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JAMOVI-based module as tool in teaching Statistics among Senior High School students

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Abstract

Aim: This study aimed to develop and evaluate a technology-enhanced self-directed learning module integrating JAMOVI software for teaching Statistics among Senior High School (SHS) students. Specifically, it sought to assess the module's content, language, layout and design, validity, practicality, acceptability, and effectiveness in improving students' performance in Statistics, thereby supporting technology-enhanced instruction and learner-centered pedagogy.

Methodology: The study employed a developmental research design using the ADDIE (Analysis, Design, Development, Implementation, and Evaluation) instructional model. Quantitative methods were utilized to evaluate the module's content validity, practicality, and acceptability through assessments conducted by five education experts and ten public senior high school Statistics teachers. A quasi-experimental pretest-posttest design involving forty-nine Grade 11 students was employed to determine the module's effectiveness. Data were analyzed using weighted mean, mean, standard deviation, dependent t-test, Cohen's *d*, and Hake's normalized gain.

Results: The developed JAMOVI-based self-directed learning module was systematically aligned with the Department of Education's Most Essential Learning Competencies (MELCs) and incorporated structured learning activities, practical JAMOVI applications, and learner-centered assessments that promoted critical thinking and self-directed learning. Expert evaluation showed that the module was highly valid, highly practical, and highly acceptable. Results further revealed a statistically significant improvement in students' performance after the implementation of the module, with a large effect size and a medium normalized gain, demonstrating its effectiveness in enhancing conceptual understanding and statistical problem-solving skills.

Conclusion: The JAMOVI-based self-directed learning module is an effective instructional tool for teaching Statistics among Senior High School students. Its integration of educational technology, structured learning activities, and alignment with curriculum competencies enhances students' conceptual understanding, engagement, and academic performance. The module offers a valuable instructional resource for promoting technology-enhanced teaching, improving learning outcomes, and supporting curriculum implementation in Statistics education.

Keywords: JAMOVI; self-directed learning; Statistics education; instructional module; educational technology

INTRODUCTION

The rapid digital transformation of education has reshaped teaching and learning worldwide through the integration of technology-enhanced learning (TEL), digital pedagogy, artificial intelligence (AI), educational software, and learning analytics. As a result of these innovations, teaching methods have shifted from a teacher-centered to a learner-centered approach, encouraging personalized, collaborative, self-directed, and technology-mediated learning. Recent studies emphasizing these technologies have shown that they improve data literacy, statistical literacy, computational thinking, and higher-order thinking skills, especially in mathematics and statistics education, allowing teachers to make evidence-based instructional decisions (UNESCO, 2023; OECD, 2023). It has thus become a global priority to integrate technology to enhance the quality of education and equip learners with the skills they need for the twenty-first century.



In the Philippines, the Department of Education (DepEd) has promoted the incorporation of technology into the K–12 curriculum and through the use of the Most Essential Learning Competencies (MELCs). However, despite these initiatives, Statistics instruction in many Senior High School classrooms continues to rely on a teacher-centered approach and manual computation, which limits the opportunity to carry out authentic data analysis, engage in self-directed learning, and develop their higher-order thinking skills (Gonda et al., 2022). It has been found that the use of educational technologies and statistical software can lead to greater student engagement, an improved understanding of concepts, and better academic achievement, as well as foster learner autonomy and positive attitudes towards the subject of Statistics (Benedictos, 2022; Dayo et al., 2024). Many Senior High School students still have trouble applying statistical concepts to real research tasks since the teaching materials tend to focus on manual computation rather than on data interpretation and the use of technology in analysis. The existence of these difficulties shows that there is a need for instructional resources that are aligned with the curriculum, incorporate technology, and help to develop students' ability in statistical reasoning, their independence as learners, and the meaningful application of statistical concepts. These findings underscore the need for technology-enhanced instructional resources that support meaningful learning and reduce unnecessary computational demands.

Previous studies have demonstrated the effectiveness of statistical software such as SPSS, R, and SGAT in enhancing statistical reasoning and data analysis skills. However, most focused on software utilization or higher education level, rather than on the development of instructional modules that align with the curriculum for Senior High School students. Furthermore, only a small number of studies have combined open-source statistical software with self-directed learning methods that correspond to the DepEd MELCs or have thoroughly evaluated the instructional materials with respect to their validity, practicality, acceptability, and effectiveness. Since educational systems around the world are still stressing digital learning and data-driven education, there is still a lack of evidence regarding technology-enhanced instructional modules that meet these requirements in the area of secondary Statistics education.

