NATIONAL ENGITECH DIGEST

VOL. 1 ISSUE 1

e-ISSN: 3030-5969

Development of an Educational Innovation: A Practical Workbook to Enhance Experiential Learning in Digital Electronics

Anis binti Abdul Kahar, Nurul Azimah binti Ahmad Arzaai, Mohd Fauzi bin Othman
Electrical Engineering Department, Politeknik Sultan Azlan Shah, 35950 Behrang, Perak
anis@psas.edu.my

Abstract:

Traditional approaches to digital electronics education often emphasize theory over practical skills, leading to gaps in practical application. The Development of an Educational Innovation: A Practical Workbook to Enhance Experiential Learning in Digital Electronics fills this gap through structured, step-by-step lab exercises that connect foundational theory with practical implementation. It covers essential topics including logic gates, combinational and sequential circuits, and microcontroller-based systems through guided experiments, simulations, and troubleshooting tasks. The primary objective is to enhance learners' ability to design, analyze, and troubleshoot digital circuits through experiential learning. By integrating se integrating hands-on activities, self-assessment questions, and interactive exercises, it supports the development of critical thinking and technical skills. To further facilitate independent learning, the workbook includes access to guided video tutorials on circuit simulation using Tinkercad. Hence, it addresses the gap between educational and industrial needs by fostering skill development and workforce readiness in embedded systems, automation, and electronics. The workbook is suitable for students, educators, and self-learners seeking a practice-oriented approach to digital electronics.

Keywords: Digital Electronics, Hands-On Learning, Practical Workbook, Technical Education.

Introduction

Despite the increasing incorporation of digital technology in education, many institutions continue to struggle with successful digital transformation. Schools frequently lack the digital capacity, infrastructure, and pedagogical innovation required to fully integrate future technologies such as IoT, AI, and digital simulations into teaching and learning (Timotheou et al., 2023). This digital preparation gap causes discrepancies in educational achievements, restricting students' capacity to learn important problem-solving and technical abilities required in today's workforce. While investment in technology has increased, studies show that the expected influence on learning quality and innovation has not been completely realized due to ineffective digital tool integration strategies (OECD, 2021; Costa et al., 2021). As a result, there is an urgent need for innovative, structured, and hands-on educational tools that can bridge the gap between theoretical knowledge and practical application, nurturing a digitally competent and industry-ready generation (Timotheou et al., 2023).

The use of digital technology in education creates both opportunities and challenges. While emerging technologies have the potential to revolutionize learning experiences, their adoption is frequently hampered by obstacles such as lack of resources, insufficient teacher training, and resistance to pedagogical innovation (Johnson et al., 2016). Many educational institutions struggle to shift from traditional teaching methods to interactive, hands-on learning approaches, limiting students' capacity to develop critical thinking and problem-solving abilities required in the digital world. True educational innovation requires structured, technology-driven solutions that enhance experiential learning and bridge the gap between academic knowledge and real-world application.

The Development of an Educational Innovation: A Practical Workbook to Enhance Experiential Learning in Digital Electronics addresses this critical need by offering a structured, interactive educational resource that promotes experiential learning. The workbook covers topics such as logic gates and Boolean algebra, combinational and sequential circuits also microcontrollers-based applications. Each topic is complete with step-by-step experimentation, simulations, case studies, troubleshooting, and exercises that require the application of digital circuits in real life. In addition, guided video tutorials on circuit simulation using Tinkercad were also embedded in the workbook.

The primary objective of this workbook is to bridge the gap between theoretical knowledge and practical skills by fostering experiential learning in digital electronics. It also aims to enhance students' capabilities in designing, analyzing, and troubleshooting digital circuits while promoting creative and analytical thinking through real-world applications. Furthermore, it also addresses the gap between educational and industrial needs by fostering skill development and workforce readiness in digital electronics and embedded systems. The workbook is suitable for students, educators, and self-learners seeking a practice-oriented approach to digital electronics.

