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Students and Teachers Perspectives on Integrating Mobile Simulation-Based with Hands-On Learning: Foundations for Enhanced Instructional Design in Basic Electronics

Mafet O. Capao[1]; Victor S. Rosales[2]; Jan Vincent H. Leuterio[3]; Roque B. Requino[4]; Faith Q. Baldonado[5]

[1]Student Department of Technology Teacher Education, College of Education, Mindanao State University, Iligan Institute of Technology, Iligan City, 9200, Philippines

[2,3,4] Department of Technology Teacher Education, College of Education, Mindanao State University, Iligan Institute of Technology, Iligan City, 9200, Philippines

[5] Department of Computer Engineering and Mechatronics, College of Engineering, Mindanao State University, Iligan Institute of Technology, Iligan City, 9200, Philippines

E-mail: mafet.oti@g.msuiit.edu.ph
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Abstract

This study explores the integration of mobile simulation-based learning with traditional hands-on laboratory activities in a Basic Electronics course. Specifically, it aims to (1) assess student acceptance of the integrated approach using the Technology Acceptance Model (TAM), (2) examine teacher perspectives on its pedagogical value and implementation challenges, and (3) propose an evidence-informed action plan for effective integration. A mixed-methods research design was employed. Quantitative data were gathered from 40 students using a TAM-based survey, measuring Perceived Ease of Use (PEU), Perceived Usefulness (PU), Attitude Towards Using (ATU), and Behavioral Intention (BI). Qualitative data were collected through semi-structured interviews with five experienced electronics teachers. Results revealed positive student perceptions across all TAM constructs, with mean scores indicating strong agreement regarding the usability, usefulness, and continued use of the integrated approach. Statistically significant correlations were found among all TAM variables, consistent with TAM's theoretical framework. Thematic analysis of teacher interviews highlighted the pedagogical benefits and instructional innovation of the integrated approach, while also revealing concerns about potential distractions and over-reliance on technology. These findings confirm high student acceptance and teachers provide insights into the conditions necessary for successful instructional integration. Based on the results, a Plan-Do-Check-Act (PDCA) instructional framework is proposed to support the structured and sustainable adoption of mobile simulations in basic electronics education. This research provides evidence-based insights and offers a foundation for developing more engaging, effective, and accessible learning environments in technical and vocational education.

Keywords: *Mobile Simulation-Based Leaning; Hands-On Learning; Integrated Approach; Technology Acceptance; Instructional Design*

Introduction

Basic Electronics courses form a cornerstone of Technical Vocational Education and Training (TVET), traditionally relying heavily on hands-on laboratory experiments to bridge theoretical knowledge with practical application (Portillo et al., 2024). These physical labs are invaluable, offering indispensable experience with physical components, wiring, real-time troubleshooting, and fostering a deeper understanding of the non-ideal behaviors inherent in electronics (Sayil, 2021). However, the reliance on physical labs is not without its limitations. They are resource-intensive requiring dedicated space (Fitriani, 2024), equipment (Dounas-Frazer et al., 2022), and consumables (Pavlou & Zacharia, 2023), can pose safety concerns (Khazri et al., 2023), may limit accessibility for repeated or self-paced experimentation (Smajic et al., 2021), and can struggle to effectively visualize abstract electrical phenomena like current flow or voltage distribution (Lee et al., 2022).

The ascent of mobile technologies has introduced a paradigm shift, offering accessible, interactive, and cost-effective simulation tools that provide novel avenues for teaching and learning electronic concepts (Tognoni & Watkins, 2024). Mobile simulations provide a dynamic virtual environment where students can design, test, and visualize circuit behavior without the risk of damaging equipment or personal injury, facilitating a vigorous understanding of abstract concepts and allowing for rapid iteration and exploration of "what-if" scenarios (Villarreal, 2024). The "anytime, anywhere" learning modality afforded by mobile devices further enhances student engagement (Antipolo & Lopez, 2021), knowledge retention (Çakir & Çitak, 2022), and offers a scalable alternative to supplement physical setups (Shen & Bian, 2022). Yet, mobile simulations also have limitations. They inherently lack the haptic feedback of manipulating physical components and may oversimplify the unpredictable nuances and non-ideal characteristics encountered in authentic, tangible circuits (Abdullah et al., 2024).

Recognizing the distinct, yet complementary, strengths and limitations of each modality, a compelling case emerges for the thoughtful integration of mobile simulations with hands-on laboratories. Such an integrated pedagogy aims to create a richer, more holistic, and effective learning environment (Ukaegbu et al., 2024); (Clarke et al., 2023). This approach allows simulations to prepare students for physical labs by familiarizing them with concepts and circuit behaviors, while hands-on work grounds simulated knowledge in practical reality, thereby addressing the limitations of each method when used in isolation.

Therefore, this study explores the integration of mobile simulation-based learning with traditional hands-on laboratory activities in a Basic Electronics course. Specifically, it aims to assess student acceptance of this integrated approach using the Technology Acceptance Model (TAM), examine teacher perspectives on its pedagogical impact on the teaching and learning process, and subsequently propose an evidence-based action plan for its effective incorporation into instructional practice.

2. Methodology

2.1 Research Design

A mixed-method research design was employed for this study. The quantitative component involved the administration of a structured survey instrument for students to provide a structured assessment of perceptions regarding usefulness and ease of use—the qualitative component employed semi-structured interviews with teachers regarding their insights into the integrated learning approach.

2.2 Research Participants

The participants in this study comprised two groups: students and teachers. Forty (40) student participants were enrolled in a Fundamentals of Electronics course during the study and had direct exposure to the integrated instructional approach. In addition, five (5) experienced Electronics teachers participated in qualitative interviews. These teachers were selected based on their extensive background in teaching Fundamentals of Electronics. Although they did not directly observe the group of students engaging with the integrated approach, the researcher presented the specific mobile simulation tool used and provided a detailed explanation of how it was integrated into the hands-on laboratory activities.

