Research Article

Project DESMOS: Development and Evaluation of Self-directed Module in Statistics and Probability

Roberto G. Sagge, Jr., Evarose E. Espiritu

West Visayas State University

ABSTRACT

Learning is weak not because learning is weak. Learning becomes weak because the modules were not prepared to become self-directed. The goal of this design and development project was to create a self-directed statistics and probability instructional module. Data were gathered from teachers, learners, and experts. The data-gathering instruments were Competency Checklist, Students' and Experts' Evaluation Checklist, and Reflection Guide. According on teacher perceptions, a survey of the learners' five least-mastered competencies served as the foundation for the development of the module. This module was pilot tested on a group of Grade 11 learners. Learners utilized the module at home and were asked to answer the exercises. Learners took pictures and short videos while they were answering the module. Afterward, learners evaluated the module. In order to assess the module's level of acceptability, experts were requested to complete the Expert's Evaluation Checklist. Thematic analysis, rank, the mean, and standard deviation were all used as data analysis tools. The results show that the following were the five least-mastered competencies: solving problems involving confidence interval of the population mean, solving problems involving regression analysis, solving problems involving sample size determination, solving problems that require population proportion test of hypothesis, and solving problems involving correlation analysis. Additionally, the experts rated the produced module's acceptability as "highly acceptable." While the learners gave the module a "highly acceptable" rating. As a result, the developed module is appropriate for assisting learners in performing the competencies in the area of Statistics and Probability. It is recommended that teachers should use the Self-directed instructional module for whatever mode of learning their school will have.

Keywords: *Development and evaluation, Self-directed module, Statistics and Probability*

Introduction

The current COVID-19 pandemic, which spread to every country in the world, is one of the most recent public health crises of international significance. The fight against the COVID-19 pandemic threats had a significant influence on nearly all sectors, particularly the educational sector. To stop the COVID-19 pandemic from spreading and to cut down on infections, the majority of nations have temporarily closed their educational institutions (UNESCO, 2020). But education shouldn't stop. Students and teachers have been forced to study and work from home as a result of national responses like community lockdown and community quarantine, which has led to the delivery of online learning platforms like Google, TV broadcasts, guidelines, resources, video lectures, and online channels (Crawford et al., 2020). Different risks, issues, and difficulties were presented by the deployment of online learning for both teachers and students (Bao, 2020).

The Basic Education-Learning Continuity Plan (BE-LCP) has been implemented by the Department of Education (DepEd) in School Year 2020–2021 to meet the needs of the students (DepEd, 2020). The K–12 Curriculum will be condensed into the Most Essential Learning Competencies (MELCs) under this strategy, which also allows for a variety of learning delivery methods. Self-Learning Modules (SLMs) must be made available in print and offline/online digital formats in order to assist students, parents, and teachers in using various learning delivery modalities (DepEd, 2020). For students with poor internet connectivity, no gadgets, or a lack of self-learning modules, adapting a variety of learning delivery choices would be problematic. Therefore, this study offers chances for responding to issues in the education sector and for supporting the DepEd Learning Community Plan in order to maintain the delivery of high-quality instruction to every school.

The majority of students do not fully acquire particular learning from the subject matter, especially in Statistics and Probability, despite the fact that teaching mathematics in high school is integrative for all levels. The high school curriculum has four grading periods, and the syllabus for teaching statistical principles is typically set during the last grading period. As a result, due to time constraints, the majority of teachers are unable to impart a thorough understanding of the subject. Face-to-face math sessions are always challenging, let alone during this pandemic. The student must have access to an unhindered Internet connection in order to participate in online learning. Online students might be unable to communicate, turn in assignments, or access resources if technical issues arise. This issue may, in turn, aggravate the student, hamper performance, and inhibit learning (Salcedo, 2010).