Research Methodology

The development of this innovation followed a systematic and phased approach to ensure effectiveness and alignment with its intended objectives. The methodology comprises the five stages: literature review, product design, module development and testing, effectiveness evaluation and lastly iterative improvement.

An initial review of relevant literature was conducted to identify the gaps in existing teaching methods, particularly in digital electronics education. This included research articles, curriculum standards, and reports on the use of digital technologies in technical and vocational education. Based on the findings, the workbook was designed with a structured layout that includes five elements, which are concise theoretical explanations, step-by-

e-ISSN: 3030-5969

step experimental activities, circuit simulations using digital platforms, self-assessment and reflection questions and lastly case studies demonstrating real-world applications.

The workbook content was developed using tools such as Canva and Heyzine Flipbook platforms. Figure 1 shows the cover page of the workbook in the Heyzine Flipbook platforms. As shown in Figure 2, the workbook is integrated with YouTube links for enhanced interactivity. The circuit simulation tasks used the Tinkercad platform. Figure 3 shows the interface Circuit Link in Tinkercad Classes, Micro-Credential and QRCode Effectiveness included in the workbook. After completion of the workbook, pilot testing was conducted with polytechnic students to evaluate comprehension, engagement, and practical application of digital electronics concepts.

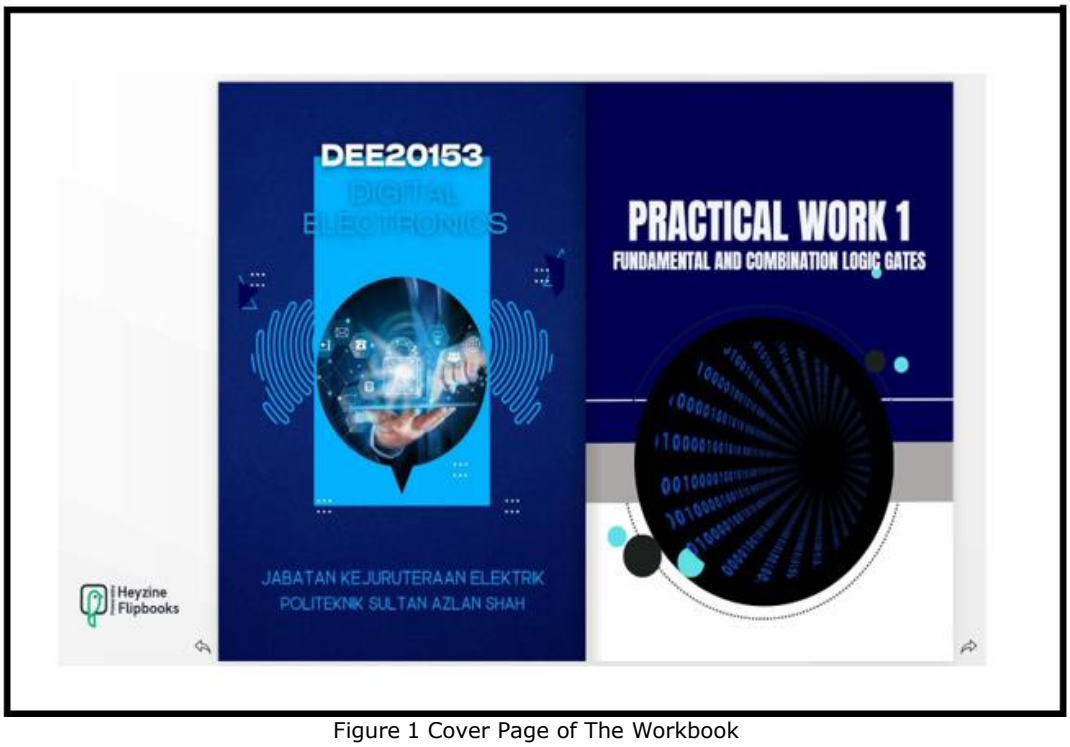

Figure 1 Cover Page of The Workbook

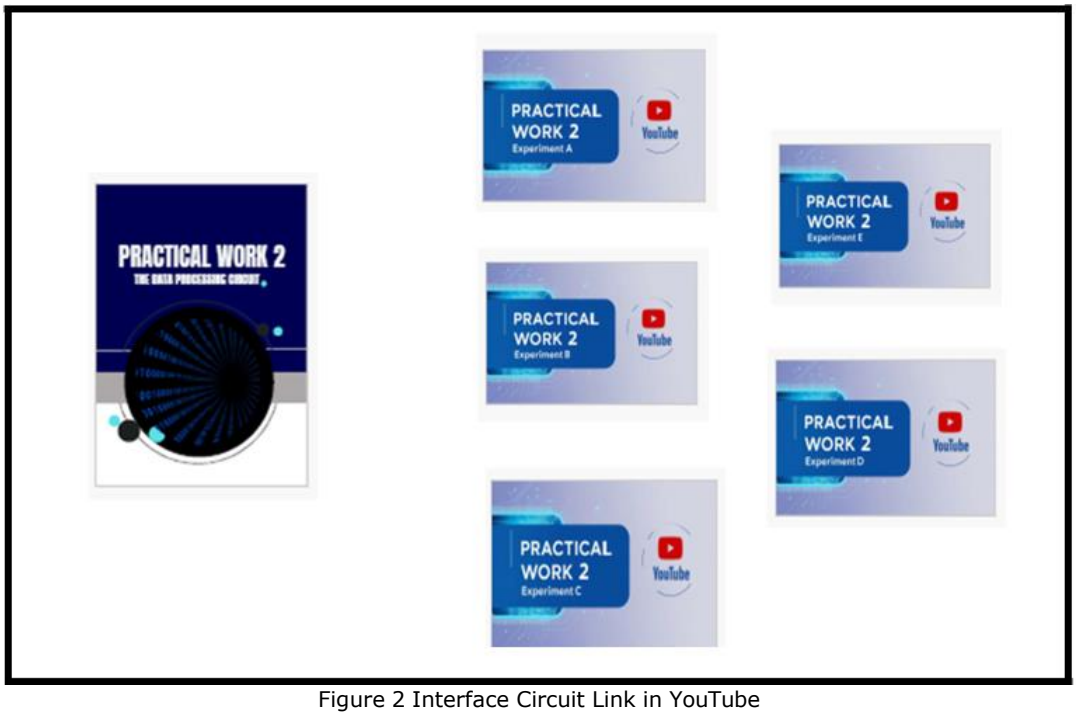

Figure 2 Interface Circuit Link in YouTube