2.3 Research Instruments

The Technology Acceptance Model (TAM) proposed by Davis (1989) served as the framework for evaluating students' perceptions of the integration of a mobile simulation tool with hands-on learning in Basic Electronics. The questionnaire measured four key constructs: Perceived Ease of Use, Perceived Usefulness, Attitude Towards Using, and Behavioral Intention. Items for each construct were adapted from previously validated instruments to ensure reliability and validity. All items were contextualized and specifically tailored to reflect the integrated instructional approach used in the study. The reliability coefficients (Cronbach's α) for each construct are as follows: Perceived Ease of Use = .874. Perceived Usefulness = .852, Attitude Towards Using = .878, and Intention to Use = .850. Responses were measured on a 5-point Likert scale, ranging from 5 (Strongly Agree) to 1 (Strongly Disagree).

In addition to the quantitative measures, qualitative data were gathered through semi-structured interviews with teachers. A content-validated, researcher-made interview guide was developed to ensure the relevance and clarity of the questions in capturing teachers' perceptions regarding the integrated instructional approach. The guide consisted of open-ended questions tailored for teachers, focusing on their assessment of the integrated approach's potential value, anticipated benefits for student learning, potential implementation challenges, and suggestions for effective integration.

2.4 Data Gathering Procedure

The data-gathering procedure for this study followed a systematic approach aligned with the mixed-methods design. Before data collection, necessary approvals and informed consent were obtained from the participating institutions, students, and teachers.

An orientation on the use of the mobile simulation application was conducted for all participants before the start of the instructional activities. The simulation tool utilized in this study was the mobile version of the Crumb Circuit Simulator. This application is designed to simulate basic electronic circuits in a mobile-friendly environment, making it accessible and convenient for students using smartphones or tablets. Learning activity worksheets were also developed and distributed, aligned with the course syllabus in Fundamentals of Electronics Technology, which emphasizes the construction of electronic circuits using both passive and active components. The activities outlined in the worksheets served as the foundation for the integrated instructional approach.

The learning sequence followed an integrated approach: participants first engaged with the mobile simulation application to construct and test virtual circuits. This enabled students to visualize circuit behavior, explore current flow and voltage levels, and identify issues in a risk-free environment. They were encouraged to adjust component values and configurations to enhance understanding. Following this, students replicated the same activities using physical components in a hands-on setup.

The TAM survey was administered to the 40 student participants after they had completed the course activities featuring the integrated learning approach, ensuring they had sufficient experience to provide informed responses. The survey was distributed in printed form, and participants were given sufficient time to respond to each item.

For the teacher participants, data collection followed a similar two-phase approach. Teachers were introduced to the mobile simulation tool and its integration with traditional hands-on learning before the data collection period. After sufficient exposure and observation of its application, they were invited to participate in semi-structured interviews.

2.6 Data Analysis

For the quantitative data analysis, descriptive statistics, including mean and standard deviation, were employed in this study. Pearson correlation analysis was conducted to examine the strength and direction of relationships between TAM constructs. The quantitative data collected through this study were coded and analyzed using the Statistical Package for the Social Sciences (SPSS) version 26 software.

For the qualitative data analysis, all interview proceedings were audio-recorded with participants' consent and transcribed verbatim. Thematic analysis was conducted following the iterative steps outlined by Braun and Clarke (2006). This method was applied independently to the student interview transcripts and the teacher interview transcripts. This process involved (1) familiarization with the data through repeated reading; (2) generating initial codes identifying significant features; (3) searching for potential themes by collating codes; (4) reviewing and refining themes about the dataset; (5) defining and naming themes; and (6) producing a coherent report of the findings, supported by illustrative quotes.

3. Results and Discussions

This study aimed to assess the perceptions of students and teachers of the integrated mobile simulation-based hands-on learning approach in basic electronics.

1. *What are the levels of Perceived Ease of Use (PEU), Perceived Usefulness (PU), Attitude Towards Using (ATU), and Behavioral Intention (BI) among students towards the integrated mobile simulation and hands-on learning approach in Basic Electronics?*

Table 1: Students Perceived Ease of Use of the Mobile Simulation Tool

Statements	**Mean±SD**	**Description**	**Interpretation**
1. The mobile simulation tool is easy to learn and operate.	4.50±0.506	Strongly Agree	Perceived Highly Easy to Use
2. The use of the mobile simulation tool does not require much assistance.	4.52±0.505	Strongly Agree	Perceived Highly Easy to Use
3. The interface of the mobile simulation tool is user-friendly.	4.50±0.554	Strongly Agree	Perceived Highly Easy to Use
4. The instructions provided by the mobile simulation tool are easy to follow.	4.57±0.500	Strongly Agree	Perceived Highly Easy to Use
5. The mobile simulation tool responds quickly to user actions.	4.45±0. 503	Strongly Agree	Perceived Highly Easy to Use
Overall mean	**4.51±0.306**	**Strongly Agree**	**Perceived Highly Easy to Use**

The data presented in Table 1 indicate that students overwhelmingly perceived the mobile simulation tool as highly easy to use (4.51±0.306). All individual statements related to PEU received mean scores of 4.45 or higher, corresponding to "Strongly Agree." These results suggest that the students found the mobile simulation tool intuitive, requiring minimal effort to learn and operate. The user-friendly interface, ease of following instructions, quick response to actions, and the perceived lack of need for assistance contributed to this high level of perceived ease of use.

