Breaking Traditions with Innovations: An e-Learning Course Packet (eLCP) in Educational Statistics Vis-à-Vis SPSS and Jamovi

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Manuscript received September 9, 2025; revised September 28, 2025; accepted October 11, 2025; published February 12, 2026

***Abstract*—Students and educators frequently encounter difficulties in applying statistical concepts due to limited exposure to statistical software and a scarcity of interactive learning materials. These challenges, alongside persistent low mathematics proficiency and frequent class disruptions in the Philippines, highlight a critical need for flexible and effective learning solutions. This paper details a design and development research focused on creating and evaluating an e-learning course packet in educational statistics. The primary aim was to enhance statistical proficiency and practical application skills among graduate students through the integration of Statistical Package for the Social Sciences (SPSS) and Jamovi. Grounded in e-learning and constructivist principles, the study employed Educational Design Research (EDR) methodology, involving a comprehensive needs assessment, validation by 10 experts, and pilot testing with 48 graduate students. The findings revealed that experts rated the course design as "Excellent" for its clarity, relevance, and technology integration. Furthermore, high student engagement was observed, with 97% module completion and substantial utilization of both SPSS (90%) and Jamovi (85%) for practical exercises. Pre- and posttest results demonstrated a statistically significant improvement in student proficiency (means: 55.2 to 82.5; $t = 10.23$, $p = 0.001$), indicating a very large effect size. Students also reported high overall satisfaction with the course packet (4.66 "Excellent"). This e-learning solution effectively bridged the theory-practice gap, equipping graduate students with essential analytical competencies and contributing to an enhanced statistical education for a data-driven world.**

***Keywords*—e-learning, educational statistics, Statistical Package for the Social Sciences (SPSS), Jamovi, statistical proficiency, educational design research**

I. Introduction

In the field of quantitative research, statistical analysis is important, especially in interpreting data, testing hypotheses, and drawing meaningful conclusions, reinforcing the assertion that statistics serves as the backbone of quantitative research [1]. With the increasing emphasis on data-driven decision-making, proficiency in statistical analysis has become essential for students and educators alike. Statistical literacy is an increasingly essential skill across various disciplines, including education, social sciences, healthcare, and business. As industries evolve to become more data-driven, educational institutions must equip students with the skills and competencies necessary to analyze and interpret data effectively. Given this, statistical software serves as a fundamental component of educational training, enabling learners to apply theoretical knowledge to practical scenarios [2].

For many years, software like Statistical Package for the Social Sciences (SPSS) has been popular for its wide range of features and ease of use [3]. More recently, open-source tools such as Jamovi, RStudio, Python, and JASP have made statistical analysis more affordable and accessible [4]. These new options can help improve how statistics is taught, making it easier for students with different needs and for schools with limited budgets. Using statistical software in classes has been shown to help students analyze data more effectively. Delport [5] notes that adding these tools to coursework helps students better understand complex ideas and feel more confident working with real data.

Recent studies show that the type of statistical software students use can shape their learning experiences. SPSS is still common because of its strong analytical tools, but Jamovi is becoming more popular because of its simple design and free access, which makes it a good choice for beginners [6]. Students who use open-source programs like Jamovi often build better computational thinking skills, since the software encourages them to try out different data analysis methods in a user-friendly setting [7]. Jamovi is easy to use and helps students understand statistical tests and data visualization through its clear graphical interface, which can make concepts easier to grasp and helps students look beyond just *p*-values [8, 9]. It also covers a wide range of analyses, such as t-tests, Analysis of Variance (ANOVA), correlation, regression, factor analysis, and SEM, so it works well in many fields [10, 11]. Because Jamovi is open-source, it removes the cost barriers of paid software, making it more accessible for students and educators [8].

As interest in open-source platforms grows, it is important to compare software tools based on usability, functionality, and how well they support teaching. Programs like SPSS require a paid license, while open-source options such as Jamovi are often easier to use and more flexible [7]. Because of these changes, teaching methods should keep up with the latest tools to help students learn effectively [12]. Using both SPSS and Jamovi in the classroom can give students a well-rounded skillset. They benefit from SPSS's strong analytical features and Jamovi's easy-to-use design [5]. This combination helps students build both technical skills and adaptability, which are important in today's research and professional environments.

Developing an e-learning course packet that uses both SPSS and Jamovi is especially important in the Philippines, where traditional classes are often disrupted. The country faces about 20 typhoons each year, which frequently lead to class suspensions [13]. Extreme heat also affects school attendance and engagement [14]. In addition, community activities like town fiestas and school events often interrupt regular academic schedules [15]. Statistics, as a branch of mathematics [16], presents additional challenges since difficulties in the former often translate into struggles with the latter. Graduate students are not exempt from these circumstances, as they too face challenges in acquiring and mastering essential mathematical skills.

Recent national reports underscore the urgency of addressing educational challenges. The EDCOM II Year Two Report, Fixing the Foundations: A Matter of National Survival, identifies significant gaps in numeracy, indicating that many students lack foundational mathematics skills [17]. The report calls for reforms in mathematics instruction, emphasizing the MATATAG Curriculum—Philippines' updated K to 12 basic education curriculum that "decongests" content to focus on essential competencies and make learning more relevant and effective. "Matatag," a Filipino word meaning "strong" or "resilient," also serves as an acronym: **MA**—Make the curriculum relevant to produce job-ready, active, and responsible citizens; **TA**—Take steps to accelerate the delivery of basic education facilities and services; **TA**—Take good care of learners by promoting well-being, inclusive education, and a positive learning environment; and **G**—Give support to teachers so they can teach better. However, persistent issues, including delayed textbook deliveries, continue to impede effective implementation [18].

International benchmarks show that Filipino students continue to face challenges in mathematics. The 2022 Programme for International Student Assessment (PISA) results indicated only minor progress since 2018, with the Philippines still ranking among the lowest performing countries [19]. Southeast Asia Primary Learning Metrics (SEA-PLM) 2019 highlighted the importance of early childhood education for math achievement, and a United Nations International Children's Fund (UNICEF) study reported that students were already a year behind curriculum standards before the pandemic. The COVID-19 crisis increased this gap to 2 to 3 years, leaving many Grades 8 and 9 students struggling with skills expected at the Grade 4 level [20].

To address the effects of these disruptions, digital learning modules have been recognized as effective tools for maintaining instructional continuity [21]. Video lessons, as a form of digital instructional material, provide equitable access to learning during interruptions and can substantially increase student engagement [22, 23]. The shift to flexible learning modalities has introduced new challenges for students, who must adapt to evolving instructional methods while benefiting from digital teaching innovations [24]. Gradually, the creation of instructional resources, such as a Robotics Training Manual for Mathematics, has been employed to improve academic performance by offering practical applications of mathematical concepts to be used in public schools [25]. Collectively, these developments reflect a national trend toward applied and digitally-supported pedagogical strategies.

