in the digital module exceeding their learning needs and requirements on their asynchronous learning utilization. One of the newly enrolled graduate mathematics education male students in Sorsogon City mentioned that "*the content and approach of the module arranged from very simple ideas to increasing complexity together with the worksheets for practice assisted me in learning the subject"*. Another manifestation of a female student from Masbate Province commented that "*Though it was a difficult subject, I am satisfied with the content of the module because I learned new topics*". The result of evaluation signifies that the material can provoke and sustain students' understanding of the content through the language used appropriately to their level of thinking.

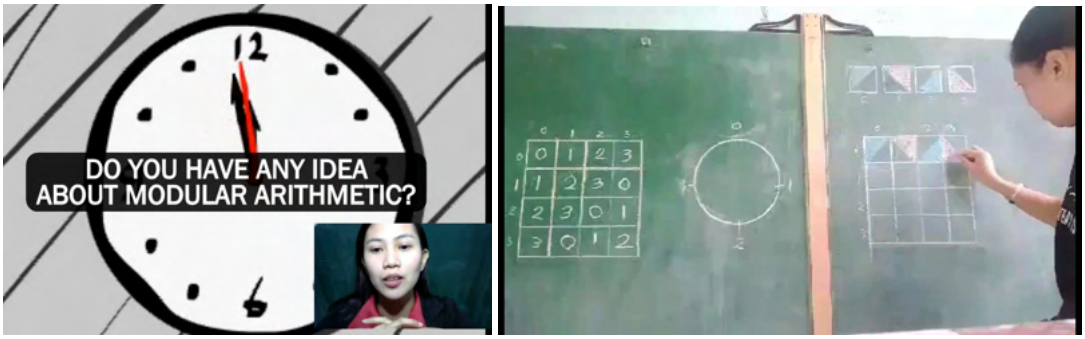

Figure 3. Screenshots of the Sample Lecture Videos Created by the Graduate Students

The very satisfactory rating along with the theoretical considerations (Mean = 4.26 ± 1.27) and appearance (Mean = 4.27 ± 1.48) also indicates that the digital module can sustain their interests in learning the content of the lesson with corresponding high internal consistency Cronbach's alpha (α) values exceeding the acceptable value of 0.70 (George and Mallery, 2003; Hair, Black, Babin & Anderson, 2010). The qualitative and quantitative data revealed that the presentation of the important concept suitable to the level of student understanding by building on their previous knowledge is necessary to capture student interest in the subject. The newly enrolled male student in Sorsogon City also expounded his appreciation of the particular topic by saying "*I enjoyed learning the mathematical concepts behind the modulo art … we were asked to do modulo art design since in our elementary years without even knowing the reasons behind the patterns*". The graduate students' appreciation of the mentioned topic can be further expounded by their output on the creation of lecture video as one of the proofs and outcome of their learning as demonstrated in Figure 3.

Learning Experiences of the Students on the Use of the Digital Module

The sudden change of the mode of instruction in any level of education brought a significant effect on the teaching-learning situation. There were some challenges encountered by both the students and teachers during the pandemic in the flexible learning environment (Laguador, 2021) limiting face-to-face interactions and promoting online distance learning through synchronous and asynchronous learning approaches. The utilization of the developed digital module for the asynchronous mode of learning boosted the learning experiences of graduate education students.

Table 2 summarizes graduate mathematics education students learning experiences based on their feedbacks and written responses in the utilization of the digital module for asynchronous independent learning showing their identified challenges encountered. The corresponding features of the digital module were designed together with their learning strategies as an adaptive mechanism to minimize, if not eliminate, the challenges encountered. The feedbacks of the

students show that their challenges can be grouped into three broad categories: (1) the nature of the subject itself, (2) online learning facilities, and (3) the learning modalities.