To support the rollout of the new curriculum, the DepEd provided some textbooks. Some of them include Probability, Statistics, and Applications for Senior High School by Bagano, et al. (2016), Statistics and Probability for Senior High School by Bagano, et al (Ocampo and Tresvalles, 2016). The contents follow and are congruent with the learning objectives, competency standards, and needs of this group of students as stated in the Statistics and Probability curriculum. It includes examples from everyday life, a concept map for how various statistical ideas relate to one another, learning objectives, statistical investigations to encourage active and cooperative learning, and conceptual knowledge of statistical ideas and practices.

A teaching manual for SHS Statistics and Probability by Albert et al. (2016) is also available has chapters on data exploration as well as the K–12 SHS Statistics and Probability Curriculum elements, content and performance criteria, and learning skills. The books indicated, nevertheless, are guidelines and resources that can be used by both teachers and students; they are not intended for self-directed learning. Due to this situation, the students must study efficiently and with greater self-direction (Winters, Greene & Costich, 2008).

The rich and challenging environment of online learning poses a greater risk of failure for students who are not self-directed learners (Abar & Loken, 2010). Results of a study on secondary online students' self-directed learning show that schools can identify students who are more independent, enabling them to enroll

in online classes made for self-directed students who can take personal responsibility for their learning and move at a pace independent of the rest of the class (Cavanaugh, Barbour, & Clark, 2009).

For the purposes of this study, creating a self-directed instructional module is one way to keep students' attention by giving them tasks that they can complete on their own after receiving the necessary direction and training in using teaching resources like workbooks or modules that can make learning engaging and advance students' knowledge, skills, and abilities.

Description of the Issue

Based on the five least mastered competences of the learners as assessed by the teachers, this study intends to construct and evaluate a self-directed instructional module in Statistics and Probability. In particular, it seeks for answers to the following questions.:
1. What competencies in Statistics and Probability do teachers perceived to be the least mastered of the learners?
2. What educational resources, including their component parts, may be created to address the learners' least-mastered Statistics and Probability competencies?
3. In terms of a) learning objectives, b) content, c) organization and presentation, d) format and design, e) learning activities, f) assessments, and g) self-directedness, how acceptable is the prepared instructional module according to experts, teachers, and the learners as a whole?

Methods

In this study, design and development research was used. It aims to produce knowledge that is based on evidence that is consistently acquired from practice (Richey, Klein, & Nelson, 2004). Moreover, the ADDIE (Analysis, Design, Develop, Implement, and Evaluation) methodology served as a guide throughout the entire research process for this study, which is based on design and development research. In order to provide new or improved models that guide the development of instructional and non-instructional products and technologies, this research design systematically examines design, development, and evaluation processes. Based on the student's considered least-mastered abilities by the teachers, the researcher analyzed, created, and developed a self-directed instructional module in Statistics and Probability for Grade 11 senior high school learners.

Additionally, this research design comes in two forms: (1) product and tool research, and (2) model research. Type 1, which created tools and products, was used in this investigation.

Research Participants

Based on information gathered from 65 Grade 11 STEM students, 10 experts, and 47 Grade 11 Statistics and Probability teachers, the self-directed instructional module in Statistics and Probability was created.

Teachers. In the second semester of the school year 2021–2022, 47 instructors of Grade 11 Statistics and Probability from 37 different schools in the Province of Capiz were used to identify the least-mastered competencies of the students in these subjects.

Learners. During the module's try-out, 65 Grade 11 students from a National High School in Capiz who were enrolled in Statistics and Probability during the second semester of SY 2021–2022 took part. The students were STEM (Science, Technology, Engineering, and Math) strand learners. The learners used the self-directed module during its implementation; they were required to study the module and respond to its Self-Pretest, Self-Check, Self-Assessment, and Additional Self-Task sections.

Experts. Ten experts used the Expert's Evaluation Checklist to assess the Self-directed Instructional Module in Statistics and Probability's level of acceptability following the module's tryout.

Data Gathering Instruments

For this study, the researcher utilized the Competency Checklist for teachers and Learners and the Experts' Evaluation Checklist for learners and experts.