The integration of e-modules with video explainers for statistical learning has demonstrated particular effectiveness. Sagge and Bacio [26] report that students achieve greater benefits when instruction combines video explainers and e-learning modules, attributing this to the combination of visual, auditory, and practical learning modalities, as well as the flexibility and accessibility of the format. Navarro [6] further supports these findings, noting that contemporary online platforms enable the incorporation of statistical tools into hybrid learning environments, thereby improving students' opportunities for experiential learning.

This study uses e-Learning Theory to guide its innovations, focusing on how technology can create interactive, learner-centered environments [27]. Based on cognitive science, this theory encourages meaningful learning with digital tools [28]. The constructivist learning principle is likewise integral to the study, suggesting that learners build knowledge through engagement and interaction [29]. These ideas shape the e-learning course packet so students do more than just receive information—they take part in real learning activities. Including SPSS and Jamovi in the course packet helps students work independently, learn at their own pace, and apply what they learn in practical ways. This approach meets both theoretical goals and real-world needs.

This study also offers value to several stakeholders. Students will have access to a structured resource for statistical learning, supporting their academic and professional development. Educators can use the e-Learning Course Packet (eLCP) to supplement instruction and strengthen students' understanding of statistical concepts. Educational institutions will gain cost-effective, scalable digital resources that enhance current curricula. Researchers may also use this initiative as a foundation for further advancements in digital learning materials.

Furthermore, this study focuses on developing an eLCP that integrates SPSS and Jamovi, targeting graduate students in taking educational statistics courses. The primary emphasis is on software usability and course packet acceptability, not on detailed technical analysis of statistical algorithms. The implementation is limited to higher education institutions, so findings may not extend to other educational levels. By clarifying these parameters, the study aims to support ongoing discussions in statistical education and technology-enhanced learning, providing students and educators with essential tools for data analysis.

Based on the identified rationale and research gap, this study developed and evaluated an eLCP in Educational Statistics. The course incorporated SPSS and Jamovi software to improve graduate students' statistical proficiency and practical application skills. The study specifically aimed to:

1) Identify the significant learning challenges faced by graduate students and educators in Educational Statistics.
2) Determine the design quality of the developed eLCP in terms of its clarity, relevance, instructional coherence, and integration of technology, as evaluated by experts.
3) Assess the level of student engagement with the eLCP, as evidenced by module completion rates and the utilization of statistical software like SPSS and Jamovi.

4) Evaluate the effectiveness of the eLCP in improving the statistical proficiency of graduate students.
5) Determine the level of student satisfaction with the eLCP, encompassing its usability, content quality, learning experience, and overall perceived value.

This eLCP extends prior digital interventions by combining licensed (SPSS) and open-source (jamovi) workflows inside a single, stepwise packet that is iteratively engineered via EDR to yield both a reusable product and design knowledge. Unlike stand-alone tutorials, the eLCP couples authentic software practice with formative scaffolds and LMS-tracked engagement, and it is evaluated on three outcomes—participation behaviors, proficiency gains, and learner satisfaction—thereby advancing an applied-theoretical contribution in statistics education.

II. Research Design and Methodology

A. Research Design

This study employs Educational Design Research (EDR), a research approach that creates and improves practical solutions to complex educational problems while generating transferable knowledge [30, 31]. EDR employs an iterative process of designing, testing, and refining educational products or programs within authentic learning environments. This research design is particularly appropriate for the present study, as it addresses real educational challenges through the development of practical interventions. The objective of this study is to develop an eLCP to enhance learners' understanding of educational statistics using statistical software such as SPSS and jamovi. In line with that objective, EDR facilitates the systematic construction, testing, evaluation, and refinement of this instructional material. Following the three-phase model proposed by McKenney [30], the study analyzes the needs and challenges in teaching statistics, designs and constructs the eLCP, and evaluates its effectiveness to inform subsequent revisions. To improve readability, the researchers presented the EDR phases in a concise, stepwise format (analysis → design → evaluation), each introduced by a one-sentence aim followed by essential procedural details only. Phase 1 (Analysis and Exploration—aim) identifies learner/teacher needs through mixed-method surveys and curriculum review; Phase 2 (Design and Construction—aim) develops the blueprint, conducts expert validation, and iteratively refines the eLCP; and Phase 3 (Evaluation and Reflection—aim) pilots the implementation with pre/posttesting, LMS analytics, and satisfaction feedback. This approach ensures a strong alignment between theoretical frameworks and practical application, thereby increasing the relevance and utility of the course packet for students. Additionally, EDR contributes to the broader knowledge base, offering guidance for educators and researchers seeking to innovate in statistics education. Thus, EDR is well-suited to support both the development of effective instructional resources and the advancement of pedagogical understanding in online educational statistics instruction.

B. Participants

This study involved three groups: graduate students, educators, and expert validators. Each group provided important insights that helped develop and evaluate the eLCP.

Graduate Student Participants. Forty-eight graduate students in Educational Statistics engaged in both the needs analysis survey and the pilot testing of the eLCP simultaneously. This diverse group was selected to represent a broad mix of academic backgrounds and experiences, with many balancing the demands of work, family, and study. Throughout the pilot period, they engaged deeply with every part of the course—completing eLCP, assessments, pretests, posttests, hands-on activities with SPSS and Jamovi, and sharing their thoughts through assessment of the challenges in learning statistics and satisfaction surveys.

The students' honest reflections and enthusiastic participation offered valuable insights into the real-world impact of the course. Many shared that the interactive platform and step-by-step guidance made complex topics approachable and engaging. Their willingness to share suggestions and highlight areas for improvement helped shape the final version of the eLCP, ensuring it would truly support future students. Their positive outcomes and active engagement not only demonstrated the course's effectiveness but also helped refine it into a more supportive and learner-centered experience.

This study included graduate students who (1) were currently enrolled during the study period and (2) gave consent to participate. Most graduate students are already working, class sizes are capped for close supervision, and the course runs on a rotating schedule that can conflict with other required subjects—all of which limit regular attendance and availability. Because of these constraints, only those who met both conditions and were present during data collection were included. In total, 48 graduate students met the inclusion criteria and formed the sample.

Educators. Three instructors in Educational Statistics participated in a needs analysis to identify challenges in teaching the course. Each instructor has taught the subject for multiple semesters and demonstrates advanced proficiency with statistical software such as SPSS and Jamovi. Their ongoing engagement with the course has enabled refinement of teaching strategies, adaptation to diverse student needs, and integration of applied statistical concepts. The instructors also update instructional materials regularly to reflect recent developments in statistical analysis and educational technology.