Challenges Encountered	Features of the Digital Module Utilization	Students' Adaptive Mechanism
Complex nature of the subject with a new set of topic/lessons encountered by the students	The module is comprehensive and informative with a complete discussion of the topics.	Eagerness to learn and upgrade their content knowledge in their area of specialization.
Some new encountered content topics/lessons need further elaborations.	Topics are arranged in increasing complexity bridging students' prior knowledge with supplemental learning materials.	Students explored available online resources such as e-books and video lectures on YouTube as supplemental materials/lessons on challenging topics.
Unstable internet facilities	Availability of digital module for asynchronous learning modality.	Students look for a place with a strong internet connection and/or available Wi-Fi.
Modular Distance Learning (MDL) is time-consuming on the part of graduate students who are working at the same time.	The digital module is available at their most convenient time for independent learning.	Students find time in reading the module and answering the worksheets to beat the agreed schedule of submission (Time management skills).
Teachers hardly provide and/or get immediate feedback on students' difficulties.	Worksheets are attached in each lesson to check student understanding of the lesson. Constant communication and monitoring of student progress through the conduct of weekly synchronous online teaching for feedbacking.	Students challenge themselves to discover and perform higher-order learning tasks.
Limited interaction among teachers and classmates.	Each module was designed in an interactive manner featuring the lesson discussions, definition, example, and practice drills (worksheets) to check their understanding.	Students develop independent learning skills in critical thinking and analyzing information.

Table 2. Learning Experiences of the Graduate Students

Nine out of 13 enrolled students in the subject have just encountered some set of topics specified in the subject since most of them are teaching at the basic education level and have not been teaching algebraic structures in general. "*I am not familiar with most of the topics, I am just*

starting to learn the concepts on my own," said one of the newly enrolled female students in the program. While the other four students are fresh graduates at the undergraduate level and able to recall some of the prerequisite contents included in the course.

Though students agreed that the digital module provided them with comprehensive inputs and information about the topics which are arranged from simple to complex, they still looked for other available online learning resources to supplement their understanding of the topics. A female graduate mathematics education student in the Municipality of Irosin mentioned that to further validate and deepen her understanding of the concepts discussed in the developed digital module she tried to search for more examples from the available materials online such as the video lecture on the YouTube website. This is supported by the feedback of her classmate in Sorsogon City who said that "*I enjoyed the given worksheets for it has driven my curiosity to read articles and watch videos on YouTube*".

This is an indication that the students at the graduate level are independent learners capable of looking for additional learning resources coupled with an eagerness to learn new things and upgrade their knowledge in their area of specialization. The module has been designed in a manner that will provide the graduate students with the overview and ideas regarding the concepts presented building on what they have learned already that would aggravate them to learn further and deepen their understanding about the abstract concepts of mathematics such as group, subgroup, and ring. The students will not able to determine whether G = {a, b, c, d} with operation * defined by the table below, as excerpted from the problems in Worksheet number 8 (Group),

*	**a**	**b**	c	**d**
a	a	b	c	d
b	b	a	d	c
c	c	d	b	a
d	d	c	a	b

is a group without understanding the concept and definition of a group as well as the binary operation as reflected in the digital module which they explored during the asynchronous independent learning. The students at the advanced education level after a walk-through of the specific topic in the digital module were given a chance to further explore the available learning resources whether print or non-print materials with an already preconceived idea about the topic, e.g., group, for their verification and deepening of conceptual understanding. This will make them more confident with the completion of the task given in the worksheets and apply the mathematics concept in solving problems in the relevant field of study. Teachers, therefore, need to design well the learning materials and activities that would provoke students' willingness to adopt the principles of independence in online distance learning despite the complex nature of the subject.

The Province of Sorsogon, together with its neighboring Provinces such as Masbate, is in the southernmost tip of Luzon Island in the Philippines experienced unstable internet connectivity especially those in the remote area as supported by the feedbacks from most of the students (8 out

of 13 students). The limitations during the online synchronous lessons such as video conferencing due to poor internet connectivity are strengthened by the utilization of the provided digital module. The provided module available on weekly basis according to the scheduled topic helped the graduate student a lot for self-learning at their most convenient time. Students were given enough time to study the module and answer the worksheets to check their understanding anytime they want. This is also supported by the feedback of an enrolled graduate student from the rural area of the Province of Masbate as follows "*For me, it is more convenient to have modules/worksheets as a mode of instruction while I am working at the same time. I can learn anytime".*