To address this gap, the present study developed a self-paced learning module for Grade 11 Statistics based on JAMOVİ and used the ADDIE instructional design model to align the module with the DepEd's MELCs. Unlike previous studies, this module combines JAMOVİ with technology-enhanced, constructivist, and self-directed learning approaches in order to foster conceptual understanding and authentic data analysis rather than merely involving routine computation. The module was evaluated through content validation as well as through assessments of its practicality, acceptability, and effectiveness, employing a quasi-experimental design. Since it presents an instructionally based innovation, the study helps with Statistics teaching, allows teachers to incorporate JAMOVİ into their technology-enhanced lessons and assessment practices, helps school administrators in strengthening their digital learning and technology integration efforts, and makes a contribution to curriculum implementation and improvements in mathematics education.

Review of Related Literature and Studies

Technology-Enhanced Learning

Technology-enhanced learning (TEL) is the strategic use of digital tools, virtual platforms, and interactive media to improve teaching methods and increase student engagement. The worldwide move towards incorporating technology into education, particularly through personalized and adaptive learning technology (PAL), affects customizing the content to meet students' needs and interests, boosting reading literacy skills, and offering valuable insights into its effectiveness in dealing with the particular challenges and diverse learning situations (Alrawashdeh et al., 2024; Timotheou et al., 2023). A systematic review shows the significance of digital technologies in the field of education; it has led to changes in educational systems all over the world, ranging from remote teaching to the adoption of sustainable practices (Khasanah, 2025; Timotheou et al., 2023).

Moreover, the latest research concerning Information and Communication Technology (ICT) has effects on the field of education and on the various factors that influence schools' digital capacity and digital transformation (Timotheou et al., 2023). It has been stressed by researchers that the mere presence of digital technology does not ensure improvements in learning; instead, teachers should adjust their decisions according to the particular teaching material and the individual needs of the students, using educational technology in a flexible way (Ruijia et al., 2025).

Mathematics Instruction

Mathematics teaching has in recent years moved away from the traditional method of rote learning towards more problem-based, realistic and digital forms of learning. In higher education, digital technology has changed the educational system by bringing in new ways of delivering instruction and aiding student learning (Langat, 2025;



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Pacheco-Olea & Villacis-Macias, 2026). Digital tools also assist in carrying out active learning activities which encourage students to work together (Coelho et al., 2024).

Moreover, digital tools help to increase students' engagement by enabling the practical application of theoretical knowledge, boosting motivation through the use of gamification, and supporting students in becoming more independent learners (Langat, 2025). The advantages highlighted are also supported by hybrid and activity-based learning methods, since these approaches promote active student participation and collaboration among peers, thus aiding students in remembering mathematical principles and applying them in real-life situations (Coelho et al., 2024; Khasanah, 2025).

Self-Directed Learning

Self-directed learning is an important part of distance education since it enables students to set realistic goals and to draw up a clear plan for achieving them. Recent research has shown that digital tools offer flexible learning resources and that opportunities for self-assessment increase student motivation (Uzorka & Odebiyi, 2025). When students have a high degree of self-regulation, they can create new opportunities for engagement, promote independent exploration, and adjust themselves to the educational context (Ruijia et al., 2025).

In addition, combining motivation, metacognition, and strategic planning helps to achieve sustainable self-directed learning. Educational frameworks stress the need to link the use of technology with pedagogical methods, content knowledge, and the learning needs of students in order to maximize the educational benefits (Alrawashdeh et al., 2024; Timotheou et al., 2023). Since educational environments are becoming more dynamic, self-learning modules are of great importance in fostering students' ability to learn independently and regulate their own learning, enabling them to gain reasoning and thinking concepts and models in Mathematics (Mallillin et al., 2024).

Statistical Software in Education

The integration of statistical software in statistics supports students in applying theoretical concepts to real-world data analysis. Statistical software supports the development of statistical literacy by enhancing students' ability to understand concepts, perform calculations, analyze data, and interpret statistical results effectively (Ramos et al., 2023; Eser, 2022). Various statistical software, including Jamovi, Comprehensive Meta-Analysis (CMA), RStudio, and Meta-Essentials, provided advantages in accessibility and functionality. Among these tools, Jamovi offered more options for heterogeneity testing and model predictions, making it well-suited for statistical learning and analysis. This highlights the importance of selecting appropriate statistical software to strengthen students' conceptual understanding, improve data analysis skills, and promote effective statistical literacy development (Eser, 2022). Furthermore, acquiring foundational theoretical knowledge enables educators to establish connections between statistical theory and practice, allowing students to develop meaningful understanding and effectively apply statistical software to analyze and interpret data (Gonda et al., 2022).