Experts. Ten highly qualified experts served as both evaluators and validators for the eLCP. This group included specialists in statistics, educational technology, and instructional design, each has a wealth of academic knowledge and real-world experience. They carefully reviewed the instructional blueprint and assessed the clarity, relevance, coherence, and technological integration of the course using a structured rubric. Drawing on their expertise, these experts offered thoughtful and constructive feedback to ensure that every aspect of the instructional materials met rigorous quality standards. Their contributions were instrumental in refining the structure and flow of the eLCP, validating that the content closely aligned with the intended learning outcomes, and confirming that the integration of SPSS and Jamovi was not only pedagogically sound but also practical and accessible for learners. In addition, their

collaborative evaluation process helped strengthen the course's foundation, ensuring it would deliver meaningful and effective learning experiences.

C. Research Instrument

To assess the challenges, effectiveness, and satisfaction of the developed eLCP in Educational Statistics, four instruments were utilized throughout various phases of the study. All instruments were validated and pilot-tested, achieving a reliability coefficient of 0.70 or higher, which meets widely accepted research standards [32].

Needs Analysis Survey Questionnaire. A structured survey questionnaire was employed during the analysis and exploration phase to identify challenges in teaching and learning Educational Statistics. The instrument, administered to graduate students, comprised 15 items. Participants selected the items they found most challenging. The questionnaire focused on difficulties with statistical concepts, prior experience with statistical software, and preferences for instructional delivery. It also gathered data on the frequency of statistical tool use, confidence in applying statistical methods, familiarity with data analysis procedures, preferred learning modalities, and the perceived relevance of statistics to each participant's field of specialization. To ensure validity, content experts validated the instrument, which was then pilot tested and subjected to item analysis before reliability testing. Reliability, measured by Cronbach's alpha, yielded a coefficient of 0.834, indicating high internal consistency. An open-ended question was included to obtain richer and more contextual insights. Responses from both closed and open-ended questions guided the design of the course content and delivery model.

Expert Validation Rubric. To ensure the course was both high-quality and truly supportive of learners, the researchers invited 10 expert validators to review the design using a structured validation rubric. This collaborative process focused on several key areas: Are the learning objectives clear and meaningful? Is the content accurate, relevant, and engaging? Does the instructional flow make sense for students at different levels? The researchers also looked closely at how well SPSS and Jamovi were integrated, and whether the multimedia elements genuinely helped students understand the material.

Each expert rated specific aspects of the course on a 5-point scoring, but the researcher also encouraged the validators to share their personal insights, concerns, and suggestions for improvement in open-ended comments. Their thoughtful recommendations led to meaningful revisions and refinements, ensuring the eLCP was as effective and learner centered as possible before it moved on to pilot implementation.

Pretest and Posttest Assessment Tool. To measure the effectiveness of the course in improving statistical proficiency, a researcher-developed 100-item multiple-choice test was constructed and administered as both a pretest and a posttest. The 100-item length was selected to ensure full coverage of all targeted competencies across Bloom's levels, permit reliable subscores for major topic domains, and achieve adequate score precision for pre–post comparisons at the course level. The test construction began with a review of the course syllabus to identify key learning objectives and core statistical competencies, including descriptive statistics, hypothesis testing, and parametric and non-parametric statistical tools. Test items were drafted to represent each competency area, ensuring a balance of difficulty levels and content coverage. Content experts then reviewed the draft items for relevance, clarity, and alignment with course objectives, and revisions were made based on their feedback. A pilot test was conducted with a sample population similar to the target group to gather data on item performance and overall test quality. Beyond expert review, validity evidence was gathered from (a) response-process checks (cognitive pretesting/think-a-louds and item-clarity interviews), (b) internal-structure analyses (item difficulty and discrimination indices, and reliability), and (c) relations to other variables (convergent associations with course assessments/grades and expected pre–post gains), all of which supported the intended interpretation of scores. The pilot test results were analyzed using the Kuder-Richardson 20 (KR-20) formula to assess internal consistency, yielding a reliability coefficient of 0.751, which indicates acceptable reliability. The validated and refined test was then used as a pretest to provide a baseline measure of students' knowledge and as a posttest to assess learning gains after course completion.

Student Satisfaction Survey. To gain deeper insight into students' experiences and perceptions of the eLCP, their feedback was gathered using a comprehensive satisfaction survey. The survey used a 5-point Likert scale, where students could choose from options ranging from 5 (very satisfied), 4 (satisfied), 3 (moderately satisfied), 2 (barely satisfied), to 1 (not satisfied). This simple and familiar format made it easy for students to honestly share how they felt about different aspects of the eLCP. The survey asked about content quality, clarity of instructions, user interface design, ease of navigation, perceived learning value, and overall satisfaction, making sure to capture a wide range of learner experiences. To ensure that the survey would accurately reflect students' opinions and provide meaningful insights, an open-ended question was added. The instrument also underwent a thorough validation process. Experts in the field reviewed the questions for relevance and clarity, and a group of students participated in a pilot test to confirm that the survey was easy to understand and answer. The reliability of the survey was measured using Cronbach's alpha, which reached a value of 0.794—indicating a high level of consistency in the responses. Overall, these steps helped create a trustworthy and approachable tool for understanding students' satisfaction with the eLCP.

D. Data Collection Procedure

This study used the Educational Design Research (EDR) methodology, following McKenney and Reeves' [33] three-phase model: analysis and exploration, design and construction, and evaluation and reflection.

During the analysis and exploration phase, the researchers gathered insights and concerns from 3 educators and 48 graduate students. They used surveys containing both closed and open-ended questions. Responses to the open-ended items provided qualitative insights that supplemented the quantitative results. These responses highlighted key challenges in learning Educational Statistics, including

mathematical anxiety and the need for practical, hands-on approaches. The survey results were supported by a thorough review of the curriculum and current literature. This ensured that the researchers' understanding was grounded in theory while remaining responsive to classroom realities.

In the design and construction phase, the researchers applied these insights to develop a course structure that prioritized support and engagement. The researchers established objectives and learning outcomes according to identified participant needs. Instructional materials included step-by-step guides, video tutorials, interactive quizzes, and self-assessment tools. These resources were designed to clarify complex concepts and facilitate learner autonomy. The inclusion of SPSS and Jamovi addressed the expressed demand for practical data analysis skills. A panel of ten expert validators reviewed the course blueprint and provided feedback that enhanced its clarity, relevance, and coherence.

The evaluation and reflection phase included pilot implementation of the eLCP to assess its effectiveness. Forty-eight graduate students participated and accessed materials via a Learning Management System (LMS). The researchers monitored logins and quiz scores and analyzed student interactions with course content, resources, and peers. Pretest and posttest assessments measured learning gains. Open-ended survey responses provided qualitative perspectives. Students reported increased confidence and described the course as supportive both academically and personally. Observed peer collaboration in study groups and active participation in discussion forums indicated the development of an authentic learning community.