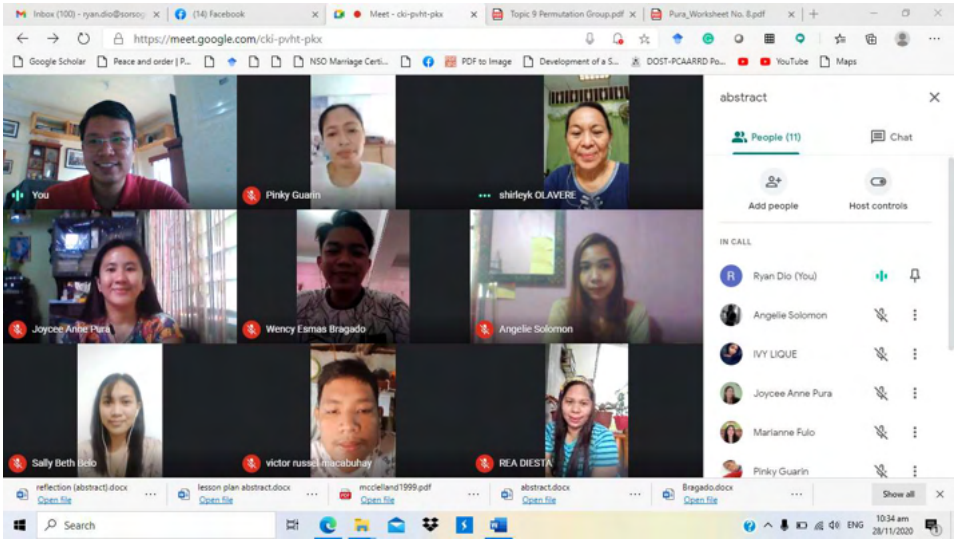

Figure 4. Captured Moments during the Video conferencing with the students

Feedback mechanism on students' outputs and learning is provided during the conduct of the online synchronous teaching where students find ways to look for a place with strong internet connectivity in their respective area once a week. Feedback from another student in Masbate Province highlighted that "*... since I am aware of poor internet connectivity in our area as one of the reasons of not participating in our video conference via google meet, I find a place where I could stay with strong internet connection for me to attend our online meeting*". The virtual sessions as shown in Figure 4 provided the students an opportunity to interact and share their experiences with their classmates. The students felt the need to attend the virtual session utilizing any available facilities, equipment, or devices such as personal computers and mobile phones with the internet connection either through Wi-Fi or prepaid load so that areas needing improvement along with the content of the module are discussed to unlock any difficulties encountered.

It is, therefore, necessary that the teachers should be vigilant on the weekly need of the students and see to it that appropriate instructions and feedbacking is provided during the conduct of online teaching. Professors may also provide for the extension of the submission of weekly outputs, if necessary, especially for those students who are working at the same time and residing

in an area with poor internet connectivity. The unexpected change of the mode of instruction implementing online distance learning for the first time has to make adjustments on the part of the professors towards accomplishing the task within the semester without sacrificing the quality of instruction.

Moreover, the independent learning modalities with the utilization of the digital module brought some big adjustments on the part of the students such as the time management skills, need for immediate feedback mechanism, and limited interactions with teachers and classmates. "*The distance learning limits interaction, and meaningful learning experience between the teachers and students which led us to rely the information on the provided module/worksheets,*" said a female student who is a fresh graduate from her undergraduate education. The conditioning mechanism on the very first day of the semester which includes orientations and leveling of expectations is necessary to implement independent online learning modalities. This conditioning mechanism is an important strategy to assess students' needs and readiness to adopt the new approach to learning. This led to the design of the digital module as a teaching-learning approach to implement asynchronous online independent learning coupled with a weekly scheduled online synchronous teaching for feedbacking. Consistency of submitting students' outputs per week is necessary, with some considerations to students' needs, to check their progress through active participation during the scheduled online teaching.

