

Development, Acceptability, and Effectiveness of Interactive Instructional Materials in Statistics Education

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ABSTRACT

This study examined the development, acceptability, and effectiveness of interactive instructional materials (IIMs) in enhancing statistics education in selected higher education institutions (HEIs) in Metro Manila. A mixed-methods research design was employed, integrating quantitative and qualitative approaches. Quantitative data were collected from 256 students through structured surveys and pre-test–post-test assessments, while 30 mathematics experts evaluated the materials using standardized checklists. Qualitative data from interviews and open-ended responses provided deeper insights into user experiences.

Findings revealed that the instructional materials were rated acceptable across all domains, including objectives, content, organization, navigation, evaluation, and application, with an overall mean of 3.97. The materials were particularly commended for their clarity, alignment with learning competencies, and learner-centered design.

Students’ academic performance significantly improved, with mean scores increasing from 29.59 (Moving Towards Mastery) in the pre-test to 38.49 (Closely Approximating Mastery) in the post-test. A paired-samples t-test indicated a statistically significant difference, $t(255) = 72.81$, $p < .001$. Furthermore, the computed effect size (Cohen’s $d \approx 4.55$) suggests an extremely large practical impact, indicating that the intervention produced substantial learning gains.

Qualitative findings highlighted the effectiveness of interactive and contextualized activities in enhancing engagement and comprehension. However, respondents recommended clearer step-by-step instructions and the inclusion of more real-life applications.

The study concludes that interactive instructional materials are an effective pedagogical innovation in statistics education. It recommends continuous refinement of instructional design and the adoption of experimental or quasi-experimental designs with control groups in future research to strengthen causal inferences.

Keywords: Interactive Instructional Materials, Statistics Education, Acceptability, Academic Performance, Mixed Methods, Higher Education

INTRODUCTION

Learning statistics in higher education presents persistent challenges, as students are required to move beyond procedural knowledge toward analytical reasoning and data interpretation. In many higher education institutions (HEIs) in Metro Manila, instruction remains predominantly lecture-based, which limits student engagement and conceptual understanding. Studies have shown that traditional approaches often fail to develop statistical reasoning and learner confidence (Gal et al., 2017).

Despite the potential of interactive instructional materials—such as simulations, dynamic visualizations, and adaptive modules—to enhance learning, empirical evidence on their acceptability and effectiveness in Philippine HEIs remains limited (Santos & Rivera, 2024). Moreover, issues such as low engagement, difficulty in understanding abstract concepts, and poor academic performance persist, often due to limited integration of technology-enhanced instructional strategies (Christensen & Knezek, 2024).

The primary purpose of this study is to examine the development, acceptability, and effectiveness of interactive instructional materials in statistics education among students in HEIs in Metro Manila. These institutions play a critical role in preparing the country's future workforce and advancing research and innovation. Yet many face challenges such as low student engagement, poor understanding of statistical concepts, and reduced performance outcomes, often linked to traditional lecture-based instruction often to traditional lecture-based instruction, limited interactive learning opportunities, and inadequate integration of technology-enhanced teaching methods (Christensen & Knezek, 2024; Santos & Rivera, 2024). By investigating how IIMs influence students' learning experiences and outcomes, this study provides evidence-based insights that educators, curriculum designers, and administrators can use to enhance engagement, improve statistical reasoning, and strengthen overall academic achievement.

The study draws on Cognitive Load Theory (CLT) (Sweller et al., 2023) and Self-Determination Theory (SDT) (Ryan & Deci, 2020). CLT posits that learners have limited working memory, and instructional materials should minimize extraneous cognitive load while optimizing germane load for knowledge integration. SDT emphasizes that supporting students' autonomy, competence, and intrinsic motivation enhances engagement and achievement. Well-designed interactive materials can scaffold complex tasks, reduce cognitive burdens, and enhance conceptual understanding, while fostering intrinsic motivation and sustained engagement.

Methodology

A mixed-methods research design was employed, integrating quantitative and qualitative approaches to provide a comprehensive analysis of the effectiveness of the interactive instructional materials. The quantitative component included structured surveys and pre-test–post-test assessments to measure student engagement, acceptability, usability, and learning outcomes. The qualitative component involved expert evaluations and open-ended responses to capture in-depth perspectives. The study involved two groups of respondents: 256 students enrolled in statistics courses and 30 mathematics experts from selected HEIs in Metro Manila. Purposive sampling was used to ensure that participants possessed relevant experience in statistics instruction and learning.

To strengthen future research, a quasi-experimental design incorporating control and experimental groups is recommended to establish stronger causal inferences. The current one-group pre-test–post-test design limits the ability to attribute improvements solely to the intervention. Purposive sampling was deemed appropriate to ensure that participants possessed relevant experience in statistics instruction and learning, thereby enhancing the validity of the findings.

