Integrating Design Thinking and Blended Learning in Science Education: Development and Expert Validation of the Inno-BlenDT Module

Muhammad Salehuddin Ahmad, Nurul Ashikin Izhar*, Zuhailah Hashim

School of Educational Studies,Universiti Sains Malaysia (USM),
11800 USM, Pulau Pinang, Malaysia
*Corresponding author: ashikinizhar@usm.my

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Abstract

Innovation in science education is critical for addressing persistent challenges in student achievement, interest, and metacognition, particularly in abstract topics such as electricity and magnetism. This study responds by developing and validating the Inno-BlenDT module, which integrates design thinking and blended learning as complementary pedagogical strategies. The module was systematically designed using the ADDIE model and validated through expert review to ensure credibility and effectiveness. Eight experts in science education, STEM, and educational technology evaluated the module using the Content Validity Index (CVI), covering constructs of objectives, content, language and format, presentation, and usability. Results demonstrated unanimous agreement, with I-CVI and S-CVI/Ave values reaching 1.00 across all constructs, exceeding recommended thresholds (I-CVI ≥ 0.78; S-CVI/Ave ≥ 0.90). These findings affirm the module's strong alignment with pedagogical standards and its potential to enhance students' learning outcomes. The validation process underscores the scholarly importance of expert review in ensuring the reliability of educational innovations before implementation in classroom practice.

Keywords: Design Thinking, Blended Learning, Validation, Module Development

Abstrak

Inovasi dalam pendidikan sains merupakan aspek yang kritikal bagi menangani cabaran berterusan berkaitan pencapaian pelajar, minat serta keupayaan metakognitif, khususnya dalam penguasaan topik abstrak seperti elektrik dan kemagnetan. Kajian ini dilaksanakan dengan tujuan membangunkan dan mengesahkan modul Inno-BlenDT yang mengintegrasikan pendekatan pemikiran reka bentuk bersama pembelajaran teradun sebagai strategi pedagogi yang saling melengkapi. Pembangunan modul ini dilaksanakan secara sistematik berasaskan model ADDIE, manakala proses kesahan kandungan dilakukan melalui semakan pakar bagi memastikan kredibiliti dan keberkesanan modul. Seramai lapan orang pakar dalam bidang pendidikan sains, STEM, dan teknologi pendidikan telah menilai modul menggunakan Indeks Kesahan Kandungan (CVI) yang merangkumi konstruk objektif, kandungan, bahasa dan format, persembahan, serta kebolehgunaan. Hasil penilaian menunjukkan persetujuan sebulat suara dengan nilai I-CVI dan S-CVI/Ave mencapai 1.00 bagi semua konstruk, melepasi ambang minimum yang disarankan (I-CVI ≥ 0.78; S-CVI/Ave ≥ 0.90). Dapatan ini membuktikan keselarasan modul dengan piawaian pedagogi serta potensinya dalam meningkatkan hasil pembelajaran murid. Proses pengesahan ini sekali gus menegaskan kepentingan ilmiah penilaian pakar dalam memastikan kebolehpercayaan inovasi pendidikan sebelum diaplikasikan dalam konteks pengajaran dan pembelajaran sebenar.

Kata kunci: *Pemikiran Reka Bentuk, Pembelajaran Teradun, Kesahan, Pembangunan Modul*

INTRODUCTION

Innovation in science education is crucial for preparing students to thrive in the 21st century, where mastery of knowledge must be supported by creativity, problem-solving, and reflective thinking. The Malaysian Education Blueprint 2013–2025 emphasizes the transformation of teaching approaches to nurture critical and innovative students who can apply scientific concepts in real-life contexts, thus strengthening the nation's competitiveness in science and technology (Kementerian Pendidikan Malaysia, 2013).

However, reality still shows significant challenges. International assessments such as PISA reveal that Malaysian students' performance in science has been declining, placing the country below the OECD average (Phang et al., 2020). Certain Topics like electricity and magnetism are often perceived difficult by students because of their abstract nature, and teacher-centered practices that often fail to spark engagement and hinder deeper understanding (Mbonyiryivuze et al., 2019; Mollel et al., 2022). As a result, many students struggle not only with achievement but also with waning interest in science and underdeveloped metacognitive skills both of which are vital for lifelong learning (Ilma et al., 2022; Mastura Mustapha & Azi Azeyanty Jamaludin, 2021).