Generally, students' reflections revealed that the digital module provided them a guide on what to learn, what to do, and what to accomplish per week which developed their time management skills, creativity, and independent learning skills which eventually improved their critical thinking skills and problem-solving skills. The graduate students enrolled in online education demonstrate a strong preference for an asynchronous mode of learning because of convenience and favored individual assignments (Butler & Pinto-Zipp, 2005). One male student mentioned that he can save a lot of money, time, and effort in traveling at a most 2-hour distance from home every weekend.

Effectiveness of the Digital Module in Asynchronous Online Independent Learning

Table 3 displays the differences between the posttest and pretest scores and the corresponding equivalent percentage scores (PS) of the students. It can be noted that eight out of the 13 enrolled students were considered in the analysis of the pretest scores since these are the only students who were able to satisfy the requirements of submitting the test within the allotted time duration during the conduct of the test. There were three out of eight students who has no sufficient knowledge of the content topics before the utilization of the digital module with an overall mean score of 3.75 or 25% level of understanding.

The pretest answer sheet of student 4 referred to in Table 3 reflected the statements as "*I humbly apologized that I have not been able to answer any of the questions because I forgot already the concepts which made me difficult to deal with the problems. I do not teach these lessons*

since my first year of teaching but I am much eager to learn and appreciate them again." This is an indication that the graduate students in this particular educational institution have different needs along with their acquired knowledge and skills of the course content of Modern Algebra including the pre-requisites of the course. These are some of the areas of concern to address in times of pandemic through the conduct of online distance learning.

Through the utilization of the digital module featuring the basic elements of discussion, definition, examples, and practice drill (worksheets) during the asynchronous learning coupled with the constant checkup and follow-up during the synchronous online learning via google meet, the aforementioned student can obtain a score of 13 or 86.7 PS during the posttest. He was able to properly execute the requirement in a problem on "Determine whether the product of the following permutation in cycle notation form (1 3 5 2 4), (1 3 5) and (2 4) in S_5 is odd or even" he obtained the product which is (1 5 3 2) that gave him the idea that the product is an odd permutation. Many of the learners of Modern Algebra find difficulty in finding a product of permutation of *n* especially when it is written in cycle notation format which he was able to perform properly the operation. After performing the given operation, the student has executed his knowledge about the number of transpositions of the given permutation, so he has able to determine whether it is odd or even.

Student	Pretest		Posttest		Difference (Post – Pre)	
	Score	PS	Score	PS	Score	PS
1	0	0.0	6	40.0	6	40.0
2	4	26.7	14	93.3	10	66.7
3	1	6.7	13	86.7	12	80.0
4	0	0.0	13	86.7	13	86.7
5	9	60.0	14	93.3	5	33.3
6	0	0.0	11	73.3	11	73.3
7	9	60.0	14	93.3	5	33.3
8	7	46.7	12	80.0	5	33.3
9	-	-	14	93.3	-	-
10	-	-	11	73.3	-	-
11	-	-	7	46.7	-	-
12	-	-	12	80.0	-	-
13	-	-	13	86.7	-	-
Mean Score	**3.75**	**25.00**	**11.85**	**78.97**	**8.10**	**53.97**
Sd	**4.06**	**27.08**	**2.61**	**17.39**	**-**	**-**

Table 3. Difference between Students' Posttest and Pretest Score

Generally, the students obtained more than thrice their pretest mean scores (MS = 3.75 $\pm$ 4.06) in the post-test (MS= 11.85 $\pm$ 2.61) with an equivalent of 78.97 MPS. The data in Table 3 also revealed that the group of graduate students involved in this investigation have a closer level

understanding of the mathematics content topics after utilization (MPS = 78.97 ± 17.39) of the digital module as compared to their pretest percentage scores (MPS = 25 ± 27.08). Moreover, all eight students showed a significant improvement in their test scores in the posttest with a mean score (MS) gain of 8.10 equivalent to 53.97 MPS.