Data collection instruments included 5-point Likert-scale student surveys for measuring acceptability, usability, engagement, and perceived learning outcomes, as well as expert evaluation checklists supplemented with open-ended prompts to assess content quality, design, and pedagogical effectiveness. Qualitative feedback from both experts and students provided rich, contextual insights that complemented the quantitative data. Triangulating these data sources enhanced the validity, credibility, and interpretive depth of the findings (Fetters et al., 2020). For future assessments, the study recommends refining measurement tools by expanding Likert-scale options, incorporating reverse-coded items to reduce response bias, and designing behaviorally specific indicators to capture nuanced variations in perceptions and experiences (DeVellis, 2021).

The study utilized structured survey instruments and expert evaluation checklists. Key constructs such as objectives, content, language and style, organization, navigation, evaluation, and application were operationally defined. In this study, navigation refers to the ease with which learners can move through the instructional material, including clarity of instructions, logical sequencing of lessons, and accessibility of activities. For future improvement, it is recommended that the instruments include expanded Likert-scale options, reverse-coded items, and behaviorally anchored indicators to minimize response bias and capture more nuanced learner perceptions. Since the study utilized a one-group pre-test–post-test design, causal inferences regarding the effectiveness of the intervention should be interpreted with caution. Future studies employing randomized or quasi-experimental designs with control groups are recommended.

The internal consistency of the survey instrument was assessed using Cronbach's alpha, yielding a coefficient of 0.91, indicating high reliability.

RESULTS AND DISCUSSION

Sub-problem No.1. What topics in Basic Statistics are found difficult.

Table 1. Results of the Examinations in Statistics as to Area of Difficulties

Area of Difficulty	Percentage	Interpretation	Ranking
1. Basic Concepts	92.21	Mastery	9
2. Collection of Data	89.16	Mastery	7
3. Organization and Presentation	88.23	Mastery	8
4. Measures of Central Tendency	55.08	Average	6
5. Measures of Variation	48.54	Average	5
6. Normal Distribution	34.15	Low	4
7. Hypothesis Testing	32.08	Low	3
8. Correlation Analysis	30.16	Low	2
9. Chi-square Test	28.13	Low	1

The results presented in Table 1 reveal a clear variation in students' performance across different areas of Statistics, highlighting domains where learning difficulties are most evident. The findings show that higher-order and inferential statistical concepts pose the greatest challenge to learners. In particular, the Chi-square Test, Correlation Analysis, Hypothesis Testing, and Normal Distribution were identified as the most difficult topics, all interpreted at a low level of mastery. This indicates that students struggle with abstract reasoning, particularly in transferring conceptual knowledge to inferential and analytical contexts, which are essential in higher-level statistical thinking.

This finding is consistent with the study of United Nations Educational, Scientific and Cultural Organization (2023), which emphasized that learners tend to experience greater difficulty in complex and higher-order cognitive tasks, particularly in subjects requiring analytical thinking such as mathematics and statistics. The report highlighted that while students can manage basic and procedural knowledge, they often face challenges when dealing with abstract concepts and inferential reasoning, underscoring the need for more interactive and concept-driven instructional approaches.

Furthermore, the moderate performance in Measures of Variation and Measures of Central Tendency suggests that although students demonstrate some level of understanding, they may still struggle with interpretation and application. In contrast, the mastery level observed in Basic Concepts, Collection of Data, and Organization and Presentation indicates that students are more comfortable with foundational and descriptive aspects of Statistics, which are generally more concrete and less cognitively demanding.

In this regard, the development of creative instructional materials in Statistics is considered an effective instructional strategy in enhancing students' skills. Such materials promote active learning and support individualized instruction, enabling learners to better understand complex concepts through interactive and engaging experiences.

Sub-problem No.2. Based on the findings, what instructional materials may be developed?

The primary objective of this study is to develop an interactive instructional material that aligns with the skills and competencies prescribed in the Statistics syllabus. The material is designed to capture students' attention and enhance engagement across various facets of mathematics through the integration of computer-based tools. It promotes meaningful learning by combining interactivity with concept development, enabling students to actively participate in the learning process while strengthening their understanding of key statistical principles.

The interactive instructional material incorporates several essential features to support effective learning.

Lessons are presented through an integrative approach that aligns clearly defined objectives with relevant content, addressing students’ diverse learning needs while fostering the development of knowledge, skills, and values. Each lesson begins with meaningful mathematical data or real-life contexts that serve as an entry point to new concepts, supported by clear illustrations and guided activities. Furthermore, a range of exercises and contextualized word problems is included to challenge students and enhance their problem-solving abilities. The material also provides exploratory tasks that promote critical thinking, deepen analytical skills, and guide learners in constructing generalizations of key statistical concepts.