The integration of student responses, expert reviews, open-ended responses, and Learning Management System (LMS) analytics facilitated a comprehensive evaluation of the course's impact. The results guided the iterative refinement of the eLCP, with a focus on compassion, encouragement, and fostering meaningful interpersonal connections within the learning environment. Fig. 1 presents the EDR model-based procedure applied in this study.

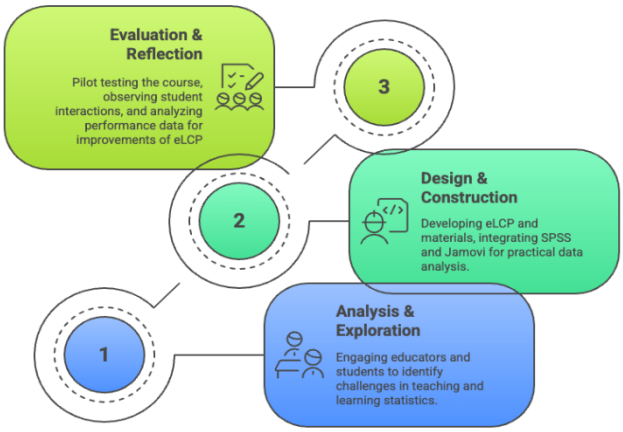

Fig. 1. The three-phase model of EDR for the development of eLCP.

E. Data Analysis Procedure.

This study utilized multiple instruments to collect data from the participants. Data analysis employed percentages to examine the challenges experienced by students and educators in teaching and learning Educational Statistics as well as the level of students' engagement with the eLCP. The mean and standard deviation were applied to evaluate experts' evaluation of the developed eLCP and the results of the student's satisfaction survey. To determine the effectiveness of the eLCP during its pilot implementation, a t-test for dependent sample was conducted with the level of significance set at 0.05. Additionally, Cohen's d was used to calculate the effect size.

F. Ethical Protocols

The research adhered strictly to established ethical policies and guidelines, including those of the American Psychological Association [34] and the College of Education at West Visayas State University, where the authors were affiliated. Researchers ensured that participants, including graduate students and educators, experienced no physical or psychological harm during surveys, pilot testing, and assessments. Participation by expert validators, graduate students, and instructors was voluntary, with the option to withdraw at any time without penalty. Confidentiality was maintained throughout the study, and all data collected through surveys, pre-tests, post-tests, and satisfaction feedback were anonymized to protect participant identities. Informed consent was obtained, particularly when identity disclosure through images or other means was required. The study maintained high ethical standards and prioritized the rights and welfare of all participants.

III. Result and Discussion

In attaining the objectives of this study, the three-phase model of EDR was followed.

A. Results

1) Analysis and exploration phase

During the analysis and exploration phase, the researchers conducted a comprehensive needs analysis that incorporated perspectives from both educators and graduate students. In addition to quantitative data, participants provided written response to open-ended questions, which the researchers analyzed to capture their academic challenges and experiences related to Educational Statistics. Considerable number of students reported difficulty with abstract concepts, while educators observed that many classes struggled to relate mathematical theory to practical application. The sentiment of being able to memorize formulas but struggling with real datasets was common among the cohort.

The results, detailed in Table 1, highlighted several issues. A striking 78% of students and 80% of educators reported difficulties in applying statistical concepts, often attributing these challenges to a lack of hands-on experience with statistical software. Several participants described feeling anxious or intimidated when faced with unfamiliar technology, noting how limited practice opportunities compounded their uncertainty. The absence of interactive learning resources was another top answer—76% of students and 85% of educators identified this gap, with some educators recalling the frustration of watching students disengage during traditional lectures.

Exposure to statistical software emerged as a particularly urgent need: 82% of students and 76% of educators admitted to having little to no experience with programs like SPSS or Jamovi. Some students recounted how they first encountered these tools during advanced coursework, which left them

feeling unprepared and underconfident. The desire for flexibility was also noticeable, with 69% of students and 70% of educators expressing the need for self-paced learning options that would allow for repeated practice and reflection. Participants frequently wrote the value of being able to return to complex topics at their own pace, especially when balancing coursework with other responsibilities.

Collectively, these findings highlight the need for interventions that effectively bridge the gap between theoretical knowledge and practical application. In response, the researchers proposed integrating interactive digital tools such as SPSS and Jamovi into the instructional design. These platforms were selected for their technical capabilities and their potential to clarify statistical concepts and enhance learner confidence. The intervention incorporates guided practice, real-world data analysis, and technology-based activities to promote active mastery of statistical skills and support student development.

Table 1. Comparison of educators' and students' responses on learning challenges in educational statistics

Identified Challenge	Students	Educators
Difficulty in applying statistical concepts	78%	80%
Limited exposure to statistical software	82%	76%
Lack of interactive learning materials	76%	85%
Need for self-paced learning options	69%	70%

2) *Design and construction phase*

During the design and construction phase, the eLCP was developed based on constructivist learning principles and e-learning theory. The primary objective was to integrate SPSS and Jamovi, enabling students to apply theoretical knowledge to real datasets. The eLCP comprised interactive modules, video tutorials with instructors, guided data analysis exercises with step-by-step instructions (as seen in Fig. 2), and formative assessments to reinforce learning and build student confidence. To address the challenges often associated with learning statistics, the researchers prioritized accessibility and inclusivity. Each unit began with a narrative or real-life case study to contextualize the material. Discussion forums and live question-and-answer sessions facilitated peer interaction and collaborative learning. The curriculum emphasized real-world scenarios, requiring students to engage in problem-solving activities using authentic datasets relevant to their prospective careers. Feedback was provided promptly and tailored to individual needs, and supplementary resources were made available to support all students.

The course design blueprint underwent a thorough and collaborative expert evaluation, as shown in Table 2. Experts not only rated the design highly—with "Excellent" scores for Clarity of Objectives (4.70), Relevance of Content (4.80), and Integration of Technology (4.70)—but also provided thoughtful feedback. Instructional Coherence received a "Very Good" rating (mean 4.50), while Overall Design Quality achieved an "Excellent" mean of 4.68. Experts praised the adaptability of materials for diverse learning styles, highlighting how visual learners could benefit from annotated screenshots and video walk-throughs, while those who preferred hands-on practice could dive into interactive simulations and software exercises. The inclusion of step-by-step guides for SPSS and Jamovi was frequently noted as a key strength, making the learning less difficult for beginners. Several reviewers remarked on the supportive and inclusive tone of the instructions, which helped learners feel encouraged and capable. These high ratings and comments from experts confirm the course's strong pedagogical foundation and effective integration of technology, ensuring it met rigorous quality standards and genuinely supported student growth.