Figure 5 reveals the way student 7 (who obtained a Pretest Score of 9 or 60.0 PS, Posttest score of 14 or 93.3 PS) answers a problem on subgroups content topic where they were asked to show the subgroup diagram of the cyclic group (Z_9, +). It can be seen in the figure the big difference of how the student responded to the problem with some maturity of response during the posttest. During the pretest, the student was able to show the set generators of the cyclic group (Z_9, +) including the set generated by each of the elements, however, student 7 did not able to show the subgroup diagram. On the other hand, the student 7 posttest response showed all the subgroups of the given cyclic group together with the description as trivial, set generator, or proper subgroup and was able to show the subgroup diagram. The illustration indicates that the use of the digital module with its basic elements of discussions, definition, and examples helped any student, whether has prior knowledge or not about the content topic, to further expand their learning and understanding of the mathematics concepts including its principles and processes.

Pretest Response	Posttest Response
Given: Z_9 = {0,1,2,3,4,5,6,7,8} <0> = {0} <1> = {0,1,2,3,4,5,6,7,8} <2> = {0,1,2,3,4,5,6,7,8} <3> = {0,3,6} <4> = {0,1,2,3,4,5,6,7,8} <5> = {0,1,2,3,4,5,6,7,8} <6> = {0,3,6} <7> = {0,1,2,3,4,5,6,7,8} <8> = {0,1,2,3,4,5,6,7,8} *Note*: I cannot create a subgroup diagram. I have no past knowledge about it.	Given: (Z_9, +) The subgroups of (Z_9, +) • <0> generates {0}, trivial subgroup • <1>, <2>, <4>, <5>, <7>, and <8> generate (Z_9, +) itself, set generators • <3> and <6> generate {0,3,6}, proper subgroup The subgroup diagram: <1> | <3> | <0>

Figure 5. Comparison of the Sample of a Student Pretest-Posttest Response

The presented illustrations above can be supported by the gain in mean score after exposure to the digital module indicating a highly significant improvement ($t=5.034$, $p<0.05$) in the level of students' understanding of the content topics. The statistical result signifies that the utilization of the digital module in the asynchronous online independent learning of the graduate students provides them with a better understanding of the content topics in Modern Algebra. The graduate

students' experiences also support that the features and basic elements of the designed digital module for asynchronous online learning are more effective when combined with a regular schedule of virtual conferencing for monitoring and evaluation of their gained knowledge and skills. The findings of the current investigation affirmed that any instructional materials designed for students' online learning will be more effective and engaging when there is constant communication with the instructor (Swan, 2011; Alrajeh & Shindel, 2020) and provide them with activities for the creation and sharing of knowledge (Holzweiss, Joyner, Fuller, Henderson & Young, 2014) and experiences via video conference.

CONCLUSIONS

The designed digital learning modules cover major topics arranged in increasing complexity for the utilization of the graduate mathematics students in an asynchronous online independent learning. The basic elements and features of the module ensuring the presence of discussions, the definition of important terms, examples, and practice drills (worksheets) to check their understanding made students satisfied with the utilization of the digital learning module. The learning experiences of the graduate students are boosted and learning outcomes are maximized when the provision of the digital module for asynchronous online independent learning is supported with the regular conduct of virtual conferences as an opportunity for feedbacking, evaluation, and discussions. The regular conduct of virtual conferences allows the students to share their ideas and thoughts responding to their needs and identified challenges along with the nature of the subject, online learning facilities, and the learning modalities during the COVID-19 pandemic. Moreover, the utilization of the developed digital module in online learning of graduate education level is an effective modality to better understand the mathematics content topics and better provide them with an independent learning experience.

Teachers and instructional practitioners at a different level of education are therefore recommended to involve themselves in the creation of the appropriate instructional materials available to students for online asynchronous independent learning coupled with regular monitoring for immediate feedbacking and evaluation. The teaching-research methodologies performed in this investigation in the creation of the digital module featuring the essential elements of discussions, definitions, examples, and practice drills (worksheets) may be further explored and replicated to support its applicability to the larger class at a different level of education. Investment along with the provision of strong internet connectivity and facilities is necessary in the provision of the best learning experiences and optimizing learning outcomes while not sacrificing the safety and health conditions of both teachers and students in times of pandemic.

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