The developed interactive instructional material serves as a strategic and responsive tool in teaching Statistics, aiming to improve student engagement, conceptual understanding, and learning outcomes through a learner-centered and technology-enhanced approach.

These findings are consistent with Hattie (2023), who emphasized that the integration of interactive and technology-supported instructional approaches significantly enhances student learning outcomes. He noted that learning becomes more effective when students are actively engaged through exploratory and feedback-rich environments, allowing them to construct knowledge meaningfully rather than passively receiving information. Similarly, the use of audio-visual materials has been recognized as an effective means of enhancing learning, as these resources support multiple sensory channels and contribute to a more comprehensive instructional process.

In this context, teachers play a critical role in designing, developing, and utilizing instructional materials that are responsive to learners’ needs, thereby ensuring more effective and engaging teaching and learning experiences.

Sub-problem No. 3. How acceptable is the interactive instructional materials to the mathematics experts in terms of:

Objectives

Table 2. Acceptability of the Interactive Instructional Materials as to Objectives

Criteria	Experts		Rank
	WM	VI	
1. The objectives are clearly stated.	4.25	VA	1.5
2. The objectives are relevant to the content, exercises, activities and feedback	4.25	VA	1.5
3. Expressed in a language that is easy to understand.	4.10	A	4
4. Specific, measurable, achievable, relevant and time bound.	4.15	A	3
5. Provide directions to the learners and to the learning contents.	3.90	A	5
6. The objectives are appropriate to the learners’ level and learning needs.	4.25	VA	1.5
Composite Mean	4.13	A	

Legend:

Scale	Numerical Value	Descriptive Value
5	4.20 – 5.00	Very Acceptable (VA)
4	3.40 – 4.19	Acceptable (A)
3	2.60 – 3.39	Moderately Acceptable (MA)
2	1.80 – 2.59	Less Acceptable (LA)
1	1.00 – 1.79	Not Acceptable (NA)

As presented in Table 2, the experts assessed all criteria related to the objectives of the interactive instructional material as acceptable. Specifically, the objectives were clearly stated (WM = 4.25), relevant to the content, exercises, activities, and feedback (WM = 4.25), and appropriate to the learners’ level and learning needs (WM = 4.25), all sharing the highest rank of 1.5. The objectives were also found to be specific, measurable,

achievable, relevant, and time-bound (WM = 4.15, rank 3), expressed in a language that is easy to understand (WM = 4.10, rank 4), and provided clear directions to the learners and learning contents (WM = 3.90, rank 5). Overall, the interactive instructional material was assessed as acceptable in terms of objectives, with a composite mean of 4.13. This indicates that the material is well-structured, learner-centered, and aligned with pedagogical best practices in facilitating meaningful engagement and learning. These results corroborate the study conducted by Sung (2022), who emphasized that well-defined and clear instructional objectives enhance the effectiveness of interactive learning materials by guiding learners' focus and facilitating the alignment of content, activities, and assessment. The study demonstrated that materials designed with specific, measurable, and learner-centered objectives significantly improved student engagement and learning outcomes in technology-enhanced learning environments. Similarly, clearly articulated directions and language that is easy to understand were found to reduce cognitive load and promote autonomous learning, supporting the design principles reflected in the current interactive instructional material.

Content

Table 3. Acceptability of the Interactive Instructional Materials as to Content

Criteria	Experts		Rank
	WM	VI	
1. It provides accurate information.	4.02	A	2
2. It is based on the learning competencies.	3.94	A	3
3. It is interesting and pleasant to read, has human interests features.	4.12	A	1
4. Contents are relevant to the target group. They answer the needs of the learners.	3.82	A	4
5. What are suggested are within the capacity and resources of the target group to try on or implement.	3.76	A	5
Composite Mean	3.93	A	

As shown in Table 3, the experts rated all criteria related to the content of the interactive instructional materials as acceptable. Specifically, the criterion “It is interesting and pleasant to read, with human interest features” obtained the highest weighted mean (WM = 4.12, rank 1), followed by “It provides accurate information” (WM = 4.02, rank 2), “It is based on the learning competencies” (WM = 3.94, rank 3), “Contents are relevant to the target group and answer the needs of the learners” (WM = 3.82, rank 4), and “Suggestions are within the capacity and resources of the target group to try or implement” (WM = 3.76, rank 5). The overall composite mean of 3.93 confirms that the content of the interactive instructional materials is acceptable, indicating that it is both accurate and aligned with learners' needs while being engaging and accessible.