Module Development

The development of modules needs a systematic approach that combines learning objectives, activities that are centered on the learners, assessments, and evaluation. Although traditional modules emphasize structured guidance and competency-based learning, e-learning modules offer flexibility by means of digital materials and interactive elements. Modules that are to be effective therefore have to be valid, practical, and responsive to the needs of the learners (Banguanga et al., 2021; Mohd Jais et al., 2022; Dahal et al., 2023). Self-learning modules are designed to meet the Most Essential Learning Competencies (MELCs), and DepEd Order No. 001, s. 2021, sets out the standards regarding content, language, layout, and design. Acceptability and practicality are important to ensure that learners are engaged, understand the material, and find the modules easy to use; well-designed modules encourage independent learning and lead to significant educational experiences while at the same time supporting both teachers and students in the learning process (Banguanga et al., 2021; Mohd Jais et al., 2022; Dahal et al., 2023).

Technology Integration

The use of digital tools, ICT, and individualized learning methods has the potential to improve students' statistical skills, their level of engagement, and overall educational results. Yet, in order to achieve effective implementation, it is necessary to deal with various difficulties, including digital inequality, ethical issues, the need for better teacher preparation, and the level of digital capability within schools (Gonda et al., 2022; Khasanah, 2025). It has been stated that for technology integration to be successful, it is essential not only to have access to digital resources but also to employ suitable implementation strategies, ensure that all stakeholders are ready, and take into account the specific contextual factors which support a sustainable digital transformation in education (Timotheou et al., 2023; Alrawashdeh et al., 2024; Ruijia et al., 2025).

Learning Outcomes

Digital learning tools have improved learning outcomes by tailoring the instruction to meet the individual needs of students and by identifying the factors related to implementation which can enhance teaching methods in various educational settings (Alrawashdeh et al., 2024; Uzorka & Odebiyi, 2025). They also encourage interactive learning, aid communication, and boost students' motivation as well as their capacity for independent learning. These findings highlight the need to strengthen digital infrastructure, provide training for staff, and incorporate interactive technologies in order to maximise learning outcomes and to support effective technology-enhanced education (Uzorka & Odebiyi, 2025).

Synthesis and Research Gap

The existing literature shows that technology-enhanced learning (TEL) is becoming increasingly important for improving educational results by means of digital tools, personalized learning, statistical software, and self-learning modules. Such innovations have a positive effect on student engagement, motivation, learner autonomy, and achievement, while also enabling flexible and learner-centered teaching methods (Alrawashdeh et al., 2024; Timotheou et al., 2023). In the field of Statistics education, technology facilitates authentic data analysis, statistical reasoning, and higher-order thinking since it allows students to concentrate on interpretation rather than carrying out manual calculations (Ramos et al., 2023; Eser, 2022). Nevertheless, the effectiveness of technology-based learning is contingent on sound instructional design, curriculum alignment, teacher preparedness, and proper implementation (Ruijia et al., 2025; Gonda et al., 2022). Even with these advances, few studies have examined the development and validation of JAMOVl-based self-directed learning modules aligned with the Department of Education's Most Essential Learning Competencies (MELCs) for Senior High School Statistics. This study tackles that gap by developing and assessing a JAMOVl-based learning module about its content validity, practicality, acceptability, and effectiveness, thus offering an evidence-based resource that aids learner-centered instruction, curriculum implementation, statistical literacy, and digital competence.

Theoretical Framework

The study is based on the ADDIE instructional design framework (see Figure 1), which encompasses five distinct phases: Analysis, Design, Development, Implementation, and Evaluation, a systematic approach that is widely employed in the development and assessment of instructional materials (Mohd Hamid et al., 2021). This model offers a structured method for determining learners' needs, designing suitable learning experiences, developing and validating instructional resources, implementing them in real classroom situations, and evaluating their effectiveness. Because of its iterative character, the instructional materials are constantly improved in light of learners' needs and the results of the evaluation, a feature that renders it appropriate for use in technology-enhanced learning environments (Fernández-Miravete & Prendes-Espinosa, 2022; Aliyu et al., 2023).

The Analysis phase of the study determined the students' learning needs and difficulties in Statistics; this information was used as the foundation for developing the JAMOVl-based module according to the DepEd Most Essential Learning Competencies (MELCs) and the self-learning module standards. In the Design and Development phases, the module was prepared and checked by experts to guarantee its content validity, practicality, and acceptability. For the Implementation phase, the module was pilot-tested with Grade 11 students, and in the Evaluation phase, its effectiveness was evaluated based on expert feedback and on the students' results from the pretest and posttest. Following the ADDIE model, the study made sure that the module was systematically designed, aligned with the curriculum, and met the instructional needs of the learners.