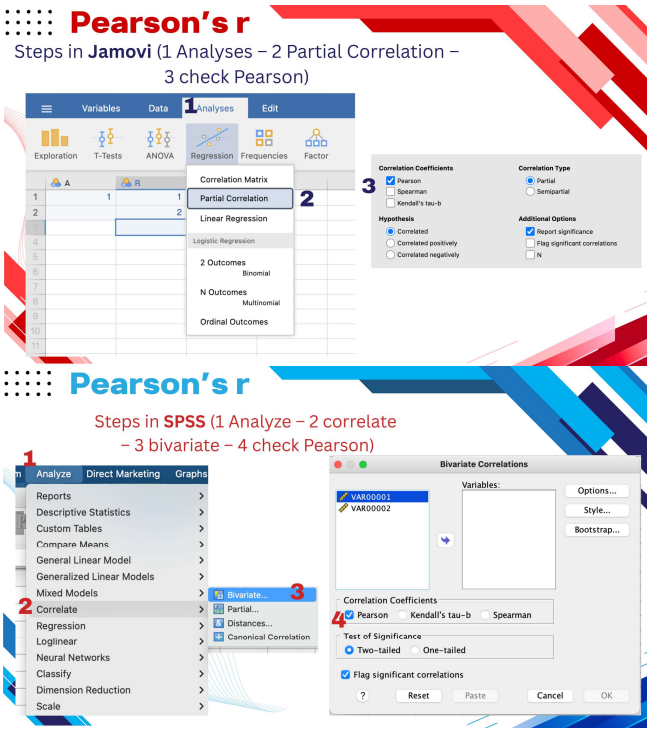

Fig. 2. Sample of eLCP in educational statistics.

Table 2. Expert ratings of eLCP in educational statistics

Criteria	Mean	Standard Deviation	Description
Clarity of Objectives	4.70	0.85	Excellent
Relevance of Content	4.80	0.71	Excellent
Instructional Coherence	4.50	1.08	Very Good
Integration of Technology	4.70	0.78	Excellent
Overall Design Quality	4.68	0.92	Excellent

Note: "Excellent" (5.00–4.51), "Very Good" (4.50–3.51), "Good" (3.50–2.51), Fair (2.50–1.51), "Needs Improvement" (1.50–1.00).

After receiving approval, instructional materials were uploaded to a Learning Management System (LMS). A pilot implementation with a small group of students informed subsequent adjustments to interface design, navigation, and accessibility.

3) *Evaluation and reflection phase*

During the evaluation and reflection phase, the researchers examined three key areas: student engagement, learning outcomes, and feedback. This approach allowed the researchers to not only measure the effectiveness of the activities, but also to understand how students participated, what they learned, and how they felt about the entire process.

Student Engagement Through the LMS. The evaluation and reflection phase provided compelling evidence of the course packet's effectiveness, particularly in terms of student engagement as tracked through the LMS. Table 3 illustrates a high level of commitment and active participation among students. Specifically, 97% of students completed all course modules, indicating strong adherence to the course structure.

In addition to quantitative data, qualitative feedback from discussion boards indicated that mastering SPSS or Jamovi

increased student confidence. Collaborative projects facilitated the development of peer relationships within the virtual environment. Students reported that accessible video tutorials reduced anxiety regarding statistical concepts, and timely instructor responses supported their learning. These experiences align with the course objective of promoting both academic development and a sense of community. Moreover, 93% of participants took part in quizzes and assessments, reflecting their sustained academic involvement and accountability. Notably, 90% of students utilized SPSS, while 85% engaged with Jamovi for practical exercises, suggesting that the integration of these digital tools effectively supported the application of statistical concepts in a real-world context.

Table 3. Quantitative indicators of student engagement

Engagement Metric	Percentage of Students
Completed all course modules	97%
Engaged in quizzes and assessments	93%
Used SPSS for practical exercises	90%
Used Jamovi for practical exercises	85%

Students reported that the self-paced format enabled them to balance academic requirements with employment, family, and other obligations. Accounts of late-night study for working with problem sets, and collaboration even after class hours highlighted the eLCP's inclusivity and adaptability. High engagement rates demonstrate the effectiveness of the course packet in promoting applied learning and underscore the importance of a supportive and flexible environment. The course facilitated the development of technical skills, self-efficacy, and resilience, outcomes that extend beyond the academic context.

Assessment of Learning Outcomes. Further evidence of the instructional intervention's effectiveness is demonstrated through the assessment of learning outcomes, as presented in Table 4. The data reveal a statistically significant improvement in students' statistical proficiency after the implementation of the developed eLCP. Specifically, the mean pretest score was 55.20, which increased to a mean posttest score of 82.50. The computed *t*-value of 10.23, with a *p*-value of 0.001, confirms that the improvement is statistically significant, indicating a strong effect of the intervention on student learning.

Beyond the numbers, students shared how the experience transformed their confidence and attitudes toward statistics. Many expressed that, prior to the course, they felt anxious or even intimidated by statistical software and data analysis. However, as they progressed, they began to see their accomplishment by successfully running their first analysis, interpreting output, or collaborating with classmates to solve complex problems. One student wrote, "I never thought I could actually enjoy statistics, but working with real data and getting immediate feedback made it feel achievable." Instructors also noticed that students who were once hesitant became more engaged in discussions and were willing to tackle challenging datasets.

To further assess the magnitude of this improvement, Cohen's d was calculated as the measure of effect size. The result yielded an effect size of 2.18, which is classified as very large based on conventional benchmarks [35]. This means that the eLCP produced a substantial and meaningful enhancement in students' learning outcomes. The use of Cohen's d as a tool for measuring effect size provides a clear indication of the intervention's educational value. Such a large effect underscores not only the importance of integrating practice-oriented approaches and digital tools—such as SPSS and Jamovi—but also the value of fostering a supportive and encouraging environment where students feel empowered to overcome challenges and succeed together.

While the effect size was very large (Cohen's $d = 2.18$), the researchers acknowledge potential inflation from familiarity with item stems or test-retest practice. Future cycles will use parallel forms and delayed posttests to assess retention effects and minimize practice gains.

Table 4. t-test results on the differences in the pretest and posttest scores of students

Test Type	Mean Score	Standard Deviation	*t*-value	*p*-value	Interpretation	Cohen's d
Pretest	55.20	8.04	-	-	-	-
Posttest	82.50	6.09	-	-	-	-
Difference	27.30	-	10.23*	0.001	Significant	2.18

Note: *$p < 0.05$ significant. Difference = Posttest – Pretest (mean = 27.30). Cohen's d (2.18) indicates a large practical effect.

Student Satisfaction of the eLCP. Student satisfaction with the eLCP was evaluated, as presented in Table 5. The data demonstrate a high level of positive feedback. Usability received the highest mean rating of 4.75, classified as Excellent, indicating that students perceived the platform as easy to navigate and intuitive. Participants reported that the clear layout and well-labeled resources facilitated efficient access to course materials. Furthermore, participants managing work or family responsibilities valued the flexibility to access materials at any time and from any device.