This outcome agrees with the conclusions of Alimisis (2021), who emphasized that instructional materials designed with accurate, competency-aligned content and engaging features significantly enhance students' understanding of abstract concepts. The well-structured materials that incorporate human-interest elements, interactive components, and learner-centered contexts foster deeper engagement and promote active learning. Moreover, such materials allow learners to explore concepts independently, thereby improving comprehension, retention, and problem-solving skills, particularly in subjects like mathematics and statistics that involve abstract reasoning.

The interactive instructional materials in this study were developed to supplement conventional teaching methods and provide an alternative to lecture-based instruction. They are designed to support students' learning needs, readiness, and individual learning styles, allowing for more autonomous and meaningful learning experiences. By integrating engaging content, contextualized examples, and technology-enhanced features, these materials aim to facilitate effective learning with minimal teacher guidance, while addressing diverse learner characteristics.

Language and Style

Table 4. Acceptability of the Interactive Instructional Materials to Language and Style

Criteria	Experts		Rank
	WM	VI	
1. Language used suits the learners’ level of comprehension.	3.88	A	3
2. The presentation is clear and simple.	4.00	A	1
3. Terms convey messages of the subject matter and topics.	3.81	A	4
4. Provide clear understanding of basic concepts and principle.	3.77	A	5
5. The structure and style are appropriately designed.	3.94	A	2
Composite Mean	3.88	A	

As shown in Table 4, the experts assessed the acceptability of the interactive instructional materials in terms of language and style as acceptable, with a composite mean of 3.88. Specifically, the criterion “The presentation is clear and simple” obtained the highest weighted mean (WM = 4.00, rank 1), followed by “The structure and style are appropriately designed” (WM = 3.94, rank 2), “Language used suits the learners’ level of comprehension” (WM = 3.88, rank 3), “Terms convey messages of the subject matter and topics” (WM = 3.81, rank 4), and “Provide clear understanding of basic concepts and principles” (WM = 3.77, rank 5). These results indicate that the materials are linguistically appropriate, well-structured, and designed to facilitate comprehension and independent learning.

This observation is reinforced by the work of Almekhlafi (2022), who emphasized that instructional materials designed with clear, concise, and learner-appropriate language enhance understanding and engagement in technology-enhanced learning environments. The use of simple presentation, consistent terminology, and well-structured content supports students’ cognitive processing, reduces misunderstanding, and encourages autonomous learning. Such design principles are particularly important in subjects like Statistics, where clarity of terms and logical presentation of concepts directly influence comprehension and application.

The interactive instructional materials in this study were therefore developed with attention to language suitability, clarity of presentation, and appropriate structure and style, ensuring that learners can navigate the content easily, grasp fundamental concepts, and engage in meaningful learning activities with minimal teacher guidance.

Organization

Table 5. Acceptability of the Interactive Instructional Materials as to Organization

Criteria	Experts		Rank
	WM	VI	
1. The materials explore topics and ideas of interests and needs of the learners.	3.84	A	4
2. The topics and ideas contained are logically organized from easy to difficult.	4.05	A	1
3. Materials are activity-oriented.	3.97	A	2
4. There is utilization of enrichment activities in each topic presented.	3.93	A	3
Composite Mean	3.95	A	

As reflected in Table 5, the experts assessed all criteria related to the organization of the interactive instructional materials as acceptable, with a composite mean of 3.95. Specifically, “The topics and ideas contained are logically organized from easy to difficult” received the highest weighted mean (WM = 4.05, rank 1), followed by “Materials are activity-oriented” (WM = 3.97, rank 2), “There is utilization of enrichment activities in each topic presented” (WM = 3.93, rank 3), and “The materials explore topics and ideas of

interests and needs of the learners” (WM = 3.84, rank 4). These results indicate that the instructional materials are carefully structured, engaging, and aligned with learners’ needs, providing a coherent progression of content that facilitates mastery learning.

Similar findings were reported by Clark (2021), who highlighted that instructional materials organized in a logically sequenced and activity-oriented manner significantly improve learners’ comprehension, engagement, and retention. The breaking content into manageable units with clearly defined objectives allows students to progress at their own pace, ensuring mastery before moving to more complex topics. This approach is particularly effective in technology-enhanced and self-paced learning environments, where learners benefit from autonomy and structured guidance simultaneously.

The interactive instructional materials in this study were therefore designed to follow a linear sequence of content units, each accompanied by activity-based and enrichment tasks. This self-paced design allows learners to study according to their individual readiness and learning speed. Slow learners can take the necessary time to master each concept, while faster learners can progress without unnecessary delays. By promoting learner autonomy and self-direction, these materials foster both mastery of lessons and active engagement, reducing dependence on the teacher while maintaining instructional effectiveness.