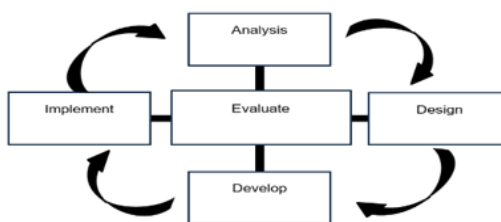


Figure 1. The ADDIE MODEL

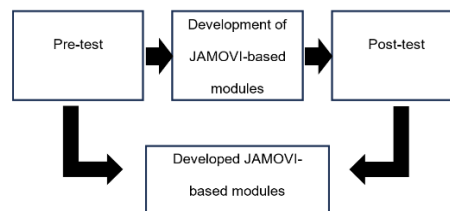


Figure 2. Research

Conceptual Framework

Figure 2 shows the conceptual framework of the study, which outlines the development, evaluation, implementation, and refinement of the JAMOVI-based learning module. The process started with giving students a 20-item pre-test that corresponded to the DepEd Most Essential Learning Competencies (MELCs) in Statistics in order to assess their initial level of performance. The module was then developed and evaluated by experts according to the DepEd guidelines regarding content, language, and layout and design in respect of content validity, practicality, and acceptability. Having taken into account the recommendations of the evaluators, the improved module was put into use with Grade 11 students, after which a post-test was administered. The module's effectiveness was established by comparing the pre-test and post-test scores through suitable statistical analyses such as normalized gain and effect size, and the results, together with the experts' feedback, were used as the basis for the final refinement of the JAMOVI-based learning module.

Statement of the Problem

Students continue to experience difficulties in analyzing, interpreting, and performing statistical procedures despite having completed formal coursework in Statistics. Although many learners possess foundational mathematical knowledge, they often struggle to apply statistical concepts, formulas, and data analysis techniques to authentic research problems. This gap between conceptual understanding and practical application limits students' statistical literacy, critical thinking, and research competencies. Traditional instructional approaches and limited access to technology-enhanced learning resources further contribute to these challenges. In response to these educational concerns, this study sought to develop and evaluate a self-directed learning module integrating JAMOVI software as an instructional tool for teaching Statistics. The study aimed to determine whether the developed module could provide an effective, practical, and learner-centered instructional resource that enhances students' performance, supports technology integration, and improves the teaching and learning of Statistics among Senior High School students.

General Objective

To develop and evaluate a JAMOVI-based self-directed learning module for teaching Statistics among Senior High School students.

Specific Objectives

Specifically, this study aimed:

1. To develop a JAMOVI-based self-directed learning module in Statistics aligned with the Department of Education's Most Essential Learning Competencies (MELCs).
2. To assess the developed module in terms of:
 - 2.1 content validity;
 - 2.2 practicality; and
 - 2.3 acceptability
3. To determine the students' performance in Statistics before and after the implementation of the JAMOVI-based learning module.
4. To determine whether there is a significant difference between the students' pretest and posttest performance.
5. To ascertain the effectiveness of the JAMOVI-based learning module using normalized gain and effect size.

Research Questions

The study sought to answer the following questions:

1. How was the JAMOVI-based self-directed learning module developed for teaching Statistics among Senior High School students?
2. How may the developed JAMOVI-based learning module be assessed in terms of:
 - 2.1 content validity;
 - 2.2 practicality; and
 - 2.3 acceptability
3. What is the level of students' performance in Statistics before and after the implementation of the JAMOVI-based learning module?
4. Is there a significant difference between the students' pretest and posttest performance after the implementation of the JAMOVI-based learning module?

5. How effective is the JAMOVI-based learning module as measured by normalized gain and effect size?

Null Hypothesis

H₀. There is no significant difference between the students' pretest and posttest performance in Statistics after the implementation of the JAMOVI-based self-directed learning module.

METHODOLOGY

Research Design

The study consisted of two phases. The first phase employed a developmental research design that focuses on the systematic design development, implementation, and evaluation of instructional materials, strategies, methods, or teaching-learning tools. The development of the self-directed learning module in Statistics was anchored in the ADDIE instructional design model, a systematic framework consisting of five phases: Analysis, Design, Development, Implementation, and Evaluation. The ADDIE provides a structured and iterative process for developing instructional materials that are aligned with learners' needs and educational objectives (Harpi, 2023; Tinoca et al., 2022).

The second phase employed a one-group quasi-experimental pretest-posttest design to evaluate the effectiveness of the developed module. This ascertained the effectiveness of the JAMOVI-based module by determining the students' learning gains before and after the intervention.

Population and Sampling

The study involved ten (10) public senior high school teachers from the Schools Division of Cavite Province, Philippines, and five (5) education experts (one (1) curriculum specialist and four (4) instructional specialists), who were purposively selected based on their expertise. The experimental phase included forty-nine (49) Grade 11 students enrolled in Statistics at Tanza National Trade School, a public technical-vocational secondary institution located in Cavite, Philippines, during School Year 2024–2025. An intact class sampling technique was employed, wherein one existing class was selected to participate in the implementation and evaluation of the JAMOVI-based learning modules.