Competency Checklist. The researcher-made Competency Checklist consisted of 70 learning competencies from Grade 11 Curriculum Guide under Statistics and Probability. Five distinct subject-matter specialists validated the

checklist. The Competency Checklist tested its reliability using Cronbach's Alpha ($\alpha = 0.953$). Thus, all competencies are reliable.

The teachers were asked to put a check on the appropriate column for their response. The following five-point scale was used: 5 - Highly Mastered, 4 – Mastered, 3 – Moderately Mastered, 2 – Less Mastered, 1- Least Mastered. This instrument was used to find out the level of competency of the learners in Statistics and Probability as perceived by the teachers.

Learners' and Experts' Evaluation Checklist. 35 questions were included in a Likert-style checklist that was divided into sections for learning objectives, content, organization and presentation, format and design, learning activities, assessments, and the module's degree of self-direction. The Cronbach's Alpha (=0.945) reliability test was also performed on this instrument. Therefore, all competencies are reliable.

The levels of agreement between learners and experts were 5 - Strongly Agree (SA), 4 - Agree (A), 3 - Moderately Agree (MA), 2 - Disagree (D), and 1 - Strongly Disagree (SD).

To interpret and determine the acceptability of the self-directed instructional module, the following scales were utilized.

Score	Description	Interpretation
4.51- 5.00	Highly Acceptable	No revisions were required because the developed self-directed educational module evenly suited the standards.
3.51 - 4.50	Acceptable	Very few adjustments are required because the self-directed educational module generated very satisfactorily met the standards.
2.51 - 3.50	Moderately Acceptable	Few adjustments are required because the produced self-directed educational module satisfactorily satisfied the standards.
1.51 - 2.50	Fairly Acceptable	The developed self-directed learning module only just met the requirements and requires changes.
1.00 - 1.50	Not Acceptable	The created self-directed educational module needs extensive changes because it did not meet the standards.

Research Procedure

Before beginning the investigation, the researcher requested approval from the Superintendent of the Division of Capiz by letter. Another letter was written to request approval from the school's principal, assistant principal, and division superintendent of Capiz to test the module.

In particular, the researcher utilized the ADDIE Model in developing the self-directed instructional module in Statistics and Probability.

Analysis. The researcher conducted a survey during the second semester of the school year. Their responses were gathered by the researcher personally. However, some teachers were not available, during the survey, they were asked to answer the Google form of the instrument or send the picture through the messenger to the researcher.

The outcome of the checklist identified the five least-mastered statistical and probability competencies by the students, based on the perception of the teachers. This process also involved selecting an instructional module, determining the price, and allocating funds for the module printout.

Design. After determining the least mastered competencies, the outline, format, and distinct features of the module were created. Each topic in the module has the following components: Topic, Least Mastered Competency Addressed, Self-Pretest, Read Me First, Self-Goals, Words I Need to Know, Self-Study, Self-Check, Self-Assessment, Additional Self-Task, Reflection Guide, Answer Key, References, Appendices, Progress Bar, Learner's Information, Learner's Progress Record, Self-directed Instruction Textbox.

This self-directed module can be used without the presence of the teacher, therefore, z-tables, and t-table are provided in the last part of the module.

Develop. The researcher researched and produced a quality instructional module containing the various components mentioned in the design stage after structuring the module. The five least-mastered competencies from the analysis phase served as the basis for the module's content.

The researcher created a preliminary page that comprises a table of contents, tips for utilizing the modules, a collection of tables and figures, the learner's details, and a record of their progress. The module's content was based on the five skills that the professors believed the students had not yet mastered. The researcher-developer included eye-catching presenting formats in the module, such as graphics and figures. In order to enhance the instructional module, the researcher also asks professionals for their opinions and recommendations. Five specialists in the field of statistics and probability examined the module's initial face evaluation.

Implementation. In this phase, orientation for the teachers and the learners was conducted before the day of the distribution. Follow-up instructions were done on the day of the distribution of the module to assure that they understand how to utilize the module that includes the date of distribution and retrieval. Parental consent was also gathered.