Previous studies highlight the need for innovative teaching methods that integrate practical applications, digital tools, and student-centered strategies. Design thinking is well known for its ability in fostering creativity, collaboration, and problem-solving (Bender-Salazar, 2023), while blended learning has transformed the way of students learn by offering flexibility and extending learning beyond the classroom (Mulenga & Shilongo, 2024). However, there is a lack of study and validated modules that integrate these approaches in the context of Malaysian science education, particularly for complex topics such as electricity and magnetism.

To address this gap, this study aims to develop the module that integrates design thinking with blended learning approach (Inno-BlenDT module) and validate through expert review for ensuring its credibility and effectiveness in enhancing students' achievement, interest, and metacognition. By doing so, the study offers a pedagogical innovation that not only aligns with national educational goals but also responds to the demands of 21st-century science learning.

RESEARCH BACKGROUND

Globally, schools are expected to develop students who can think scientifically, create solutions, and respond to complex problems shaped by technology, sustainability, and rapid social change (Berg et al., 2021). Yet in Malaysia, science education continues to face persistent challenges, as international assessments consistently report declining student performance (Laukaityte et al., 2024; Sadera et al., 2020). These results raise important questions about how science learning can be redesigned to become more engaging, meaningful, and future-ready. Evidence shows that Malaysian students still perform far below global benchmarks, particularly in PISA and TIMSS, where scores have declined across recent cycles (Azahar & Cheng, 2024; Lew & Krishnasamy, 2023). In Malaysia, the long-standing goal of achieving a 60:40 ratio of students in science versus arts remains unmet, reflecting deeper issues in sustaining interest in science (Ong et al., 2021).

The concern becomes more pressing when looking specifically at students' low achievement in the topic of electricity and magnetism, one of the most conceptually demanding areas in the lower secondary science curriculum. Studies show that this topic is frequently identified as difficult to master because its concepts are abstract, challenging to visualise, and often disconnected from students' everyday experiences (Hermawati, 2022). As a result, many students struggle to understand fundamental principles and repeatedly demonstrate conceptual errors when solving related problems (Rendon et al., 2022). Study shows that electrical and magnetism concepts consistently record low mastery, by teachers reporting that students facing difficulties grasping ideas such as electric current, electromagnetic induction, and the relationship between electricity and magnetism (Boateng & Mushayikwa, 2022; Mollel et al., 2022).

A major factor contributing to these challenges is the continued reliance on teacher-centred instruction (Grabau, 2022). In many classrooms, knowledge is still delivered through direct teaching, where students listen, take notes, and complete routine exercises. Such practices often leave students disengaged because they struggle to connect abstract science concepts with meaningful real-life contexts (Levitt et al., 2023). Many students perceive science as difficult and irrelevant, which reduces their interest and lowers their achievement (Bahru et al., 2018). Limited opportunities for inquiry, collaboration, and hands-on exploration further restrict students' curiosity, contributing to negative attitudes toward science (Abdullah et al., 2022). These issues are made more serious by the lack of focus on metacognition where students are rarely guided to plan, monitor, and evaluate their own thinking, resulting in weak self-regulation skills necessary for deep learning (Wirzal et al., 2022; Yasir et al., 2020). Additionally, the lack of effective teaching aids and limited practical activities further restricts students' opportunities to explore and apply concepts, resulting in low retention and weak conceptual understanding (Koca et al., 2025; Vavasis et al., 2022). These issues collectively demonstrate that current teaching approaches are insufficient and that a new student-centred pedagogy is urgently needed to reshape science learning (Hartini & Faridah, 2022).

Design Thinking has emerged as one such promising approach. It positions students as active creators of knowledge and encourages them to explore problems, generate ideas, and refine solutions through iterative cycles (Rauth et al., 2010). Its five phases start from empathise, define, ideate, prototype, and test guide students to examine authentic problems while developing creativity and problem-solving skills (Brown, 2008; Razzouk & Shute, 2012). Evidence shows that Design Thinking improves students' conceptual understanding and promotes meaningful learning across disciplines, including science (Komathy et al., 2021; Rusmann & Ejsing-Duun, 2022). Ladachart et al. (2022) further found that Design Thinking supports students' exploration of complex and abstract scientific concepts. These strengths show that Design Thinking can help address key challenges faced by Malaysian students, particularly in developing deeper understanding and improving interest.