This high Perceived Ease of Use is crucial for technology acceptance (Davis, 1989; Venkatesh & Davis, 2000). Well-designed mobile learning applications with intuitive interfaces significantly enhance user acceptance and usability (Naranjo et al., 2024).

Table 2: Students' Perceptions of the Usefulness of the Integrated Mobile Simulation and Hands-on Learning Approach (n = 40)

Statements	Mean±SD	Description	Interpretation
1. The integration of the mobile simulation tool and hands-on learning improves my understanding of basic electronics.	4.52±0.505	Strongly Agree	Perceived Highly Useful
2. The integration of the mobile simulation tool and hands-on learning enhances my skills in building electronic circuits.	4.72±0.452	Strongly Agree	Perceived Highly Useful
3. The integration of the mobile simulation tool and hands-on learning helps me perform electronics activities more efficiently.	4.50±0.506	Strongly Agree	Perceived Highly Useful
4. The integration of the mobile simulation tool and hands-on learning increases my learning productivity	4.57±0.500	Strongly Agree	Perceived Highly Useful
5. The learning experience becomes more effective when I use both simulation and real components.	4.67±0.474	Strongly Agree	Perceived Highly Useful
Overall mean	**4.60±0.323**	**Strongly Agree**	**Perceived Highly Useful**

Table 2 shows students' perceptions of the usefulness of the integrated mobile simulation and hands-on learning approach. The overall mean score of 4.60±0.323 indicates that students perceived this integrated approach as highly useful in enhancing their learning of basic electronics. Specifically, they strongly agreed that the integration improved their understanding, enhanced their circuit-building skills, increased their efficiency and learning productivity, and made the learning experience more effective. Students recognized the added value of combining mobile simulation with physical laboratory work. They believed that this blended approach significantly contributed to their comprehension of electronic concepts and the development of practical skills.

The strong perception of usefulness highlights the pedagogical benefits of integrating simulation tools with traditional hands-on learning in electronics education. This aligns with recent systematic reviews showing that virtual labs and simulations can enhance conceptual understanding and practical skills in technical fields like electronic circuits (Tokatlidis et al., 2024); (Wahyudi et al., 2024).

Table 3: Students' Attitudes Toward the Integration of Mobile Simulation and Hands-on Learning (n = 40)

Statements	Mean±SD	Description	Interpretation
1. I think combining the mobile simulation tool with hands-on learning is a good instructional approach.	4.55±0.503	Strongly Agree	Very Positive Attitude
2. I have a positive attitude toward using both the mobile simulation tool and hands-on in learning basic electronics.	4.62±0.490	Strongly Agree	Very Positive Attitude
3. I feel more confident when I practice with the mobile simulation tool before	4.57±0.500	Strongly Agree	Very Positive Attitude

doing physical circuit work.			
4. I find learning electronics through both simulation and hands-on activities enjoyable and motivating.	4.52±0.505	Strongly Agree	Very Positive Attitude
5. Overall, I like the integration of the mobile simulation tool with hands-on learning in my electronics classes	4.60±0.496	Strongly Agree	Very Positive Attitude
Overall mean	**4.57±0.357**	**Strongly Agree**	**Very Positive Attitude**

As presented in Table 3, students exhibited a very positive attitude towards the integration of mobile simulation and hands-on learning, with an overall mean score of 4.57±0.357. They expressed strong agreement with statements indicating that they found the integrated approach good for instruction, held a positive attitude towards it, felt more confident practicing with the simulation before physical work, and found the learning enjoyable and motivating. The students' positive affective responses to the integrated learning approach suggest that they were engaged and motivated by the combination of simulation and hands-on activities. The increased confidence reported after using the simulation prior to physical construction underscores the role of simulation in preparing students for laboratory work. Positive attitudes are linked to increased engagement and satisfaction in technology-enhanced learning environments (Blackburn et al., 2018).

Table 4: Students' Behavioral Intention on Mobile Simulation Integrated with Hands-on Learning (n = 40)

Statements	Mean±SD	Description	Interpretation
1. I intend to continue using the mobile simulation tool together with hands-on learning to achieve my learning objectives.	4.55±0.503	Strongly Agree	Strong Intention to Use
2. I am likely to use the mobile simulation tool with hands-on activities in future electronics courses.	4.62±0.490	Strongly Agree	Strong Intention to Use
3. I plan to use mobile simulation tools regularly when studying or reviewing electronic circuit building.	4.50±0.506	Strongly Agree	Strong Intention to Use
4. I plan to incorporate mobile simulation tools whenever I engage in electronics activities.	4.65±0.483	Strongly Agree	Strong Intention to Use
5. I am willing to recommend mobile simulation tools integrated with hands-on learning to other students learning electronics.	4.45±0.552	Strongly Agree	Strong Intention to Use
Overall mean	**4.55±0.318**	**Strongly Agree**	**Strong Intention to Use**

Table 4 demonstrates a strong intention among students to continue using mobile simulation integrated with hands-on learning (Overall mean = 4.55±0.318). They indicated a strong likelihood of using this approach in future electronics courses, regularly incorporating mobile simulation tools in their study and review, and even recommending it to other students. The high scores for behavioral intention indicate that students not only found the integrated approach useful and easy to use but were also willing to adopt it for their future learning (Buabeng-Andoh, 2020).

This willingness to continue using the approach and recommend it to others signifies a positive and sustainable acceptance of this pedagogical strategy.

2. How do PEU, PU, ATU, and BI interrelate for students within the context of this integrated learning approach, and do these relationships align with the established TAM framework?