The developed module together with the Parental consent form and Learners' Evaluation Checklist was distributed to 65 Grade 11 learners. Both the researcher and the adviser facilitated the distribution of the module on May 17, 2022. Learners utilized the Self-directed Instructional Module in Statistics and Probability at their homes. Learners were also asked to take pictures or short videos while they are answering the learning task in the module. The modules were retrieved on May 31, 2022, two weeks after they received the module. Pictures/Short videos, learners' Evaluation Checklist, and Parental Consent Forms

were also gathered. Safety Protocols and ethical considerations were observed throughout the implementation.

Following the module's tryout, it underwent revision based on the insightful remarks and recommendations made by students during the implementation.

Evaluation. After the implementation, the revised module was evaluated by the learners and ten experts. Their suggestions and comments were considered by the researcher upon the revisions of the module.

Strict adherence to health norms and ethical considerations were observed throughout these activities. The mean, standard deviation, and rank were used to analyze and interpret the data that had been collected.

Results and Discussion
Competencies in Statistics and Probability that Learners have the Least Mastery

Table 2 shows the least mastered competencies of Grade 11 learners as perceived by the teacher for the whole topics in Statistics and Probability. The five least mastered competencies were the following: "solves problems involving confidence interval of the population mean" (M = 2.19, SD = 0.537) and "solves problems involving regression analysis" (M = 2.19, SD = 0.9). Both tied in the first rank; "solves problems involving sample size determination" (M = 2.34, SD = 0.841) and "solves problems involving test of hypothesis on the population proportion" (*M* = 2.34, *SD* = 0.841). Both also tied for the second rank. In rank 5 was "solves problems involving correlation analysis" (*M* = 2.40, *SD* = 1.014). The result shows that the learners have a low mastery of the topics as perceived by the teachers. With this, the researcher developed a module to address the least mastered competencies as supported by the study of Cabiles (2022) that to address the learners' least mastered competencies, teachers should develop contextualize instructional materials. Moreover, the module is self-directed so that the learners to use it without the help of the teachers, especially in the new mode of learning.

Table 2. Least Mastered Competencies in Statistics and Probability as perceived by Teachers

Learning Competency	SD	M	Rank
solves problems involving confidence interval of the population mean	0.537	2.19	1.5
solves problems involving regression analysis	0.90	2.19	1.5
solves problems involving sample size determination	0.841	2.34	3.5
solves problems involving hypothesis testing of the population proportion	0.841	2.34	3.5
solves problems involving correlation analysis	1.01	2.40	5

The study of Sadiq (2014) provided evidence to corroborate the results above. He came to the conclusion that the modular teaching strategy improved the learners' test scores. Therefore, it is advised that the modular method be widely adopted at all educational levels. Additionally, according to Bacio and Sagge's (2019a & b) research, printed materials are the ideal tool for enhancing learning transfer since they may mimic the efficient and successful teaching methods of a human facilitator. Additionally, not all students are proficient in using statistics in research. To adapt to the new instructional format, it is also advised that teachers complete distance learning, blended learning, and online instruction training (Toquero, 2020).

Developed Self-directed Instructional Module in Statistics and Probability

Based on the results of the Competency Checklist, which identified the five least mastered competencies in Statistics and Probability, the researcher chose the topics to be covered in the module. The researcher created a quality teaching module with several components and a unique feature. The experts approved of the module's initial appearance. Based on expert input and ideas, the researcher revised the educational program.

The title, overview, objectives, discussion of the topic, self-assessment test, evaluation activities, and references should be included in the instructional module (CLSU-ILO, 2000). Additionally, it follows from the list of Bacio and Sagge's (2022a) components for a typical module.

Learners' and Experts' Acceptability Evaluation of the Module

This study assessed the created Module's general acceptability in terms of its learning objectives, content, structure, presentation, format, and design, as well as its learning activities, evaluation, and self-direction. The material has been reviewed and rated by 65 students and ten experts.