Research Instruments

The study utilized two researcher-developed instruments. The first was a 30-item survey questionnaire used to evaluate the content validity, practicality, and acceptability of the JAMOVI-based learning module. It underwent face and content validation by six experts—three university instructors and three senior high school Statistics teachers—and was pilot-tested to determine reliability. Cronbach's alpha coefficients of .91, .93, and .82 indicated excellent to good internal consistency, confirming the instrument's reliability. The second instrument was a 20-item achievement test aligned with the Most Essential Learning Competencies (MELCs) in inferential Statistics and hypothesis testing to measure students' performance before and after the intervention. Following expert validation and pilot testing, the test obtained a KR-20 reliability coefficient of .85, indicating high internal consistency and confirming its suitability for assessing students' learning outcomes.

Data Collection Procedure

After the JAMOVI-based learning module and the research instruments had been developed, data were gathered from January 20 to April 30, 2025, via both online and in-person methods. Before collecting the data, approval was secured from the Schools Division Superintendent of Cavite Province, Philippines, and informed consent was obtained from all the participants. The module was assessed by a number of education experts who had been deliberately chosen, using Google Forms and printed questionnaires to examine its content validity, practicality, and acceptability, and then the suggested revisions were carried out. The improved version of the module was subsequently put into use with the Grade 11 students at Tanza National Trade School on a one-group pretest-posttest basis. These students took a researcher-developed achievement test both before and after the intervention, which took place once a week for one hour, and the data obtained were analyzed by means of appropriate statistical techniques in order to assess the effectiveness of the JAMOVI-based learning module.

Treatment of Data

Data gathered from all the respondents and participants were statistically cleaned, organized, interpreted, and analyzed using appropriate statistical tools. Statistical measures such as weighted mean, standard deviation, mean, dependent t-test, Hake's normalized gain, $\langle g \rangle$, and Cohen's d were used in the study. The weighted mean was used to determine the validity, practicality and acceptability of the data. The paired sample t-test was used to determine the significant difference between pre-test and post-test. Cohen's d used to determine the improvement of treatment data and Hake's g was used to determine the normalized gain on the learner's scores during the administration of pre-test and post-test.

Ethical Considerations

Ethical standards in accordance with Department of Education (DepEd) research protocols and the Data Privacy Act of 2012 (Republic Act No. 10173). Before data collection, institutional approval was obtained from the researchers' university, while permission to conduct the study was secured from the Schools Division of Cavite Province, Philippines, and the administration of Tanza National Trade School. Informed consent and assent forms were secured from all participants, informing them of the purpose of the study, the procedures of data gathering, potential risks and benefits in participation, and their rights to withdraw at any time. Participation in actual data gathering is voluntary, ensuring that it would not affect the institution, respondents' academic status, and privileges. Participants' anonymity and confidentiality were maintained.

RESULTS and DISCUSSION

This section presents the interpretation and analysis of the data gathered from both the teacher-respondents and the students.

1. Development of the JAMOVİ-based Learning Module

The JAMOVİ-based learning module was systematically developed in alignment with the Department of Education's Most Essential Learning Competencies (MELCs) for Grade 11 Statistics. The content progresses logically from foundational concepts to complex inferential topics—specifically tests of difference, correlation, and regression analysis—ensuring students build both procedural skills and data interpretation abilities. To foster learner autonomy and metacognitive awareness, the module incorporates self-directed sections such as "What I Know" and "What's New." These features allow students to draw on prior knowledge, navigate lessons at their own pace, and monitor their progress. Furthermore, embedding technology-assisted activities drives active student involvement, supporting prior research that digital tools enhance motivation, engagement, and personalized learning experiences (Coelho et al., 2024; Uzorka & Odebiyi, 2025).

To ensure continuous feedback and self-assessment, the module incorporates comprehensive formative and summative evaluations alongside analytical rubrics and answer keys. These structured assessment tools enable learners to monitor their own understanding and regulate their learning process, reinforcing the vital role of feedback in metacognitive development (Nicol, 2021). Additionally, the module uses contextualized, real-world problem scenarios to bridge mathematical procedures with practical applications. Connecting abstract statistical concepts to everyday situations helps students develop a more meaningful, long-term understanding of data analysis (Saldivar, 2025).

Regarding visual layout and organization, the module strictly adheres to the standards prescribed in DepEd Order No. 018, s. 2020 (Department of Education, 2020). It features clear structural sections, clean formatting, visual infographics, and actual JAMOVİ software screenshots to boost readability and guide learners through computer-assisted data analysis. Ultimately, by seamlessly integrating curriculum alignment, self-directed learning strategies, contextualized instruction, and technology-enhanced methods, the module serves as a highly effective instructional resource that strengthens statistical literacy and elevates student engagement in senior high school mathematics.