Table 5: Intercorrelation Matrix of TAM Constructs

Perceived Ease of Use (PEU)			
Perceived Usefulness (PU)	552**		
Attitude Towards Using (ATU)	53**	714**	
Behavioral Intention (BI)	393*	07**	551**

**. Correlation is significant at the 0.01 level (2-tailed).
*. Correlation is significant at the 0.05 level (2-tailed).

Table 5 presents the intercorrelation coefficients among the constructs of the Technology Acceptance Model (TAM), specifically Perceived Ease of Use (PEU), Perceived Usefulness (PU), Attitude Towards Using (ATU), and Behavioral Intention to Use (BI). All variables were found to have statistically significant positive correlations with one another, indicating strong interrelationships in the acceptance of mobile simulation-based learning tools among the participants. A significant moderate correlation was found between PEU and PU ($r = .552$, $p < .01$), suggesting that students who found the mobile simulation tool easy to use also perceived it as more useful. This finding aligns with recent study of (Lefrid et al., 2023), who confirmed that ease of use strongly influences perceived usefulness in the adoption of educational technologies. Similarly, a strong correlation between PU and ATU ($r = .714$, $p < .01$) implies that the more useful students perceive the simulation-based learning tool, the more positively they feel about using it. This relationship supports the findings of (Darling et al., 2024), who reported that perceived usefulness is a key determinant of users' attitudes toward technology-enhanced learning environments. In addition, ATU showed a significant positive correlation with BI ($r = .551$, $p < .01$), indicating that students with favorable attitudes toward the integrated instructional approach were more likely to intend continued use of the mobile simulation tool. This is consistent with the assertions of (Or, 2024), who emphasized the critical role of learner attitude in shaping behavioral intentions to use educational technologies. The relationship between PU and BI was also robust ($r = .607$, $p < .01$), reinforcing the idea that perceived usefulness directly influences students' intention to adopt and continue using the technology. Lastly, PEU was moderately correlated with BI ($r = .393$, $p < .05$), suggesting that while usability contributes to intention to use, its effect may be more indirect, possibly mediated by perceived usefulness and attitude (Toros et al., 2024).

These findings underscore that incorporating mobile simulation with physical hands-on activities may have strengthened the perceived ease and usefulness of the learning experience, thereby shaping positive attitudes and strong intentions to use the technology in future learning activities.

3. What are the perceptions of experienced Electronics teachers regarding the integrated approach?

Teachers Perceptions of the Integrated Mobile Simulation Based and Hands-on Learning

The experienced electronics teachers shared their perspectives on integrating mobile simulation with hands-on learning, highlighting both the promising aspects and potential hurdles they foresee:

Theme 1: Acknowledgment of Pedagogical Benefits

Teachers generally acknowledged the pedagogical advantages of integrating mobile simulation tools into electronics instruction. They emphasized that such tools have the potential to enhance students' conceptual understanding and increase their engagement, particularly when used as preparatory activities prior to hands-on laboratory work. One teacher shared:

“...Simulations can help students visualize abstract concepts like current flow before they get to the lab. This could make their practical work more efficient and less prone to errors.” (T2)

This sentiment reflects the view that mobile simulations can serve as effective scaffolding tools, enabling students to develop cognitive frameworks that translate into more productive physical practice. Another teacher shared:

“...It’s a great way to build foundational knowledge. Students can explore and make mistakes in the simulation without the fear of damaging real components.” (T5)

This underscores the low-risk, exploratory nature of simulations, which facilitates experiential learning without the material constraints and risks associated with real equipment. Another teacher observed,

“...Using simulations before hands-on activities gives students a chance to test their understanding. It creates a smoother transition to real-life application.” This reflects the belief that simulations can act as cognitive primers, improving students' readiness for real-world application and reducing trial-and-error during lab activities. (T1)

These findings are consistent with prior research indicating that simulations enhance conceptual understanding through dynamic visualization (Zhu & Liu, 2021); (Minev, 2024). Furthermore, when simulations are used as preparatory tools, they have been shown to improve the efficiency and effectiveness of subsequent hands-on activities (Adebusuyi et al., 2023). Collectively, the teachers’ perspectives in this study affirm the value of an integrated instructional approach that leverages the strengths of both virtual and physical learning environments.

Theme 2: Recognition of Instructional Innovation and Relevance in Modern Teaching

The teachers recognized the potential of integrating mobile simulation with hands-on learning as an innovative and timely pedagogical approach. They reflected on its alignment with current educational demands and the opportunities it offers for improving student engagement and competency development.

"...The integrated approach makes a lot of sense. Students today are so used to using their phones—it’s practical to bring learning to a platform they’re already comfortable with.”

"...Integrating simulation before actual lab work is a smart move. It gives students the confidence and familiarity they need to perform better with physical tools later on." (T4)

"The method shared with us seems very student-centered. I appreciate how it allows for visual learning and independent exploration before they move to the tactile phase." (T1)

"This kind of instructional design is exactly what technical education needs right now—something engaging, flexible, and still grounded in skill development. It’s very relevant, especially with the growing use of technology in the workplace." (T2)

These teacher perspectives are consistent with recent literature highlighting the value of technology-enhanced instruction in technical education. Studies emphasize that mobile simulations support active learning, visualization of abstract concepts, and flexible access to content (Behera, 2023).

Moreover, blended learning approaches are shown to enhance student motivation and autonomy (Fearn, 2022), while still preserving the importance of hands-on experience for psychomotor development (Rashevska & Kiianovska, 2023).