Navigation

Table 6. Acceptability of the Interactive Instructional Materials as to Navigation

Criteria	Experts		Rank
	WM	VI	
1. The materials provide clear and easy-to-follow instructions.	4.15	A	1
2. The lessons are logically sequenced and easy to navigate.	3.80	A	3.5
3. Navigation features (buttons, links, menus) are user-friendly	3.95	A	2
4. Learners can easily access activities and assessments.	3.80	A	3.5
5. The layout and interface support smooth lesson progression.	3.75	A	5
Composite Mean	3.89	A	

As presented in Table 6, the experts assessed all criteria related to the navigation of the interactive instructional materials as acceptable, with a composite mean of 3.89. Among the indicators, “The materials provide clear and easy-to-follow instructions” obtained the highest weighted mean (WM = 4.15, rank 1), followed by “Navigation features (buttons, links, menus) are user-friendly” (WM = 3.95, rank 2). Meanwhile, “The lessons are logically sequenced and easy to navigate” and “Learners can easily access activities and assessments” both received a weighted mean of 3.80 (rank 3.5), while “The layout and interface support smooth lesson progression” obtained the lowest mean (WM = 3.75, rank 5).

These findings indicate that the instructional materials are generally effective in facilitating user navigation, with particular strengths in clarity of instructions and usability of interface features. However, relatively lower ratings in layout design and lesson flow suggest areas for improvement, particularly in enhancing interface consistency and optimizing the progression of content.

This result supports Moreno (2022), who emphasized that well-designed navigation structures in instructional materials reduce cognitive load and enable learners to focus on content rather than interface challenges. Clear instructions, intuitive navigation tools, and accessible learning pathways contribute significantly to learner autonomy, engagement, and retention.

Therefore, the interactive instructional materials were designed to ensure ease of use through clear guidance, structured sequencing, and accessible navigation features. Further refinement of layout design and lesson progression may enhance the overall user experience and instructional effectiveness.

Evaluation

Table 7. Acceptability of the Interactive Instructional Materials as to Evaluation

Criteria	Experts		Rank
	WM	VI	
1. The evaluation is congruent to the objectives and topics presented.	3.90	A	4
2. The evaluation really assesses learning gained.	3.84	A	5
3. The evaluation is enough for each topic.	4.10	A	2
4. The evaluation has a clear purpose regarding what is to be assessed among learners.	4.08	A	3
5. The directions in the evaluation are clearly presented and understandable.	4.18	A	1
Composite Mean	4.02	A	

As shown in Table 7, the experts assessed all criteria related to the evaluation component of the interactive instructional materials as acceptable, with a composite mean of 4.02. Specifically, “The directions in the evaluation are clearly presented and understandable” obtained the highest weighted mean (WM = 4.18, rank 1), followed by “The evaluation is enough for each topic” (WM = 4.10, rank 2), “The evaluation has a clear purpose regarding what is to be assessed among learners (WM = 4.08, rank 3), “The evaluation is congruent to the objectives and topics presented” (WM = 3.90, rank 4), and “The evaluation really assesses learning gained” (WM = 3.84, rank 5). These results indicate that the evaluation component of the materials is well-designed, clear, and aligned with the learning objectives, effectively supporting the measurement of students’ learning outcomes.

This is in line with the findings of Sung (2022), who emphasized that evaluations embedded in interactive instructional materials are most effective when they are clearly aligned with objectives, appropriately sequenced, and provide explicit directions for learners. The well-structured evaluations not only measure learning gains accurately but also guide learners in reflecting on their understanding, thereby enhancing retention and promoting self-directed learning.

The interactive instructional materials in this study were therefore developed with clear evaluation guidelines, sufficient assessment items for each topic, and alignment with objectives and content. These features ensure that learners can meaningfully engage with the evaluation, accurately demonstrate mastery of the lessons, and receive feedback that supports ongoing learning.

Application

Table 8. Acceptability of the Interactive Instructional Materials as to Application

Criteria	Composite Mean		Rank
	WM	VI	
1. Enough activity is provided to apply the knowledge gained in each unit.	3.95	A	5
2. The activities really focus on the development of lifelong skills for the learners.	3.99	A	4
3. The application provides clear instructions regarding all the activities to be taken by the students	4.02	A	2.5
4. It provides suitable and acceptable vocabulary that would ensure better understanding of the concepts and skills to be performed.	4.02	A	2.5
5. The application provides clear information, simple and understanding of the concept statistics discussed in every activity.	4.08	A	1
Composite Mean	4.01	A	

As presented in Table 8, the experts assessed all criteria related to the application component of the interactive instructional materials as acceptable, with a composite mean of 4.01. Specifically, “The application provides clear information, simple and understandable explanation of the statistical concepts discussed in every activity” received the highest weighted mean (WM = 4.08, rank 1). This was followed by “The application provides clear instructions regarding all the activities to be taken by the students” and “Provides suitable and acceptable vocabulary that ensures better understanding of the concepts and skills to be performed” (WM = 4.02, rank 2.5), “The activities really focus on the development of lifelong skills for the learners” (WM = 3.99, rank 4), and “Enough activity is provided to apply the knowledge gained in each unit” (WM = 3.95, rank 5). These results indicate that the interactive instructional materials effectively facilitate learners’ application of knowledge, promote skill development, and provide clear, understandable guidance for performing tasks.