2. Assessment of the JAMOVİ-based Learning Module

The JAMOVİ-based module took nearly two months to develop and was then assessed by five education experts and ten Statistics teachers from the Senior High School level in the Schools Division of Cavite Province, Philippines. Table 1 shows the module's assessment regarding content validity. The results showed that the module was strongly in line with the DepEd Most Essential Learning Competencies (MELCs) ($WM = 3.93$; $SD = .23$), included the essential instructional design features that helped achieve the learning objectives ($WM = 3.93$; $SD = .26$), and had no computational or factual errors ($WM = 3.93$; $SD = .26$). The evaluators also strongly agreed that the module contained self-directed learning strategies, appropriate learning tasks, and formative assessments ($WM = 3.80$; $SD = .41$), encouraged higher-order thinking skills ($WM = 3.80$; $SD = .41$), and kept the assessments aligned with the objectives and the content ($WM = 3.80$; $SD = .41$). These findings show that the module had strong content alignment, accuracy, and instructional coherence, in agreement with Bustoba and Dela Cruz (2022), who stressed the importance of aligning educational tools with target competencies to meet learning objectives. Likewise, the evaluated module exhibited high accuracy, coherent instruction, and strong alignment with content standards.

The fact that the module received a high overall rating for content validity ($WM = 3.84$; $SD = .24$) shows that the assessors saw it as being of good quality, relevant, and in line with academic standards. This high score means that the module's structure, the learning activities included, and the assessment elements had been properly designed to promote meaningful learning in the subject of Statistics. This result is in agreement with Dahal et al. (2023), who pointed out that well-developed learning modules can improve metacognitive skills by means of structured activities,

feedback systems and instructional materials discovered that have been validated lead to better learning outcomes provided they are systematically developed and evaluated.

Table 1*Assessment on the Content Validity of the JAMOVI-based Learning Module*

Item/Statement: <i>The JAMOVI-based module. . .</i>	<i>WM</i>	<i>SD</i>	Interpretation
1. is aligned with the DepEd's Most Essential Learning competencies (MELCs).	3.93	0.23	Strongly Agree
2. contributes to the attainment of specific learning objective(s) in test statistics for population mean, Pearson r and regression analysis.	3.87	0.35	Strongly Agree
3. uses a variety (at least 3) of self-directed techniques, learning tasks, and formative assessment	3.80	0.41	Strongly Agree
4. contains essential instructional design elements (i.e., activities and assessments) that contribute to the achievement of learning objectives.	3.93	0.26	Strongly Agree
5. develops 21 st century skills and higher order cognition (i.e., critical thinking, creativity, learning by doing, problem solving).	3.80	0.41	Strongly Agree
6. provides at least 3 assessment activities that will help the learner track his/her progress and mastery of the target competencies.	3.80	0.41	Strongly Agree
7. has free from computational and factual errors.	3.93	0.26	Strongly Agree
8. has assessments that are aligned with the specific objectives and contents (i.e., lesson/topic)	3.87	0.35	Strongly Agree
9. has the topics and ideas presented from one lesson to the next are coherent and integrated with each other.	3.80	0.41	Strongly Agree
10. the references are properly cited in the reference list containing the name of creator, title of source and publication details.	3.67	0.49	Strongly Agree
OVERALL	3.84	0.24	Strongly Agree/ Highly Valid

Moreover, Timotheou et al. (2023) stressed that technology-enhanced resources are more effective when they are aligned with curriculum objectives and use appropriate pedagogical methods. These results suggest that the JAMOVI-based module developed could function not only as a supplementary instructional material but also as a useful resource for teachers, curriculum developers, and school administrators who wish to strengthen Statistics instruction and promote digital pedagogy in Senior High School.

Table 2.*Assessment on the Practicality of the JAMOVI-based Learning Module*

Item/Statement: <i>The JAMOVI-based module...</i>	<i>WM</i>	<i>SD</i>	Interpretation
1. activities and assessment are easily identified by the learners, that is guided by the objectives.	3.93	0.26	Strongly Agree
2. directions and examples are easy to comprehend.	3.93	0.26	Strongly Agree
3. visuals and design are appropriate to understand each topic.	3.93	0.26	Strongly Agree
4. is a self- learning module.	3.87	0.35	Strongly Agree
5. can easily perform by G11 students.	3.73	0.46	Strongly Agree
6. can be used to understand and interpret the topic.	3.80	0.41	Strongly Agree
7. step by step procedure of each topic are easy to follow.	3.73	0.46	Strongly Agree
8. activities and assessments can help the G11 students to master the topic.	3.80	0.41	Strongly Agree
9. supports a cost-effective tool for students.	3.87	0.35	Strongly Agree
10. will make students to enjoy the hands-on activity and well – guided instructions.	3.73	0.46	Strongly Agree
OVERALL	3.83	0.27	Strongly Agree/ Highly Practical