Theme 3: Concerns About Distraction and Over-Reliance on Technology

A common worry among teachers was the potential for mobile devices to become a source of distraction in the classroom, as well as the risk of students becoming overly dependent on simulation tools at the expense of essential hands-on skills.As one teacher stated,

"...My main concern is keeping them focused. When they have their phones or tablets out, it's so easy for them to drift off to social media or games. We'd need really clear guidelines and activities designed to keep them on task with the simulation itself. It's a balancing act – harnessing the tech without letting it become a distraction." (TI)

This highlights the challenge of integrating mobile technology thoughtfully to maintain educational focus. Research on mobile device use in education has indeed pointed to the dual nature of these tools, with potential for both engagement and distraction (Ramlan & Nasir, 2023). Effective classroom management strategies and purposeful integration are crucial. Another significant concern was that simulations, while beneficial, might not fully replace the tactile and psychomotor skill development gained from physical hands-on work, and could potentially lead to over-reliance.

"...There's a real danger that students might become too dependent on the simulation. They still need to learn how to physically build a circuit, troubleshoot with actual instruments, and feel the components. We need to make sure the hands-on part remains a core element." (T3)

This resonates with the arguments emphasizing the importance of haptic feedback and psychomotor skills in technical education (Arifin et al., 2024). While simulations offer cognitive benefits, the development of practical dexterity and troubleshooting skills with real equipment remains crucial (Muoghalu & Ahmad, 2024). The key is finding a balance, as suggested by the integrated approach in this study (Mansour, 2024).

4. *Based on these findings, what is a proposed action plan for successfully integrating mobile simulation-based learning with hands-on learning in basic electronics?*

Proposed Action Plan for Integrating Mobile Simulation-Based with Hands-on Learning

Based on the quantitative findings of student acceptance and the rich qualitative insights from experienced teachers, an action plan was proposed. The Plan-Do-Check-Act (PDCA) framework was used as the guiding model. This framework consists of four key phases—planning, doing, checking, and acting—to ensure continuous improvement and effective execution of the integration process. The framework employed is aimed at promoting systematic and evidenced-based approach integrating mobile-simulation with hands-on learning in basic electronics instruction.

Table 6: *Proposed Action Plan for Integrating Mobile Simulation-Based and Hands-On Learning in Basic Electronics Using the PDCA Framework*

Phase and Timeline	**Actions**	**Responsible Persons**	**Expected Outputs**
Phase 1 – Plan Timeline: Before the start of the first semester	Review and align the course syllabus for the possible updates and changes in the contents and methods.	Electronics Instructors, Department Chairman, Field of Experts	Updated and aligned course syllabus for Fundamentals of Electronics
	Determine integration points for mobile simulation-based learning within the course structure.	Electronics Instructors	Defined integration areas for mobile simulation-based components.
	Develop student learning activity worksheets integrated with mobile simulation based and hands on learning	Electronics Instructors	Drafted integrated learning activity worksheets.
	Validate the learning activity worksheets in terms of content, technical, and instructional qualities.	Validators, Field of Experts	Validated and approved learning activity worksheets.
	Prepare evaluation tools including pretest, posttest, and skills-based practical assessments.	Electronics Instructors	Finalized pretest, posttest, and performance-based assessment tools.
Phase 2- Do Timeline: Throughout the Semester	Administer pre-intervention assessments to establish baseline knowledge	Electronics Instructors	Collected baseline data on students' knowledge
	Implement the use of the integrated learning activity worksheets during laboratory classes.	Electronics Instructors	Completed implementation of integrated lessons in laboratory activities.
	Provide ongoing support and monitor student progress and engagement during the integration	Electronics Instructors	Observations and notes on student participation and tool usability.
Phase 3 – Check Timeline: End of the Semester	Assess student outputs using posttests and skills-based practical assessments.	Electronics Instructors	Posttest results and skills-based performance results
	Conduct focus group discussions (FGDs) or semi-structured interviews with students to gather feedback.	Electronics Instructors,	Transcribed qualitative data from interviews and FGDs.
	Gather feedback from instructors regarding instructional delivery and student responsiveness.	Electronics Instructors,	Teaching feedback report
	Analyze data for emerging patterns on student perception, learning outcomes, and instructional quality	Electronics Instructors,	Comprehensive report on effectiveness and user perceptions.
Phase 4- Act Timeline: Post Semester	Refine worksheets and instructional approach based on evaluation findings.	Electronics Instructors	Improved and contextualized materials and instructional plan.
	Document best practices and challenges encountered.	Electronics Instructors	Compiled report on best practices and implementation challenges.
	Plan for broader implementation and possible integration into other electronics courses.	Electronics Instructors, Program Coordinators	Strategic plan for upscaling or broader integration of the approach.

As shown in the table 6, the emphasis of the first phase is on groundwork and preparation. This phase begins by reviewing and updating the course syllabus with subject matter experts to discuss potential updates and changes to the content and methods. Instructors identify suitable integration points for mobile simulation-based learning within the course structure based on a thorough needs assessment. Once an overall understanding of the syllabus is established, available school resources such as textbooks and supplementary learning references are examined, as these resources are critical to effectively support the integration process (Khan & Alamri, 2017; Molaudzi, 2020). Careful planning is then undertaken to determine how mobile simulation can be combined with traditional hands-on learning. Following the conceptualization and strategic identification of integration points, instructors design and develop learning activity worksheets that combine mobile simulation with hands-on experiments. Each worksheet is structured to include essential instructional components—such as a brief introduction to the components used, a schematic diagram, a blank breadboard layout, procedures, parts lists, experimental learning objectives, observations, and reflection questions. According to (Buffalari, 2022; Susanto et al., 2020), when all of the components in a structured worksheet are carefully considered, it leads to an effective learning process. Experts validate the worksheets to ensure quality in content, technical, and instruction. Evaluation tools like pretests/posttests (Goel et al., 2020; Schiekirka et al., 2013) and rubrics (Olson & Krysiak, 2021) are designed to assess knowledge and practical skills, aligning with the intended learning outcomes.