This trend is also observed in the study of Spector (2020), who emphasized that well-designed interactive instructional materials should integrate clear instructions, appropriate vocabulary, and meaningful application activities that align with learning objectives. When learners are provided with structured and guided opportunities to apply knowledge in authentic contexts, deeper understanding and competency development are enhanced. Moreover, application activities that develop transferable skills contribute to learner autonomy and long-term retention.

The interactive instructional materials in this study were therefore developed to provide sufficient and clearly guided application activities, using appropriate terminology and step-by-step instructions. These materials not only support the immediate understanding of statistical concepts but also promote the development of practical skills that learners can apply beyond the classroom, ensuring meaningful and lasting learning experiences.

Table 9. Summary on the Acceptability of the Interactive Instructional Materials

Variables	Composite Mean		Rank
	WM	VI	
1. Objectives	4.13	A	1
2. Content	3.93	A	5
3. Language and Style	3.88	A	7
4. Organization	3.95	A	4
5. Navigation	3.89	A	6
6. Evaluation	4.02	A	2
7. Application	4.01	A	3
Overall Weighted Mean	3.97	A	

As shown in Table 9, the experts rated all domains of the interactive instructional materials as acceptable. Specifically, Objectives received the highest weighted mean (WM = 4.13, rank 1), followed by Evaluation (WM = 4.02, rank 2), Application (WM = 4.01, rank 3), Organization (WM = 3.95, rank 4), Content (WM = 3.93, rank 5), Navigation (WM = 3.89, rank 6), and Language and Style (WM = 3.88, rank 7).

The overall weighted mean of 3.97 indicates that the interactive instructional materials are generally acceptable across all evaluated criteria. This suggests that the materials are well-designed to support learner engagement, provide clear guidance, and facilitate effective learning. The high ratings for objectives, evaluation, and application, in particular, reflect the materials’ clarity of purpose, structured assessment strategies, and opportunities for practical application, which collectively enhance students’ understanding and mastery of statistical concepts.

These findings align with recent studies emphasizing the importance of comprehensive instructional materials that integrate learner-centered strategies and technology-enhanced activities to improve engagement and learning outcomes Kurt (2021). Overall, the results confirm that the interactive instructional materials are an effective resource for teaching Statistics in a structured, accessible, and pedagogically sound manner.

Sub-problem No.4. What is the performance of the students who were subjected to the interactive instructional material in the pre-test and post-test in Statistics?

Table 10. Result of the Pre-test and Post-test in Statistics

Pre-test		Verbal Interpretation	Post-test		Verbal Interpretation
Mean	MPS		Mean	MPS	
29.59	79.59	Moving Towards Mastery	38.49	88.49	Closely Approximating Mastery

MPS	Descriptive Equivalent
96 – 100%	Mastered
86 – 95%	Closely Approximating Mastery
66 – 85%	Moving Towards Mastery
35 – 65%	Average
15 – 34%	Low
5 – 14%	Very Low
0 - 4%	Absolutely No Mastery

As shown in Table 10, students’ mean scores increased from 29.59 in the pre-test to 38.49 in the post-test. Based on the descriptive equivalents, the pre-test performance was interpreted as “*Moving Towards Mastery*” (MPS = 79.59), while the post-test performance was interpreted as “*Closely Approximating Mastery*” (MPS = 88.49). This improvement indicates that students demonstrated higher performance levels after using the interactive instructional materials, suggesting a positive and meaningful effect of the intervention on students’ learning outcomes in Statistics.

This evidence is substantiated by Zhang (2024), who reported that the use of well-designed interactive learning materials in mathematics and statistics courses significantly improved students’ academic performance compared to traditional instructional approaches. Zhang noted that interactive elements, including multimedia explanations, scaffolded activities, and real-time feedback, help students build stronger conceptual understanding and increase engagement, leading to measurable gains from pre-instruction to post-instruction assessments.

Similarly, Ramirez (2023) emphasized that interactive instructional environments support active learning and learner autonomy, which in turn enhance students’ confidence, problem-solving abilities, and mastery of complex topics. Ramirez’s study found statistically significant improvements in post-test scores for groups using interactive instructional technologies versus those using conventional materials, particularly in subjects requiring analytical reasoning.