However, using Design Thinking only in face-to-face classrooms may limit its full potential. Implementation often depends on teacher guidance, and opportunities to extend learning outside class hours remain underused (Shé et al., 2022). Without technology, Design Thinking activities risk becoming isolated classroom tasks rather than a continuous learning process that supports deeper understanding (Noh & Karim, 2021; Nur Hafizah Razali et al., 2022). For Design Thinking to be more effective, it must be modernised through digital integration that connects learning across different spaces and times. Blended learning provides a strong foundation for such enhancement. By combining online activities with face-to-face interactions, blended learning allows students to learn flexibly while still participating in discussions and collaborative tasks (Lalima & Dangwal, 2017). Research shows that blended learning improves achievement, increases motivation, and strengthens engagement more effectively than traditional approaches (Kaur & Kaur, 2023; Olatunde-Aiyedun & Adams, 2022). In science education, blended learning environments offer interactive tasks that support deeper and more accurate understanding of abstract concepts (Brakhage et al., 2023). Yet scholars caution that blended learning must be guided by a strong pedagogical structure to avoid fragmented learning experiences (Buhl-Wiggers et al., 2023). Many studies still focus on the technical delivery of blended learning rather than its pedagogical purpose (Krismadinata et al., 2020). This suggests blended learning works best when paired with a clear instructional framework such as Design Thinking that ensures coherent, inquiry-driven learning.

Integrating Design Thinking with blended learning therefore offers a powerful direction for addressing current issues in science achievement, interest, and metacognition. The Inno-BlenDT Module builds on this integration and is grounded in Social Constructivism by Vygotsky 1978, which emphasises that learning occurs through collaboration, dialogue, and shared meaning-making. In the Design Thinking process, students discuss ideas, justify decisions, and refine solutions together, exemplifying co-constructed understanding (Ghaedi et al., 2020; Mishra, 2023). Blended learning further strengthens these collaborative processes by providing digital tools for communication, peer review, and shared artefact creation (Haleem et al., 2022). Together, these elements support a richer, more interactive learning experience.

The module also embeds Metacognition Theory, which highlights the importance of students planning, monitoring, and evaluating their thinking (Flavell, 1979). Each phase of Design Thinking activates metacognitive processes, for example, students reflect on the problem they define, monitor their progress while developing prototypes, and evaluate their approach during testing. Blended learning adds supportive structures such as self-paced videos, online quizzes, reflective journals, and digital feedback, all of which strengthen metacognitive awareness and self-regulation (Wirzal et al., 2022). This combined approach directly responds to the documented need for improved metacognitive support among Malaysian students. Despite these strengths, research integrating both approaches especially in the topic of electricity and magnetism still remains limited. Few studies examine achievement, interest, and metacognition together, even though students often struggle with misconceptions and difficulty visualising abstract concepts (Burde et al., 2021). This gap highlights the need for a new innovative pedagogical solution.

The Inno-BlenDT Module is designed to fill this gap by providing a structured, theory-driven approach that blends Design Thinking and online learning to enhance achievement, interest, and strengthen metacognitive skills. Expert validation ensures its quality and relevance, offering evidence for a pedagogical innovation that can transform science learning and support students in becoming more confident, reflective, and capable students.

RESEARCH OBJECTIVES

The objectives of this article are:

1. Develop a Blended Design Thinking Module (Inno-BlenDT) for the topic of Electric and Magnetism.
2. Determine the validity of the Blended Design Thinking Module (Inno-BlenDT).

RESEARCH METHODOLOGY

Module Development

The development of the Inno-BlenDT Module was systematically guided by the ADDIE instructional design model, which outlines five fundamental phases: Analysis, Design, Development, Implementation, and Evaluation. This model was selected because its structure supports a clear, systematic, and iterative process essential for developing an instructional module that integrates Design Thinking and blended learning elements effectively (Branch, 2010). In this study, ADDIE served as the main framework to ensure that the module addressed students' learning needs, aligned with curriculum standards, and incorporated appropriate pedagogical strategies suitable for enhancing achievement, interest, and metacognition in the topic of Electricity and Magnetism.

Analysis

The needs analysis conducted with secondary school teachers revealed clear instructional gaps in teaching Electricity and Magnetism. Teachers reported that this topic is among the most difficult to teach due to its abstract concepts and students' limited ability to connect ideas to the real-world. They highlighted issues such as persistent misconceptions, low engagement, and a lack of teaching materials that lead to uneffective hands-on activities to support conceptual understanding. These challenges align with reports that traditional teacher-centred methods hinder meaningful learning and reduce students' interest in science (Grabau, 2022; Kubiatko, 2023; Muhamad Zakwan Hamizan Ramli & Lee, 2023). The analysis further indicated a strong need for a structured, innovative module that integrates active learning, real-world tasks, and technology-supported activities to improve students' achievement and interest in the topic.