During the second phase, the focus is on enabling students to explore, design, and test circuits. After completing the simulation exercises, they proceed to construct the corresponding physical circuits using real components. This approach deepens their understanding of theoretical concepts and their practical applications. Additionally, interventions must undergo regular evaluation (Phase 3) and subsequent revision and improvement (Phase 4). Ajmal et al. (2024) underscore the importance of continuous evaluation and feedback in refining instructional design and enhancing teaching effectiveness. Similarly, Chan et al. (2024) and Berge (2021) highlight that sustaining instructional innovations requires iterative refinement grounded in classroom evidence and learner feedback.

Effective teaching necessitates thorough planning to ensure that instructional strategies, learning materials, and assessment methods harmonize with educational goals and learner needs. Karngbeae and Kennedy (2022) assert that planning is a foundation for successful instruction, fostering coherence between objectives, content, and pedagogy. Lawrence (2023) emphasizes the principle of constructive alignment, suggesting that teaching activities and assessments should be intentionally designed to support the desired learning outcomes. Ubaidah et al. (2023) also underscore the importance of systematic instructional design in promoting meaningful learning and skill development. Additionally, Meng (2023) highlights the necessity of aligning instruction with effective learning strategies and advocating for active, contextual, and reflective learning experiences.

Conclusion

The findings of this study offer valuable insights into the perceptions of students and teachers regarding the integration of mobile simulation with hands-on learning in basic electronics. Quantitative results revealed high levels of perceived ease of use and usefulness among students, accompanied by a very positive attitude and a firm behavioral intention to continue using the integrated instructional approach. These findings suggest a high level of student receptiveness and an evident appreciation for the educational benefits of integrating mobile simulations with hands-on learning.

Qualitative feedback from teachers reinforced these outcomes by highlighting three key themes: an acknowledgment of the pedagogical benefits of simulation-based learning, recognition of its instructional innovation and relevance in modern teaching, and concerns about potential distractions and the risk of over-reliance on technology at the expense of hands-on skill development.

Based on the result, a PDCA-based instructional action plan was proposed. The proposed action plan, derived directly from these empirical findings, offers a structured and evidence-based framework for educators and institutions to design, implement, and iteratively refine integrated learning experiences in Basic Electronics. By strategically combining the strengths of mobile simulations for conceptual exploration, safe experimentation, and pre-lab preparation with the indispensable practical skills developed in hands-on labs, educators can create a more engaging, effective, and holistic learning environment. Ultimately, this approach aims to better prepare students for the demands of real-world technical careers and foster a deeper, more resilient understanding of this foundational technical field.

Limitations

This study has some limitations. The student sample was from a single institution and a specific course, which may limit the generalizability of the findings. The teachers interviewed did not directly observe the student group using the integrated approach but were presented with the methodology; direct observation might have yielded different or additional insights. Furthermore, this study focused on perceptions and intentions rather than direct measures of learning outcomes, although perceived usefulness often correlates with learning gains. Future research could investigate the impact of this integrated approach on actual student learning outcomes and skill development using experimental design.

Ethical Procedures

All procedures involving human participants were performed in accordance with the ethical standards. Informed consent was obtained from all individual participants included in the study. Anonymity of survey respondents and anonymity of interview participants were maintained throughout the research process to ensure confidentiality.

References

Abdullah, N. R., Nawi, N. M. N. M., Salameh, N. a. A., Deraman, N. R., & Harun, N. a. N. (2024). Enhancing Collaborative Learning in Mobile Environments through Interactive Virtual Reality Simulations. International Journal of Interactive Mobile Technologies (iJIM), 18(11), 15–26. https://doi.org/10.3991/ijim.v18i11.49049.

Adebusuyi, O. F., Olajumoke, T. O., Akinnifesi, J. B., & Karinatei, S. M. (2023). The effectiveness of Computer-Based simulations and traditional hands-on activities on secondary school students' performance and science process skills in practical chemistry. Journal of Education in Black Sea Region, 8(2), 108–120. https://doi.org/10.31578/jebs.v8i2.297.

Ajmal, M., Basit, I., & Sadaf, S. (2024). Evaluating the role of students' feedback in enhancing teaching effectiveness. Pakistan Journal of Humanities and Social Sciences, 12(2). https://doi.org/10.52131/pjhss.2024.v12i2.2255.

Antipolo, J. J., & Lopez, M. L. (2021). Simulation App: Improving the procedural knowledge of Electronics Technology students in electric Circuits. American Journal of Educational Research, 9(8), 488–497. https://doi.org/10.12691/education-9-8-4.

Arifin, A., Seth, N. H. N., Zainuddin, N. M. M., & Haron, H. N. (2024). Learning Outcomes of Psychomotor Domains in Welding Technology: VR Welding Kit Assessment: A Systematic Literature review. Journal of Education Culture and Society, 15(2), 599–616. https://doi.org/10.15503/jecs2024.2.599.616.

Behera, D. K. (2023). Technological Interventions in Education: An empirical review of their impact on learning outcomes. ALSYSTECH Journal of Education Technology, 1(1), 62–77. https://doi.org/10.58578/alsystech.v1i1.1674.

Berge, Z. L., PhD. (2021). Secret of Instructional Design revisited. Frontiers in Education Technology, 4(4), p26. https://doi.org/10.22158/fet.v4n4p26.

Blackburn, R. a. R., Villa-Marcos, B., & Williams, D. P. (2018). Preparing students for practical sessions using laboratory simulation software. Journal of Chemical Education, 96(1), 153–158. https://doi.org/10.1021/acs.jchemed.8b00549.

Braun, V., & Clarke, V. (2006). Using thematic analysis in psychology. Qualitative Research in Psychology, 3(2), 77-101.

Buabeng-Andoh, C. (2020). Exploring University students' intention to use mobile learning: A research model approach. Education and Information Technologies, 26(1), 241–256. https://doi.org/10.1007/s10639-020-10267-4.