Taken together, these recent studies corroborate the improvement shown from pre-test to post-test performance in this study, reinforcing the conclusion that interactive instructional materials can effectively facilitate learning gains, improve comprehension of statistical concepts, and foster higher-order thinking skills.

The significant improvement in students’ post-test performance demonstrates that the interactive instructional materials developed in this study effectively enhanced achievement in Statistics, highlighting their value as a learner-centered, technology-enhanced, and pedagogically sound instructional approach.

Sub-problem No.5. Is there a significant difference between the pre-test and post-test results of the students who were subjected in the interactive instructional materials in Statistics?

Table 11. Significant Difference in the Pre-test and Post-test Mean Score of the Students

Computed t-value	Critical value at .05	df	Decision	Interpretation
72.81	1.645	255	Reject H ₀	Significant

As presented in Table 11, the computed t-value of 72.81 with 255 degrees of freedom is greater than the critical value of 1.645 at the .05 level of significance, indicating a statistically significant difference between the pre-test and post-test mean scores of the students. Consequently, the null hypothesis is rejected. This result demonstrates that the interactive instructional materials in Statistics significantly improved the students' performance, confirming the effectiveness of the materials in enhancing learning outcomes.

This is supported by empirical evidence from Hussain (2022), who reported that students exposed to interactive, technology-enhanced instructional materials in mathematics courses showed significant improvement in post-test scores compared to traditional instruction. The structured, interactive activities and immediate feedback facilitate better understanding of abstract concepts, increase engagement, and improve overall academic performance.

The significant increase in post-test scores further confirms that interactive instructional materials provide an effective learner-centered approach, enabling students to actively construct knowledge, practice skills, and apply concepts in meaningful contexts. This underscores the potential of such materials to enhance both comprehension and mastery in Statistics, making learning more efficient and impactful.

In addition to statistical significance, the magnitude of the effect was examined using Cohen's d. The computed Cohen's d of approximately 4.55 indicates an extremely large effect size, far exceeding conventional benchmarks (0.2 = small, 0.5 = medium, 0.8 = large). This suggests that the observed improvement is not only statistically significant but also educationally substantial, demonstrating the strong impact of the interactive instructional materials on student learning outcomes.

Interview Results

The interviews with selected mathematics experts and students provided in-depth qualitative insights into the acceptability and effectiveness of the interactive instructional materials in Statistics. Experts consistently highlighted the clarity, structure, and alignment of the materials with the learning objectives. One expert noted, "The materials are well-organized and interactive, facilitating comprehension of complex statistical concepts." Students similarly observed the practical benefits of the activities, with a participant stating, "The exercises helped me understand concepts that I previously found difficult in class." These findings are supported by Johnson and Lee (2023), who reported that interactive, learner-centered instructional materials significantly enhance engagement, conceptual understanding, and knowledge retention in STEM disciplines.

Despite the positive feedback, respondents identified opportunities for enhancement. Some students suggested including more step-by-step guidance, noting, "Certain exercises could benefit from clearer instructions to follow the process effectively." Experts also recommended integrating additional real-life contextual examples to strengthen application skills. This is further confirmed by Patel et al. (2022), who emphasized that contextualized learning activities in instructional materials improve students' ability to apply abstract concepts in practical situations.

Participants further highlighted the effectiveness of the evaluation strategies embedded in the materials. Experts observed that assessment items were appropriately aligned with the objectives and provided accurate measures of learning outcomes. One expert remarked, "The evaluation aligns with the objectives and effectively tracks students' understanding and progress." This corresponds with the findings of Ramli & Wong (2021), who noted that clear, objective-aligned assessments in technology-enhanced learning environments enhance both student performance and motivation.

Overall, the interview results suggest that the interactive instructional materials are effective in promoting student engagement, comprehension, and mastery of statistical concepts. Targeted improvements such as more detailed stepwise instructions and additional real-life examples can further optimize the usability and educational impact of the materials.

Thematic Analysis

Analysis of the interview data revealed four overarching themes regarding the effectiveness and acceptability of the interactive instructional materials:

1. **Clarity and Alignment of Learning Objectives.** Experts emphasized that clearly defined, measurable objectives guide learners' focus and ensure that activities and assessments are purposefully connected to intended outcomes.
2. **Engagement through Interactive and Contextualized Activities.** Respondents highlighted that hands-on exercises and real-world examples maintain learner interest and facilitate understanding of abstract statistical concepts.
3. **Effectiveness of Evaluation and Feedback.** Participants noted that well-structured evaluation items provide meaningful feedback, reinforce mastery of key concepts, and support self-assessment.
4. **Ease of Navigation and Learner-Centered Design.** The organization, logical sequencing, and accessible language were identified as critical for enabling self-directed learning and minimizing cognitive load.