The JAMOVI-based learning module was evaluated as highly practical ($WM = 3.83$, $SD = 0.27$), with participants praising its clear objectives, user-friendly instructions, and visual design ($WM = 3.93$, $SD = 0.26$), alongside positive ratings for its structured hands-on activities ($WM = 3.73$, $SD = 0.46$). These findings align with Mallillin et al. (2024), who stressed that self-learning modules encourage self-paced learning, and Timotheou et al. (2023), who highlighted the importance of accessible digital resources for effective technology integration. Consequently, teachers

can utilize this module to enhance learner-centered Statistics instruction, supported by school administrators through digital resource provision and professional development.

Table 3*Assessment on the Acceptability of the JAMOVl-based Learning Module*

Item/Statement: <i>The JAMOVl-based module...</i>	WM	SD	Interpretation
1. has an appropriate choice of words or expressions.	3.87	0.35	Strongly Agree
2. has an appropriate length of sentence for the target learners.	3.80	0.41	Strongly Agree
3. thoughts or ideas are logically sequenced.	3.87	0.35	Strongly Agree
4. has an appropriate subject-verb agreement.	3.87	0.35	Strongly Agree
5. phraseology of titles, presentations, or introductions of new chapters or units is consistent.	3.93	0.26	Strongly Agree
6. size of letters and font styles is appropriate to the target learners.	3.93	0.26	Strongly Agree
7. visuals used are simple, relevant, and easily recognizable.	3.93	0.26	Strongly Agree
8. visuals are proportionately drawn in size, appropriately placed on the page, and use appropriate color when needed.	3.87	0.35	Strongly Agree
9. visuals of a process involving separate steps or actions are consistent and have individual pictures or frames.	3.93	0.26	Strongly Agree
10. all the necessary elements (preliminary page, body, references, and answer key) are complete.	3.93	0.26	Strongly Agree
OVERALL	3.89	0.17	Strongly Agree/ Highly Acceptable

The acceptability assessment of the JAMOVl-based learning module received a highly favorable rating, with an overall weighted mean of 3.89 ($SD = .17$). The assessors strongly agreed that the module met the required standards regarding language, organization, and visual presentation, particularly in having consistent sections, suitable fonts, clear visuals, well-organized procedures, and complete instructional components ($WM = 3.93$, $SD = .26$). The sentence structure was also appropriate for Grade 11 learners ($WM = 3.80$, $SD = .41$), indicating that the module's design supported learners' focus on statistical concepts. This finding supports Bustoba & Dela Cruz (2022), who stressed that well-structured modules improve understanding, and Coelho et al. (2024), who pointed out that accessible digital resources increase learner motivation and participation. It therefore seems possible for the JAMOVl-based module to act as a supplementary resource in the teaching of Statistics, and curriculum developers and school administrators could promote the use of validated technology-enhanced materials in order to strengthen digital learning practices.

3. Students' Performance in Statistics

Having established that the learning module based on JAMOVl was highly valid, practical, and acceptable, the researchers took the experts' recommendations on board and put the revised module into use with the Grade 11 students at Tanza National Trade School. These students first sat for a pre-test to evaluate their existing knowledge of inferential Statistics, after which a six-week implementation phase took place, during which the topics of hypothesis testing, tests of difference and relationship, and regression analysis were covered. A post-test and student feedback were then collected in order to assess the effect of the module on their performance in Statistics, the results of which are given in Table 4.

Table 4*Students' performance before and after the implementation of JAMOVl-based Module*

Performance	Pre-test		Post-test	
	Frequency	Percent	Frequency	Percent
Outstanding	1	2.04	15	30.61
Very Satisfactory	1	2.04	1	2.04
Satisfactory	3	6.12	2	4.08
Fairly Satisfactory	2	4.08	8	16.33
Did Not Meet Expectation	42	85.71	23	46.94
Total	49	100	49	100

Pre-test: $Mean=58.6$ (Did Not meet Expectation); $SD=12.5$; $Min=35.0$; $Max=90.0$ Post-test: $Mean=75.8$ (Fairly Satisfactory); $SD=15.2$; $Min=50.0$; $Max=100.0$

The implementation of the JAMOVI-based learning module among the Grade 11 students at Tanza National Trade School led to better performance in Statistics, since the proportion of students who did not meet the expected standard fell from 85.71% in the pre-test to 46.94% in the post-test, the number of students achieving Outstanding performance from 2.04% to 30.61%, and the mean scores increased from 58.6 (SD = 12.5) to 75.8 (SD = 15.2). These results indicate that the module helped improve students' understanding and ability to apply statistical concepts by changing the approach to learning from manual computation to one involving data interpretation, problem-solving, and technology-assisted analysis. This is in line with the findings of Ramos et al. (2023), who found that technology-supported statistical tools have a positive effect on achievement, and with those of Timotheou et al. (2023), who stressed that effective integration of digital technology leads to better learning outcomes. The findings imply that teachers could make use of validated digital modules to enhance their Statistics teaching, while school administrators could help by providing access to technology resources and offering professional development opportunities.