Buffalari, D. (2022). Structured worksheets: simple active learning strategies to increase transparency and promote communication. PubMed, 20(2), A241–A253. https://doi.org/10.59390/vohj7109.

Çakir, A., & Çitak, Ü. (2022). Simulation of logic circuit tests on Android-Based mobile devices. Jurnal Ilmiah Teknik Elektro Komputer Dan Informatika, 8(1), 27. https://doi.org/10.26555/jiteki.v8i1.22200.

Chan, P. E., Konrad, M., Gonzalez, V., Peters, M. T., & Ressa, V. A. (2024). The critical role of feedback in formative instructional practices. Intervention in School and Clinic, 50(2), 96–104. https://doi.org/10.1177/1053451214536044.

Clarke, K., Torres, A., Peixoto, M. J. P., & Dubrowski, B. K. a. A. (2023). MOBILE LEARNING AND SIMULATION FOR THEDEVELOPMENT OF HANDS-ON CLINICAL SKILLS. https://www.iadisportal.org/digital-library/mobile-learning-and-simulation-for-the-development-of-hands-on-clinical-skills.

Darling, M. G., Inteseful, T. F., Peprah, K. O., & Arthur, Y. D. (2024). Assessing the Effectiveness of Virtual Reality simulation in ICT Education: A study based on the Technology Acceptance Model. International Journal of Information Technology and Computer Engineering, 46, 26–40. https://doi.org/10.55529/ijitc.46.26.40.

Davis, F. D. (1989). Perceived usefulness, perceived ease of use, and user acceptance of information technology. MIS Quarterly, 13(3), 319–340.

Dounas-Frazer, D. R., Gillen, D., Herne, C. M., Howard, E., Lindell, R. S., McGrew, G., I., Mumford, J. R., Nguyen, N. H., Osadchuk, L. C., Crane, J. P., Pugeda, T. M., Reeves, K., Scanlon, E. M., Spiecker, D., & Xu, S. Z. (2022, February 2). Increase investment in accessible Physics Labs: a call to action for the physics education community. arXiv.org. https://arxiv.org/abs/2202.00816.

Fearn, L. J. (2022). Transforming Teacher Education with Mobile Technologies. Open Learning the Journal of Open Distance and e-Learning, 37(2), 209–212. https://doi.org/10.1080/02680513.2022.2042229.

Fitriani, A. (2024). Comparison of the Effect of Using Virtual Laboratory Based on PhET Simulation and Real Laboratory in Improving Mastery of Electronic Concepts of Physics Education Students. Teknopedagogi, 14(2), 22–28. https://doi.org/10.22437/teknopedagogi.v14i2.37487.

Goel, N., Deshmukh, K., Patel, B. C., & Chacko, S. (2020). Tools and rubrics for assessment of learning outcomes. In Advances in educational technologies and instructional design book series (pp. 211–254). https://doi.org/10.4018/978-1-7998-4784-7.ch013

Karngbeae, L. D., & Kennedy, G. M. (2022). Instructional planning: its importance and basic components. INTERNATIONAL JOURNAL OF SOCIAL SCIENCE AND EDUCATION RESEARCH STUDIES, 02(12). https://doi.org/10.55677/ijssers/v02i12y2022-13.

Khan, S., & Alamri, S. (2017). Technology integration in education. Imam Journal of Applied Sciences, 2(1), 1. https://doi.org/10.4103/ijas.ijas_32_16.

Khazri, Y., Laouina, Z., Moussetad, M., Adhiri, R., & Mourdane, S. (2023). Remote Laboratories E-Lab FSBM: architecture and implementation of new experiments. In Lecture notes in networks and systems (pp. 207–216). https://doi.org/10.1007/978-3-031-42467-0_19.

Lawrence, J. E. (2023). The application of constructive alignment Theory in designing a curriculum unit in information systems. The Educational Review USA, 7(4), 471–482. https://doi.org/10.26855/er.2023.04.015.

Lee, S., Guthery, C., Kim, D., & Calkins, A. (2022). Open-Source Virtual Labs with Failure-Mode-Inspired Physics and Optics Experiments. The Physics Teacher, 60(6), 453–456. https://doi.org/10.1119/5.0056462.

Lefrid, M., Cavusoglu, M., Richardson, S., & Donnelly, C. (2023). Simulation-Based Learning Acceptance Model (SBL-AM): Expanding the Technology Acceptance Model (TAM) into Hospitality Education. Journal of Hospitality & Tourism Education, 1–15. https://doi.org/10.1080/10963758.2023.2188217.

Mansour, A. (2024, October 29). Exploring the use of virtual Reality in vocational training for electricians in Egypt. https://www.paradigmpress.org/rae/article/view/1374.

Meng, S. (2023). Enhancing Teaching and Learning: Aligning Instructional Practices with Education Quality Standards. Research and Advances in Education, 2(7), 17–31. https://doi.org/10.56397/rae.2023.07.04.

Minev, P. (2024, December 20). Visual simulation of a digital hardware model. Science Series "Innovative STEM Education." https://www.math.bas.bg/vt/stemedu/paper.php?article=2024.0612en.

Molaudzi, A. M. (2020). The role of resources in promoting teaching and learning in South Africa. In Global education systems (pp. 1–20). https://doi.org/10.1007/978-3-030-43042-9_35-1.

Muoghalu, N. C., & Ahmad, A. B. (2024, November 28). Exploring Practical skills requirements in Auto Electricity/Electronics in Motor Vehicle Mechanic Program for maintenance of modern vehicles in Technical Colleges in Nigeria. https://hrmars.com/index.php/IJARBSS/article/view/23657/Exploring-Practical-Skills-Requirements-in-Auto-ElectricityElectronics-in-Motor-Vehicle-Mechanic-Program-for-Maintenance-of-Modern-Vehicles-in-Technical-Colleges-in-Nigeria.