Both Content Quality and Engagement Level received mean scores of 4.60, rated as Excellent. These results indicate that students valued the relevance, clarity, and interactivity of the course materials. Participants identified real-life examples and interactive quizzes as factors that enhanced their learning experience.

The Learning Experience received a mean score of 4.70, also rated as Excellent, indicating that students considered the course enriching and supportive of their learning objectives. Participants reported appreciation for prompt instructor responses and the sense of community established through discussions and problem sets.

The Overall Satisfaction score averaged at 4.66, falling under the "Excellent" category. This high level of satisfaction indicates that the instructional design effectively met the students' needs. In open-ended survey responses, students frequently expressed gratitude for the supportive atmosphere and the encouragement they received from both instructors and classmates. One participant noted, "It felt like someone was cheering me on every step of the way." Others described how the course helped them overcome their initial fears of statistics and provided practical skills they could immediately apply to their work or studies.

The consistently high ratings across all indicators suggest a positive relationship between learner satisfaction, engagement, and academic performance in the e-learning environment. These findings confirm that the eLCP delivered high-quality content and provided a well-structured, engaging online learning experience. Student feedback further indicates that the course supported their ability to address new academic challenges with increased confidence.

Table 5. Student satisfaction survey results

Category	Mean	Standard Deviation	Description
Content Quality	4.60	0.81	Excellent
Usability	4.75	0.92	Excellent
Learning Experience	4.70	0.95	Excellent
Engagement Level	4.60	0.81	Excellent
Overall Satisfaction	4.66	0.86	Excellent

Note: "Excellent" (5.00–4.51), "Very Good" (4.50–3.51), "Good" (3.50–2.51), Fair (2.50–1.51), "Needs Improvement" (1.50–1.00)

A. Discussion

The findings underscore the significant impact of the developed eLCP on improving statistical literacy among graduate students. The analysis phase clearly identified that a lack of hands-on experience with statistical software and insufficient interactive learning resources were major impediments to students applying statistical concepts effectively. The design and construction of the course directly addressed these issues by integrating SPSS and Jamovi, providing a structured and interactive learning environment.

The evaluation phase provided strong evidence of the course packet's effectiveness. The high rates of student engagement—particularly in completing modules and utilizing both SPSS and Jamovi for practical exercises—demonstrate that the self-paced, interactive digital platform successfully enhanced student motivation and autonomy. This aligns with results from the study of Uchima-Marin *et al*. [36] emphasizing the benefits of interactive digital platforms for engagement.

The statistically significant improvement in pretest-posttest scores provides empirical evidence of substantial learning gains directly attributable to the intervention. This highlights the importance of practice-oriented approaches and well-designed formative assessment and scaffolding strategies in boosting learning outcomes, as supported by educational theories [37]. The high student satisfaction further reinforces that the instructional materials were not only effective but also well-received by the learners, confirming the positive correlation between learner satisfaction, engagement, and performance in online learning environments.

The "Excellent" and "Very Good" ratings from expert validators affirm the pedagogical soundness and technical integration of the course design. This expert validation is crucial for instructional materials, ensuring they meet quality standards and align with theoretical principles of learning.

Beyond the local context, our results mirror international evidence that interactive e-learning environments and constructivist tasks improve engagement and achievement in statistics and related fields [38]—particularly when learners work on authentic analyses using accessible tools like jamovi and SPSS [6, 8]. The high completion and tool-usage rates we observed are consistent with global reports of improved participation and confidence in digitally mediated, practice-oriented courses [39]. These alignments indicate that the eLCP's gains are not idiosyncratic to a single setting but reflect broader patterns reported internationally.

The observed engagement and proficiency gains are theoretically coherent with e-learning affordances (e.g., on-demand interaction, multimedia scaffolding) that mediate learner activity toward performance outcomes [28], and with constructivist principles wherein knowledge is built through guided work on authentic tasks [29, 32]. The eLCP's step-by-step software tasks operationalize these mechanisms by situating learners in repeated, feedback-rich analyses of real data.

Evidence from group discussions indicated that students experienced a sense of achievement through both academic performance and successful problem-solving in collaborative projects. Reports of increased participation and resource sharing suggest a positive shift in classroom dynamics [40]. Additionally, several learners noted that improved analytical abilities had an immediate impact on their research and professional responsibilities. These outcomes highlight the potential of integrating human support, flexible instructional design, and real-world application in online education [41].

Overall, the results strongly suggest that the e-learning course packet successfully bridges the gap between theoretical knowledge and practical application of statistical concepts, equipping graduate students with essential analytical competencies. Beyond measurable gains, the journey through the course was marked by numerous personal milestones—students who once felt intimidated by data analysis shared stories of newfound curiosity and pride in their achievements. Many described how, for the first time, they could interpret statistical results with confidence and even help peers outside the classroom. One participant recounted teaching a colleague how to use Jamovi, expressing surprise at their own ability to explain complex concepts so clearly.

This approach provides a viable solution to challenges in statistical education, especially in contexts where traditional instruction is disrupted and there is a need to prepare students for data-driven environments. The course fostered technical proficiency, resilience, self-efficacy, and a sense of community among learners. By emphasizing support, flexibility, and real-world application, the program enabled students to develop the skills and competencies required for future academic and professional challenges.

B. Limitations

Findings reflect a single-institution pilot with graduate students and may not generalize to other levels or contexts. The convenience sample and the absence of alternate test forms also limit causal inference. Future research should involve multi-site cohorts, parallel assessments, and longitudinal follow-ups.

IV. Conclusion

Statistical analysis is foundational to research, and proficiency in statistical software is a crucial skill. Filipino students face unique challenges in mathematics proficiency, exacerbated by external factors and systemic issues in education. This study successfully developed and evaluated

an eLCP that integrates SPSS and Jamovi to address these needs. Grounded in e-Learning Theory and constructivist principles, the eLCP was designed to enhance practical skills and foster active learning in Educational Statistics.

The research identified a critical need for hands-on experience with statistical software and interactive learning resources among graduate students. The designed course packet, developed through a rigorous EDR process, was highly rated by experts for its clarity, relevance, and technological integration. Its implementation demonstrated high levels of student engagement and resulted in a significant improvement in learning outcomes, with students expressing strong satisfaction regarding the course's usability and overall learning experience.

Breaking traditions with innovations functions as an effective instructional resource that develops essential analytical competencies by connecting theoretical knowledge to practical application. Beyond formal instruction, the course encouraged students to apply statistical concepts in everyday contexts, such as personal finance management and interpreting statistical information in media. Students also reported increased confidence in understanding complex concepts and communicating statistical results to others, as evidenced by their participation in discussion forums.