4. Effectiveness of JAMOVI-based Learning Module

To evaluate the effectiveness of the module, students' pretest and posttest scores were compared. A dependent samples t-test was employed to determine whether a significant difference existed between their scores before and after intervention. See Tables 5 and 6.

Table 5

Difference on the students' performance before and after the implementation of the learning module

Test	Mean	SD	t-value	p-value	Interpretation
Pre-test	58.6	12.5	-6.500	<.001	Significant
Post test	75.8	15.2			

Table 5 shows that students' mean score increased from 58.6 (SD = 12.5) in the pre-test to 75.8 (SD = 15.2) in the post-test. A dependent samples t-test showed that there was a significant difference between the two scores, $t(48) = -6.500$, $p < .001$, indicating that the JAMOVI-based learning module helped to improve students' performance in Statistics. By combining JAMOVI with self-directed learning, the students were able to concentrate more on data interpretation and problem-solving than on carrying out lengthy manual calculations, a factor that led to a better conceptual understanding and greater engagement. This is in line with the findings of Timotheou et al. (2023), who stressed that meaningful technology integration leads to improved learning outcomes, and with those of Ramos et al. (2023), who found that statistical tools supported by technology boost students' achievement in Statistics. The results indicate that teachers could incorporate validated digital modules in order to strengthen Statistics teaching, while school administrators could help by providing professional development and by improving access to digital resources.

Table 6

Normalized gain on students' scores and effect size

Test	Mean	Mean Difference	<g>	N-gain	D	Effect Size
Pre-test	58.6	17.2	.42	Medium	.929	Large
Post-test	75.8					

Table 6 also illustrates the effectiveness of the intervention, as it has a medium normalized gain ($\langle g \rangle = .42$) and a large effect size (Cohen's $d = .929$), which means that the improvement in students' performance was both statistically and educationally significant. The results indicate that the JAMOVI-based learning module was successful in enhancing students' conceptual understanding, analytical thinking, data literacy, and their ability to learn independently using technology-supported statistical investigations. This is in line with the findings of Dahal et al. (2023), who found that validated digital learning materials result in improved student achievement, and with those of Pacheco-Olea and Villacís-Macías (2026), who emphasized that technology-enhanced learning environments lead to better STEM learning outcomes when combined with appropriate pedagogical strategies. The findings also suggest that validated technology-assisted instructional materials could be included in Statistics education in order to strengthen learner-centered instruction, digital competence, and data literacy.

Conclusions

Based on the findings, it was concluded that the JAMOVI-based self-directed learning module effectively enhanced Senior High School students' performance in Statistics. The module demonstrated high content validity, practicality, and acceptability, indicating its suitability as a technology-enhanced instructional resource aligned with the Department of Education's Most Essential Learning Competencies (MELCs). Its integration of self-directed learning strategies and statistical software promoted students' conceptual understanding, engagement, and application of



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statistical concepts. The study contributes to instructional innovation by providing an evidence-based teaching resource that supports technology-enhanced learning, curriculum implementation, and improved instructional practice in Statistics education. Furthermore, the findings provide valuable insights for teachers, school leaders, curriculum developers, and teacher education institutions seeking to strengthen digital pedagogy and data literacy in mathematics education.

Recommendations

Based on the findings, the following recommendations are offered:

1. Statistics teachers may integrate the JAMOVİ-based learning module as a supplementary instructional resource to promote technology-enhanced, learner-centered instruction.
2. School administrators may support the implementation of the module by providing professional development opportunities and access to appropriate technological resources.
3. Curriculum developers may consider incorporating technology-assisted statistical learning materials into the implementation of the Statistics curriculum to strengthen students' analytical and digital competencies.
4. Teacher education institutions may integrate JAMOVİ and similar statistical software into pre-service teacher preparation programs to enhance future teachers' instructional competencies.
5. Educational policymakers may encourage the development, validation, and dissemination of technology-enhanced instructional materials that promote digital transformation in mathematics education.
6. Future researchers may expand the module by including additional Statistics competencies, larger participant groups, different educational settings, and comparative experimental designs to further establish its effectiveness.

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