Overall Acceptability. The self-directed educational module received an overall evaluation of "Acceptable" (M = 4.41, SD = 1.11) for acceptability. This shown that there aren't many adjustments required because the module has satisfactorily met the specifications. Additionally, the experts found a similar overall rating of "Highly Acceptable" (M = 4.67, SD = 0.56) and the learners' overall acceptance rating was "Acceptable" (M = 4.37, SD = 1.16) for both groups.

With a mean of 4.44 and SD of 0.39, the learning activities section in particular has received the highest ratings from the students. The learning objectives also received the highest rating from the experts (M = 4.74, SD = 0.48). In terms of the average mean, the learning objectives received the greatest rating (M = 4.74, SD = 0.40), although self-directedness received the lowest rating (M = 4.38, SD = 0.79), but it still received the grade "Acceptable"

Based on the findings, the participants agreed that the module's learning objectives, content, organization, and presentation, format and design, learning activities, assessment, and self-direction overall rating are acceptable. This suggests that the printed module is valuable because it was created to fit the learners' level. Additionally, the module can be used as a teaching tool for students to learn Probability

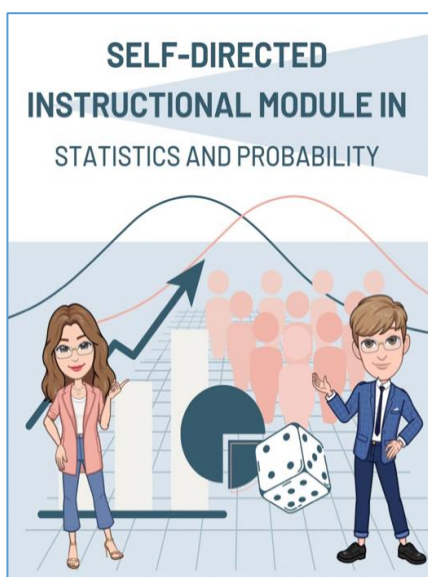and Statistics on their own, free from the guidance of a teacher.

This result is confirmed by the research of Bacio and Sagge (2022b), which found that instructional material can be appropriate for intended users if its objectives, substance, activities, and evaluation were sufficient.

The analysis of Roman (2016) sources provided evidence to support the aforementioned conclusions. According to his research, the produced Statistics module has an extremely high degree of validity in terms of its specific aims, content, language, and evaluation procedures. Self-instructional materials are especially helpful as a strategy for teaching fundamental

concepts to a whole class, freeing up lecture-discussion time for more "discussions" and less "lecture," an enrichment activity for gifted learners, a strategy to make up for an absent student, and a strategy for a student who needs remedial lectures.

According to Ritchey, Klein, and Tracey's (2011) study, self-directed learning has many advantages, such as independence, professional autonomy, improved choice, and motivation.

The experts' and students' assessments of the module's general acceptability are shown in Table 11.

SELF-DIRECTED INSTRUCTIONAL MODULE IN STATISTICS AND PROBABILITY

PREFACE

Design and developmental research are the systematic study of design, development and evaluation processes with the aim of establishing an empirical basis for the creation of instructional and non-instructional products and tools and new or enhanced models that govern their development. The development of module using the ADDIE (Analysis, Design, Develop, Implement, and Evaluation) Model includes a set of common characteristics, including a focus on measurable goals and outcomes derived through an initial analysis phase, the selection of content and strategies that match these goals, a process of routinely evaluating the products prior to finalizing the project, and the assessment of the learning and performance outcomes.

This module is designed as Self-directed Instructional Module for Grade 11 students taking Statistics and Probability course. It aims to develop the competencies prescribed for Grade 11 Statistics and Probability Core Subject as stated in K-12 Basic Education Curriculum for Senior High School by the Department of Education.

This Self-directed Instructional Module has the following parts:

Topic. This is a brief but comprehensive statement of the entire topic in a specific module. It serves as a guide for you on what certain instructional module has to offer.

Least Mastered Competency Addressed. This is a competency which is identified to be one of your least mastered as perceived by the teachers.