The success of the course demonstrates the effectiveness of innovative digital learning materials in improving statistical education and fostering a collaborative online learning environment. Student feedback indicated appreciation for instructor support and peer collaboration, which contributed to increased motivation and engagement. These findings suggest that technology, combined with supportive instructional practices, can enhance both analytical skill development and personal growth, preparing students for the demands of a data-driven society and future professional challenges.

This study makes a meaningful contribution to the ongoing discourse on statistical education and technology-enhanced learning, offering a practical and scalable solution for preparing students to meet the analytical demands of a data-driven society.

Given the demonstrated success of the eLCP indicates that educational institutions are recommended to explore the adoption and adaption of similar digitally-supported pedagogical strategies. Initiatives that integrate hands-on statistical software such as SPSS and Jamovi within flexible, interactive learning environments are essential for developing students' analytical competencies and building in an increasingly data-driven world, particularly in contexts facing educational disruptions.

Conflict of Interest

The authors declare no conflict of interest.

Author Contributions

All authors contributed significantly to the completion of the work. RSJ and SPBJ contributed to the preparation and presentation of the published work, specifically by writing the initial draft, design and development of the eLCP, and testing it to participants; ADC and MGAC were responsible for critical review, revisions, proofreading the article, and finalizing the format; RVHJ and GCC handled the application of statistical, mathematical, and computational techniques to analyze data. All authors had agreed the final version of the paper.

Funding

This research was funded by University Research and Development Center (URDC) of West Visayas State University through the Journal Publication Policy for Externally Funded Research, in accordance with BOR Resolution No. 55-2021.d.

Acknowledgment

The authors extend heartfelt gratitude to the University Research and Development Center of West Visayas State University, for their generous financial support, which facilitated the completion of this research and covered the APC for this article.

References

[1] H. S. Darling, "Statistical errors in scientific research: A narrative review," *Cancer Research, Statistics and Treatment*, vol. 7, no. 2, pp 241–249, Apr.–Jun. 2024. http//doi.org/10.4103/crst.crst_283_23

[2] W. Cao and M. Li, "Application and practice of Stata statistical software in the teaching of finance courses," in *Proc. 2023 Int. Conf. Intelligent Computing, Communication and Convergence (ICI3C)*, 2023, pp. 81–86. http//doi.org/10.1109/ICI3C60830.2023.00026

[3] B. Coetzee and A. Kagee, "Training staff and students in psychology in the R computer language: Implications for the psychology curriculum in South Africa," *Africa Education Review*, vol. 18, no. 1–2, pp. 33–50, 2021. http//doi.org/10.1080/18146627.2022.2107940

[4] S. A. Sardareh, G. T. L. Brown, and P. Denny, "Statistical software usability for novice research students in the social sciences: An eye-tracking study," *Journal of Statistics and Data Science Education*, 2025. http//doi.org/10.1080/26939169.2025.2497550

[5] D. H. Delport, "The development of statistical literacy among students: Analyzing messages in media articles with Gal's worry questions," *Teaching Statistics*, vol. 45, no. 2, pp. 61–68, 2023. http//doi.org/10.1111/test.12308

[6] D. J. Navarro and D. R. Foxcroft, *Learning Statistics with Jamovi: A Tutorial for Beginners in Statistical Analysis*, pp. 1–492, 2025. http//doi.org/10.11647/OBP.0333

[7] J. A. Villa-Ochoa, J. A. Carmona-Mesa, D. A. Quiroz-Vallejo, A. Castrillon-Yepes, and D. Farsani, "Computational thinking in mathematical modeling projects. A case study with future mathematics teachers," *Lecture Notes in Networks and Systems*, vol. 414, pp. 460–470, 2022. http//doi.org/10.1007/978-3-030-96293-7_38

[8] A. B. Duthie, *Fundamental Statistical Concepts and Techniques in the Biological and Environmental Sciences: With Jamovi*, Boca Raton, FL, USA: CRC Press, pp. 1–347, 2024. https://doi.org/10.1201/9781032692388

[9] K. K. Strunk and M. Mwavita, *Design and Analysis in Educational Research Using Jamovi: ANOVA Designs*, New York, NY, USA: Routledge, pp. 1–302, 2021. https://doi.org/10.4324/9781003154297

[10] R. Calin-Jageman and G. Cumming, "From significance testing to estimation and open science: How ESCI can help," *Int. J. Psychol.*, vol. 59, no. 5, pp. 672–689, 2024. https://doi.org/10.1002/ijop.13132

[11] C. A. Sequeira and E. M. Borges, "Enhancing statistical education in chemistry and STEAM using JAMOVI. Part 2. Comparing dependent groups and Principal Component Analysis (PCA)," *J. Chem. Educ.*, vol. 101, no. 11, pp. 5040–5049, 2024. https://doi.org/10.1021/acs.jchemed.4c00342

[12] P. K. Goel and V. Garg, "Tools-based value-added approaches and methodologies in student-centric learning," *Transdisciplinary Approaches to Learning Outcomes in Higher Education*, pp. 154–179, 2024. http//doi.org/10.4018/979-8-3693-3699-1.ch005.

[13] M. J. M. Salvilla and A. C. F. Dit, "HabagatPlus: Providing recommendations for localized class suspension in schools during inclement weather conditions using Naive Bayes classifier," in *Proc. 6th Int. Conf. Artif. Intell. Inf. Commun. (ICAIIC)*, 2024, pp. 419–424. http//doi.org/10.1109/ICAIIC60209.2024.10463336

[14] E. M. Preña and C. P. Labayo, "Policy responses to extreme heat and its impact on education: The Philippine experience," *Policy Futures in*

Education, vol. 23, no. 3, pp. 652–675, 2025. http//doi.org/10.1177/14782103241288276

[15] R. S. Bondoc Jr., "Motivation and attitudes of college varsity players towards community-based sports initiatives: Precursor to grassroots sports program," *Environment and Social Psychology*, vol. 8, no. 2, 1702, 2023. http//doi.org/10.54517/esp.v8i2.1702

[16] A. Paul, "Basic principles and application of statistics in drug research," *Introduction to Basics of Pharmacology and Toxicology: Volume 3: Experimental Pharmacology: Research Methodology and Biostatistics*, vol. 3, pp. 841–846, 2022. http//doi.org/10.1007/978-981-19-5343-9_58

[17] N. M. McKevett, R. S. Codding, and K. R. Running, "The effects of representational instruction and The Great Race on preschoolers' early numeracy skills," *Remedial and Special Education*, vol. 45, no. 1, pp. 18–29, 2024. http//doi.org/10.1177/07419325231160292

[18] D. R. B. Demate, M. S. Aclis, F. C. P. Catbagan, G. G. Molina, N. U. Ramos, and F. F. Patacsil, "Teacher perspectives on MATATAG curriculum: Challenges and collaborative solutions," *Multidisciplinary Reviews*, vol. 8, no. 11, e2025351, 2025. http//doi.org/10.31893/multirev.2025351