These themes reinforce the quantitative findings, demonstrating that the interactive instructional materials are not only well-received and learner-centered but also effective in improving students' engagement and mastery of statistical concepts. Enhancing step-by-step guidance and incorporating more contextually relevant examples could further optimize comprehension, facilitate practical application, and deepen overall learning outcomes.

CONCLUSIONS

Based on the findings of the study, students and mathematics experts generally perceive the interactive instructional materials in Statistics as highly acceptable, effective, and learner-centered. The materials were assessed positively across all domains, including objectives, content, language and style, organization, navigation, evaluation, and application. Experts highlighted the clarity, alignment with learning objectives, and structured design, while students emphasized the benefits of engaging, contextualized, and interactive activities that facilitate understanding of complex statistical concepts. These findings indicate that the developed materials effectively support meaningful learning, promote student engagement, and enhance mastery of Statistics.

The results further revealed a significant improvement in students' performance from pre-test to post-test, demonstrating that the interactive instructional materials had a positive and measurable effect on learning outcomes. Statistical analysis confirmed a significant difference between pre-test and post-test scores, reinforcing the effectiveness of the materials in improving comprehension, problem-solving abilities, and application of statistical concepts. This suggests that interactive, technology-enhanced approaches are more effective than traditional instructional methods in facilitating understanding of abstract and higher-order statistical topics.

Despite the overall positive outcomes, the study also identified areas for refinement. Feedback from students and experts indicated the need for more detailed step-by-step guidance and additional real-life contextual examples to further support practical application of statistical concepts. Enhancing these aspects could improve learner comprehension, engagement, and the ability to transfer knowledge to real-world situations.

Insights from the thematic analysis corroborate the quantitative results, emphasizing that clarity of objectives, engagement through interactive activities, effective evaluation, and learner-centered design are key factors contributing to the success of the materials. These findings highlight that instructional effectiveness depends not only on content accuracy but also on how materials are structured, presented, and aligned with learners' needs.

The interactive instructional materials developed in this study are an effective tool for teaching Statistics. They promote active learning, support mastery of complex concepts, and facilitate meaningful engagement. By incorporating more detailed guidance and contextual examples, these materials can be further optimized to enhance comprehension, practical application, and overall learning outcomes, making them a valuable resource in technology-enhanced, learner-centered Statistics instruction.

Overall, the findings affirm that well-designed interactive instructional materials have strong potential as a transformative and scalable innovation in statistics education. By fostering active engagement, enhancing conceptual understanding, and supporting higher-order thinking, these materials can bridge persistent learning gaps and improve academic outcomes in higher education.

While the findings of the study demonstrate the effectiveness of the interactive instructional materials, it is important to note that the respondents were limited to selected higher education institutions in Metro Manila. Thus, the generalizability of the results may be constrained. Future studies involving multiple regions and diverse institutional contexts are recommended to validate and extend the applicability of the findings.

This study contributes to the growing body of evidence supporting technology-enhanced, learner-centered instruction as a viable strategy for improving statistical literacy in higher education.

RECOMMENDATIONS

In light of the study's findings and conclusions, the following recommendations are suggested:

1. Future researchers are encouraged to incorporate a control or comparison group using experimental or quasi-experimental designs to establish stronger causal relationships between the use of interactive instructional materials and student performance.
2. Researchers may include effect size measures (e.g., Cohen's d) alongside significance testing to better interpret the magnitude and practical impact of learning gains.
3. Teachers are encouraged to integrate more real-life and contextualized examples to enhance students' ability to apply statistical concepts in practical situations.
4. Educators may maximize the use of interactive and multimedia features such as simulations, animations, and adaptive exercises to cater to diverse learning styles and increase engagement.
5. Future studies may adopt a longitudinal research design to assess long-term retention, transfer of learning, and sustained impact of interactive instructional materials.
6. Curriculum developers are encouraged to conduct regular review and refinement of instructional materials, ensuring alignment with evolving competencies and learner needs.
7. Researchers and educators may include documentation of instructional materials (e.g., screenshots, module samples, activity descriptions) in the appendices to enhance transparency and replicability.
8. Future research may expand the scope by including multiple regions and institutions, thereby improving the generalizability of the findings.
9. Instrumentation may be further improved by incorporating more robust measurement techniques, such as reverse-coded items and behavior-based indicators.
10. Advanced statistical analyses (e.g., ANCOVA, regression analysis) may be employed in future studies to further validate findings and explore relationships among variables. Future studies are also encouraged to employ randomized sampling techniques where feasible to further enhance external validity.

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