The effectiveness of the workbook was assessed through comparative analysis of student performance before and after using the module, as well as feedback surveys from students and instructors. Feedback gathered during testing was used to refine the workbook content, improve the flow of activities, and enhance the overall usability and interactivity to better support diverse learning environments.

Figure 3 Interface Circuit Link in Tinkercad Classes, Micro-Credential and QRCode Effectiveness

Analysis and Discussion

The development of The Development of an Educational Innovation: A Practical Workbook to Enhance Experiential Learning in Digital Electronics addresses a critical need in technical education, the gap between theoretical knowledge and practical application. Traditional methods of teaching digital electronics often rely heavily on lectures and textbooks, which can limit students' ability to engage actively with the subject matter. This workbook offers a novel approach by integrating hands-on learning, simulations, and real-world problem-solving tasks.

One of the key strengths of this innovation is its alignment with modern pedagogical trends, such as experiential learning and student-centered education. By providing step-by-step experiments and circuit simulations, students can construct their own understanding of digital concepts through exploration and experimentation. This enhances knowledge retention and encourages deeper learning.

The workbook also supports the development of critical thinking and troubleshooting skills, which are essential in preparing students for careers in electronics, automation, and embedded systems. Through the inclusion of reflection questions and real-life case studies, learners are not only able to reinforce their technical skills but also build confidence in applying them in industry-relevant scenarios.