[19] J. Y. Haw and R. B. King, "Understanding Filipino students' achievement in PISA: The roles of personal characteristics, proximal processes, and social contexts," *Social Psychology of Education*, vol. 26, no. 4, pp. 1089–1126, 2023. http//doi.org/10.1007/s11218-023-09773-3

[20] L. Moulin and M. Soncin, "Persistent impacts of the COVID-19 pandemic on student outcomes in Italy," *Research in Economics*, vol. 79, no. 2, 101031, 2025. http//doi.org/10.1016/j.rie.2025.101031

[21] S. P. Bacio Jr., "Identifying learners' least-mastered competencies in Filipino 11: A foundation for digital module development," *International Journal of Information and Education Technology*, vol. 15, no. 6, pp. 1277–1288, 2025. http//doi.org/10.18178/ijiet.2025.15.6.2330

[22] P. M. Torion and S. P. Bacio Jr., "Video lessons for the course Introduction to Computing through Online/offline Mode (ICOM): Its development and evaluation," *International Journal of Information and Education Technology*, vol. 14, no. 6, pp. 845–855, 2024. http//doi.org/10.18178/ijiet.2024.14.6.2110

[23] R. G. Sagge Jr. and R. T. Segura Jr., "Designing and developing video lessons in mathematics using code-switching: A design-based research," *International Journal of Information and Education Technology*, vol. 13, no. 9, pp. 1391–1398, 2023. http//doi.org/10.18178/ijiet.2023.13.9.1942

[24] S. M. C. Quero and S. P. Bacio Jr., "Podcasts developed through the Successive Approximation Model 1 (SAM 1): A tool for teaching research to broadcasting students," *International Journal of Information and Education Technology*, vol. 15, no. 3, pp. 525–538, 2025. http//doi.org/10.18178/ijiet.2025.15.3.2263

[25] I. J. M. Galupar, R. G. Sagge Jr., S. P. Bacio Jr., R. V. Herrea Jr., and F. I. D. Solomon, "Advancing pedagogical methodologies through the development of a Robotics Training Manual (RTM) for mathematics," *International Journal of Information and Education Technology*, vol. 14, no. 12, pp. 1789–1798, 2024. http//doi.org/10.18178/ijiet.2024.14.12.2210

[26] R. G. Sagge Jr. and S. P. Bacio Jr., "Video explainer, e-module, or both: Which is better to improve statistics performance of graduate students?" *International Journal of Evaluation and Research in Education*, vol. 13, no. 5, pp. 3194–3201, 2024. https://doi.org/10.11591/ijere.v13i5.28945

[27] I.-L. Wu, P.-J. Hsieh, and S.-M. Wu, "Developing effective e-learning environments through e-learning use mediating technology affordance and constructivist learning aspects for performance impacts: Moderator of learner involvement," *Internet and Higher Education*, vol. 55, 100871, 2022, http//doi.org/10.1016/j.iheduc.2022.100871

[28] A. U. Gehret and L. B. Elliot, "Perceptions of e-learning by deaf and hard of hearing students using asynchronous multimedia tutorials," *Educational Technology Research and Development*, 2025. http//doi.org/10.1007/s11423-025-10476-z

[29] A. Mirosavljević, "Teacher professional development within constructivism learning theory," *Acta Iadertina*, vol. 19, no. 2, pp. 225–240, 2022. http//doi.org/10.15291/ai.3470 (in German)

[30] S. McKenney, "Educational design research for oracy development: Why, what, how?" *English Language Education*, vol. 36, pp. 73–85, 2024. https://doi.org/10.1007/978-3-031-59321-5_5

[31] S. McKenney and T. C. Reeves, "Educational design research," in *Handbook of Research on Educational Communications and Technology*, 4th ed., J. M. Spector, M. D. Merrill, J. Elen, and M. J. Bishop, Eds., New York, NY, USA: Springer, pp. 131–140, 2014. http://doi.org/10.1007/978-1-4614-3185-5

[32] C. Gugiu and M. Gugiu, "Determining the minimum reliability standard based on a decision criterion," *Journal of Experimental Education*, vol. 86, no. 3, pp. 458–472, 2018. http//doi.org/10.1080/00220973.2017.1315712

[33] S. McKenney and T. C. Reeves, "Educational design research: Portraying, conducting, and enhancing productive scholarship," *Medical Education*, vol. 55, no. 1, pp. 82–92, 2021. http//doi.org/10.1111/medu.14280

[34] H. P. Hailes, C. J. Ceccolini, E. Gutowski, and B. Liang, "Ethical guidelines for social justice in psychology," *Professional Psychology: Research and Practice*, 2020. http//doi.org/10.1037/pro0000291

[35] R. M. Conroy, "Calculating effect size for continuous variables: D537—A robust, quantile-based approach," *Physiotherapy*, vol. 97, no. 4, pp. 309–312, 2011. http//doi.org/10.1016/j.physio.2011.08.004

[36] C. Uchima-Marin, J. Murillo, L. Salvador-Acosta, and P. Acosta-Vargas, "Integration of technological tools in teaching statistics: Innovations in educational technology for sustainable education," *Sustainability (Switzerland)*, vol. 16, no. 19, 8344, 2024. http//doi.org/10.3390/su16198344

[37] B. Carcamo and B. Pino, "Developing EFL students' multimodal literacy with the use of infographics," *Asian-Pacific Journal of Second and Foreign Language Education*, vol. 10, no. 1, 16, 2025. http//doi.org/10.1186/s40862-025-00322-3.

[38] S. Poelmans and P. Wessa, "A constructivist approach in a blended e-learning environment for statistics," *Interactive Learning Environments*, vol. 23, no. 3, pp. 385–401, 2015. http//doi.org/10.1080/10494820.2013.766890

[39] L. A. Sharp, "Collaborative digital literacy practices among adult learners: Levels of confidence and perceptions of importance," *International Journal of Instruction*, vol. 11, no. 1, pp. 153–166, 2018. http//doi.org/10.12973/iji.2018.11111a

[40] K. Arifin, M. Sirih, A. Munir, Jahidin, and M. Sabilu, "The influence of multimodal learning strategies on prospective biology teachers' literacy-numeracy learning outcomes," *Eurasia Journal of Mathematics, Science and Technology Education*, vol. 21, no. 1, pp. em2563–em2563, 2025. http//doi.org/10.29333/ejmste/15802.

[41] S. K. Kakhki, N. Aghebati, and H. K. Moonaghi, "Exploring the impact, challenges, and integration of podcasts in patient education: A systematic review," *BMC Medical Education*, vol. 25, no. 1, 690, 2025. http//doi.org/10.1186/s12909-025-07217-4

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