Naranjo, F. a. V., Toapanta, W. V. C., & Ocaña, L. a. L. (2024). Analysis of the design and usability characteristics of mobile applications preferred by students: perspectives from the unidad educativa .

González Suárez. Data & Metadata, 3. https://doi.org/10.56294/dm2024.232.

Olson, J. M., & Krysiak, R. (2021). Rubrics as tools for effective assessment of student learning and program quality. In Advances in mobile and distance learning book series (pp. 173–200). https://doi.org/10.4018/978-1-7998-7653-3.ch010.

Or, C. (2024). Watch That Attitude! Examining the Role of Attitude in the Technology Acceptance Model through Meta-Analytic Structural Equation Modelling. International Journal of Technology in Education and Science, 8(4), 558–582. https://doi.org/10.46328/ijtes.575.

Pavlou, Y., & Zacharia, Z. C. (2023). Using physical and virtual labs for experimentation in STEM+ education: from theory and research to practice. In Contributions from biology education research (pp. 3–19). https://doi.org/10.1007/978-3-031-44792-1_1.

Peserta Didik Pada Praktikum Tulang. BIODIK, 6(3), 372–383. https://doi.org/10.22437/bio.v6i3.9459.

Portillo, F., Soler-Ortiz, M., Sanchez-Cruzado, C., Garcia, R. M., & Novas, N. (2024). The impact of flipped learning and digital laboratory in basic electronics coursework. Computer Applications in Engineering Education, 33(1). https://doi.org/10.1002/cae.22810.

Ramlan, M. F., & Nasir, M. K. M. (2023, September 24). The Impact of Mobile Applications in Education: A Concept paper. https://hrmars.com/index.php/IJARPED/article/view/19609/The-Impact-of-Mobile-Applications-in-Education-A-Concept-Paper.

Rashevska, N. V., & Kiianovska, N. M. (2023). Improving blended learning in higher technical education institutions with mobile and cloud-based ICTs. Educational Dimension, 9, 13–31. https://doi.org/10.31812/ed.608.

Sayil, S. (2021, July 26). Enhancing student learning via hardware in homework. https://peer.asee.org/enhancing-student-learning-via-hardware-in-homework.

Schiekirka, S., Reinhardt, D., Beibarth, T., Anders, S., Pukrop, T., & Raupach, T. (2013). Estimating learning outcomes from Pre- and posttest student Self-Assessments. Academic Medicine, 88(3), 369–375. https://doi.org/10.1097/acm.0b013e318280a6f6.

Shen, L., & Bian, X. (2022). Mobile semi-physical experiment platform using ultra-compact real-time simulator Pocket Bench for power electronics courses. Computer Applications in Engineering Education, 30(6), 1885–1902. https://doi.org/10.1002/cae.22563.

Smajic, H., Sanli, A., & Wessel, N. (2021). Education 4.0: Remote learning and experimenting in laboratory for automation. In Advances in intelligent systems and computing (pp. 49–55). https://doi.org/10.1007/978-3-030-67209-6_6.

Susanto, F. N., Anggraeni, S., & Supriatno, B. (2020). Analisis dan Rekontruksi Komponen Lembar Kerja .

Tognoni, I., & Watkins, S. E. (2024, July 24). Interactive virtual tool for OPAMP circuits. https://peer.asee.org/interactive-virtual-tool-for-opamp-circuits.

Tokatlidis, C., Tselegkaridis, S., Rapti, S., Sapounidis, T., & Papakostas, D. (2024). Hands-On and Virtual Laboratories in Electronic Circuits Learning—Knowledge and Skills Acquisition. Information, 15(11), 672. https://doi.org/10.3390/info15110672.

Toros, E., Asiksoy, G., & Sürücü, L. (2024). Refreshment students' perceived usefulness and attitudes towards using technology: a moderated mediation model. Humanities and Social Sciences Communications, 11(1). https://doi.org/10.1057/s41599-024-02839-3.

Ubaidah, U., Ibrahim, N., & Siregar, E. (2023). The Epistemology of Transformative Learning: A Systematic instructional Design Framework model in Transformative learning. International Journal of Multi Discipline Science (IJ-MDS), 6(1), 18. https://doi.org/10.26737/ij-mds.v6i1.3545.

Ukaegbu, I. A., Onyejegbu, E., Mokogwu, F., & Kizilirmak, R. C. (2024). A Cost-Effective and simplified integration of simulations and hands-on experiments in the teaching of Electronic Instrumentation and Measurement laboratory course. Journal of Higher Education Theory and Practice, 24(4). https://doi.org/10.33423/jhetp.v24i4.6942.

Villarreal, E. V. (2024). Simulador PhET como Alternativa de Aprendizaje en la Materia de Circuitos Eléctricos a Nivel Técnico. Revista De Investigación E Innovación Educativa, 2(2), 57–71. https://doi.org/10.59721/rinve.v2i2.21.

Wahyudi, M. N. A., Budiyanto, C. W., Widiastuti, I., Hatta, P., & Bakar, M. S. B. (2024). Understanding Virtual Laboratories in Engineering Education: A Systematic Literature review. IJPTE International Journal of Pedagogy and Teacher Education, 7(2), 102. https://doi.org/10.20961/ijpte.v7i2.85271.

Zhu, L., & Liu, C. (2021). Development and analysis of electronic and electrical experiment simulation technology. Journal of Physics Conference Series, 1754(1), 012002. https://doi.org/10.1088/1742-6596/1754/1/012002.

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