Self-Pretest. This is a short assessment that evaluates your knowledge and skill prior to starting the module. Your result in the Self-Pretest is compared to the result of your Self-Assessment and indicates the effectiveness of the instruction.

Read Me First. This gives you a bird's eye view of the module, and it arouses your interest to study each lesson in the module. The significance of the topic to the students is presented.

Self-Goals. This is list of specific learning competencies that you should acquire for each lesson. It serves as guide for you on what exactly expected on you as you go through the module.

Words I Need to Understand. This is the list of terms with corresponding definitions that may appear in the topic.

Self-Study. This part of the module presents the lesson clearly and comprehensively with specific examples. It is designed to deepen your knowledge and improve your skills since this part presents important terms and some examples about the topic. It includes steps on how to solve the problems and specific examples with solutions.

Self-Check. This is prepared for assessing what you have learned from the Self-Study part. This is also a follow-up exercise that serves as reinforcement towards the mastery of the concept. Solutions should be written in the space provided.

Self-Assessment. This is a short assessment that is similar to Self-Pretest. This part includes the specific lessons that are aligned with the learning objectives of the module. This consists of exercises for you to apply and review concepts or procedures.

Additional Self-Task. This part includes additional activity/activities to enrich your knowledge or skills of the lesson learned. This also helps you to remember the learned concepts, specifically in problem-solving.

Reflection Guide. This serves as guide questions that reflect and monitor your progress. You are encouraged to write your experiences upon using the module in a narrative form.

Answer Key. This is the list of correct responses for the exercises in the Self-Pretest, Self-Check, Self-assessment, and Additional Self-Task.

Table 11. Overall Acceptability of the Module

	Learners		Description	Experts		Description
	SD	M		SD	M	
Learning Objectives	0.76	4.35	Acceptable	0.48	4.74	Highly Acceptable
Content	0.81	4.39	Acceptable	0.45	4.70	Highly Acceptable
Organization and Presentation	0.80	4.35	Acceptable	0.49	4.72	Highly Acceptable
Format and Design	0.77	4.36	Acceptable	0.66	4.62	Highly Acceptable
Learning Activities	2.39	4.44	Acceptable	0.63	4.62	Highly Acceptable
Assessments	0.77	4.36	Acceptable	0.64	4.56	Highly Acceptable
Self-directedness	0.92	4.33	Acceptable	0.54	4.70	Highly Acceptable
Overall Rating	1.16	4.37	Acceptable	0.56	4.67	Highly Acceptable

Conclusion

The existence of the least mastered competence suggests that, despite the fact that the learners have completed statistics and probability courses, there are competencies that they have not yet mastered. This could be because of the pandemic-induced learning mode and individual differences. Teachers must recognize the unique characteristics of each student, which necessitates preparing for the adoption of the best teaching strategies to support each person's growth and development at their own rate. Thus, there is a need to address this by providing materials so that learners can be helped to master the competencies expected from them. The module also needs to be self-directed so that even without the teacher, the learners can still work with it. They can even work at their own pace since several studies have already proven that learners learn more if it is based at their own pace. Provided they can meet the deadlines set by the teachers or school. Distinct features of a self-directed module are a progress bar, learner's information, and learner's progress record can help the learners monitor their learning progress.

Recommendations

The module could be used by teachers to serve as a model for teaching the lesson. They can use it as a resource to improve the effectiveness and efficiency of the teaching and learning process. On the other side, they can design a special module that works with the current modality. Other instructors may also use this research's outcome to test its efficacy further.

Curriculum designers may conduct training and seminars about developing an output in teaching Mathematics aligned to specific learning competencies of the core subject. The results could also be used as a basis to make curriculum and instructional materials design flexible enough to address the demands of the 21st-century learners.

Textbook Writers may write an instructional module and integrate it into their textbooks through activities and problem-solving tasks, making lessons more interactive and interesting for learners and providing meaningful and relevant knowledge for independent and self-directed learning.

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