Design

The insights acquired informed the next phase by outlining the structuring of the learning objectives, the corresponding teaching methods, and the appropriate assessment tools. Objectives were aligned to the Malaysian Form Three Science curriculum standards and mapped to Bloom's revised taxonomy. The aim of the design was to incorporate the phases of design thinking (empathize, define, ideate, prototype, and test) into a blended learning environment, where the ability to ideate and prototype integrated systematically taught creativity, reflective practice, and collaboration. The instructional methods emphasized inquiry-centred strategies, and the assessments combined both formative and summative approaches. It also incorporated pedagogical considerations regarding how much time would be spent online and how much in physical face-to-face contact, ensuring blended pedagogical coherence.

Development

During the development phase, the instructional materials, digital learning resources, lesson plans, teacher guides, and student activity sheets were prepared. An interactive approach was used, including online collaboration tools, digital simulations, and other blended delivery methods. After the first draft, the module was expert-reviewed to determine content validity. It was validated through the Content Validity Index (CVI), which included item-level (I-CVI) and scale-level (S-CVI/Ave) measures (Lynn, 1986; Polit & Beck, 2006). The module was assessed by experts in science education, STEM and educational technology where it covers five constructs: objectives, content, language and format, presentation, and usability. The revisions were made based on the feedback to comply with pedagogical and practical standards of classroom teaching.

Implementation

The implementation phase involved three key components: the teacher training workshop, preparation of learning facilities, and the classroom execution of the Inno-BlenDT Module. Teachers first received intensive training to ensure they understood the module, digital tools, and instructional strategies required for effective delivery (Branch, 2010). This workshop helped them master the blended design thinking approach and prepare for facilitation during student activities, aligning with the module's goals for improving achievement, interest, and metacognition. Adequate preparation of digital equipment, internet access, and module materials was also ensured to avoid disruptions during lessons. Finally, teachers will implement the module in real classroom settings, guiding students through hands-on and online activities as planned in each design thinking phase.

Evaluation

The evaluation phase saw the articulation of both the effectiveness and the validity of the Inno-BlenDT module. Content validity was assessed using the CVI expert review, with I-CVI values $\geq$0.78 and S-CVI/Ave $\geq$0.90 deemed acceptable (Polit & Beck, 2006). Effectiveness was examined using three instruments: (i) the Science Achievement Test of Electricity and Magnetism, (ii) the Interest towards Science Questionnaire, and (iii) the Metacognition Questionnaire. Data were captured using the pre-test–post-test–delayed-post-test design, which allowed the measurement of immediate and prolonged learning gains. Quantitative data were statistically analyzed to determine levels of attainment, interest, and metacognition.

Validation Process

The validity of the Inno-BlenDT module was established using the Content Validity Index (CVI), which quantified the degree of consensus among experts regarding the relevance of each item (Lynn, 1986). Content validity was assessed at two levels: the I-CVI, which described individual items, and the S-CVI/Ave, which was used to describe the entire scale. The I-CVI was determined by taking the total number of relevant ratings a given item received and dividing it by the number of experts, with a cut-off point of 0.78 for six experts (Lynn, 1986; Polit & Beck, 2006). An S-CVI/Ave of ≥0.90 was considered to indicate outstanding validity (Davis, 1992; Polit & Beck, 2006). As recommended by (Sidek Mohd Noah & Jamaludin Ahmad, 2005), eight experts were used to ensure the items were consistent with the module's aims and the constructs to be measured. The profiles of the experts who were involved in the validation of the module were presented in Table 1.

Table 1 *Details of the experts participating in the validation process*

Expert	Area of Expertise	Position
1	Science Education, Module Development	Senior Lecturer Institute of Teacher Education (IPG)
2	STEM	School Improvement Specialist Coaches (SISC+)
3	Science Education	Senior Lecturer Institute of Teacher Education (IPG)
4	STEM	School Improvement Specialist Coaches (SISC+)
5	Science Education	Senior Lecturer Institute of Teacher Education (IPG)
6	Science Education	Senior Lecturer Institute of Teacher Education (IPG)
7	Educational Teachnology	Senior Lecturer Institute of Teacher Education (IPG)
8	Science Education	School Improvement Specialist Coaches (SISC+)