Furthermore, as shown in Figure 2 and 3, the integration of digital platforms such as Tinkercad and YouTube enhances accessibility and flexibility in learning. Students can interact with the material beyond the classroom, fostering independent study and digital literacy. This is especially valuable in the context of remote learning or institutions with limited hardware resources. Additionally, by integrating simulation-based learning, students can experiment with digital circuits virtually, reducing hardware costs and minimizing risks associated with physical prototyping.

Feedback from early implementation indicated increased student engagement, improved understanding of digital circuit design, and greater motivation to participate in practical sessions. Instructors also reported reduced preparation time and more effective delivery of complex topics using the workbook. This workbook serves as a comprehensive teaching tool, providing a structured approach to delivering lessons with minimal preparation effort. It supports curriculum alignment with modern educational standards and enhances interactive learning through self-assessment and real-world problem-solving exercises.

From an industry perspective, the workbook contributes to workforce readiness by equipping students with the skills required in electronics, embedded systems, and automation. By learning to troubleshoot and debug circuits systematically, students develop practical competencies that are highly valued in technical fields. Furthermore, the emphasis on design challenges and innovation fosters creativity and adaptability, essential traits in today's rapidly evolving technological landscape.

Despite its strengths, some challenges were noted, including the need for basic digital literacy to navigate simulation tools and time constraints during classroom implementation. However, these challenges can be mitigated through training and phased adoption.

In summary, this innovation successfully bridges the educational gap by offering a comprehensive, hands-on, and industry-relevant learning tool. It not only enhances the teaching and learning of digital electronics but also contributes to workforce readiness in a technology-driven world and learning of digital electronics but also contributes to workforce readiness in a technology-driven world.

Conclusion and Recommendation

In conclusion, The Development of an Educational Innovation: A Practical Workbook to Enhance Experiential Learning in Digital Electronics has proven to be an effective and innovative educational tool in bridging the gap between theoretical concepts and practical application in digital electronics. Through its structured approach, the workbook enhances student engagement, supports critical thinking, and cultivates technical skills that are vital in today's digital and automated industries. By combining guided experiments, simulation-based activities, real-world applications, and self-assessment tools, this workbook empowers learners to take ownership of their learning journey. It also provides educators with a ready-to-use resource that complements existing curricula while reducing instructional burden. The successful implementation and positive feedback from both students and instructors highlight the workbook's potential to be widely adopted in technical

and vocational education settings. With continued refinement and integration of emerging technologies, this innovation has the capacity to evolve further and serve as a model for hands-on learning in other areas of engineering and technology education. Ultimately, this innovation contributes meaningfully to the development of a skilled, digitally competent, and industry-ready workforce, fulfilling the demand for more practical, interactive, and impactful learning experiences in the 21st century.

References

Johnson, A. M., Jacovina, M. E., Russell, D. E., & Soto, C. M. (2016). Challenges and solutions when using technologies in the classroom. In S. A. Crossley & D. S. McNamara (Eds.), Adaptive educational technologies for literacy instruction (pp. 13-29). New York: Taylor & Francis.

Organisation for Economic Co-operation and Development. (2021). *21st-century readers: Developing literacy skills in a digital world*. OECD Publishing. https://doi.org/10.1787/a83d84cb-en

Sistem Digit: Prinsip Dan Kegunaan (Edisi Kelapan). (2003). Prentice Hall.

Silibus DEE20153- Digital Electronics DET-DEP-DTK. (2024). JPPKK

Timotheou, S., Miliou, O., Dimitriadis, Y., Sobrino, S. V., Giannoutsou, N., Cachia, R., Martínez Monés, A., & Ioannou, A. (2023). Impacts of digital technologies on education and factors influencing schools' digital capacity and transformation: A literature review. Education and Information Technologies, 28, 6695–6726. https://doi.org/10.1007/s10639-022-11431-8