FINDING AND DISCUSSION

The validation outcomes showed that every construct in the Inno-BlenDT module received the highest scores possible, with every item under each objective attaining an I-CVI of 1.00 and an S-CVI/Ave of 1.00. These reported scores far exceeded the I-CVI minimum of ≥0.78 and the S-CVI/Ave minimum of ≥0.90 when evaluated by six or more experts (Lynn, 1986; Polit & Beck, 2006). This result signified that the experts unanimously concurred that the objectives were well defined and relevant, the content was exhaustive and aligned with the learning outcomes, the language and format were accessible and appropriately organized, the presentation was clear and engagingand the module demonstrated strong potential in enhancing students' achievement, fostering greater interest, and promoting higher levels of metacognitive regulation. Ultimately, it was evident and well supported that the Inno-BlenDT module attained a significant level of content validity and received strong endorsement across all dimensions.

Table 2 *Module I-CVI and S-CVI/average*

Item	Aspect Evaluated	Statement	Expert in Agreement	I-CVI value (n=8)	Interpretation
1	Module Objectives	The objectives in the Inno-BlenDT Module are stated clearly.	6	1.0	Excellent
2		The objectives in the Inno-BlenDT Module are well planned and organized.	6	1.0	Excellent
3		The objectives in the Inno-BlenDT Module stated are specific, measurable, and achievable.	6	1.0	Excellent
4		The objectives are relevant to the topics in each chapter of the module.	6	1.0	Excellent
5		The objectives consider the students' needs.	6	1.0	Excellent
6	Module Content	The content of each chapter is directly related to the objectives set.	6	1.0	Excellent
7		The content of each chapter is clear and easy to understand.	6	1.0	Excellent
8		The topics in each chapter are fully discussed.	6	1.0	Excellent
9		The topics are supported with illustrative examples, and the writing of each activity is appropriate to the students' level.	6	1.0	Excellent
10		Each topic is given equal emphasis in every chapter.	6	1.0	Excellent
11		The module provides effective and useful student activities.	6	1.0	Excellent
12		The content of this module integrates elements of blended design thinking.	6	1.0	Excellent
13		The activities provided in this module integrate elements of blended design thinking.	6	1.0	Excellent
14	Module Language & Format	The chapter format/arrangement is attractive and well-organized.	6	1.0	Excellent
15		The language used is easy to understand.	6	1.0	Excellent
16		The language used is clear, concise, and precise.	6	1.0	Excellent
17		The instructions in this module are simple and easy to follow.	6	1.0	Excellent
18	Module Presentation	The presentation of the module content is systematic.	6	1.0	Excellent
19		The chapters in the module are presented in a unique and original sequence.	6	1.0	Excellent
20		Student activities are presented clearly.	6	1.0	Excellent

continued

21		The presentation of each chapter is interesting and able to capture students' interest.	6	1.0	Excellent
22		Each chapter is provided with sufficient examples and writing activities.	6	1.0	Excellent
23	Module Usability	This module is expected to attract students' interest in learning science, specifically the topic of electricity and magnetism.	6	1.0	Excellent
24		This module will help students master the topic of electricity and magnetism according to their individual abilities.	6	1.0	Excellent
25		This module will enable students to expand their knowledge of electricity and magnetism.	6	1.0	Excellent
26		This module is expected to improve science achievement in the topic of electricity and magnetism.	6	1.0	Excellent
27		This module is expected to increase students' interest in science.	6	1.0	Excellent
28		This module is expected to enhance students' metacognition.	6	1.0	Excellent

Based on the CVI results, the module is considered to be not only comprehensive but also congruent with the established pedagogical standards. Objectives were set as specific, measurable, and attainable while the content was classified as pertinent, coherent, and directly related to the intended learning outcomes. Such alignment is crucial to ensure that the module addresses the persistent difficulties that students experience in dealing with abstract issues like electricity and magnetism (Moodley & Gaigher, 2019; Simeon et al., 2022).

No less important, the language in which the module is written, the format, and the manner of presentation were all positively appraised. Experts attested that the module employs straight forward language which is adequately arranged and structured, accompanied by well-designed, and interactive chapter illustrations. The blended design thinking approach was also noted to be a strength because it encourages creativity, teamwork, and digital tools to maintain active engagement. Usability wise, the module is more likely to enhance, interest, and foster achievement and metacognitive regulation, the latter which is a consistent feature in science education reform.

Nonetheless, experts brought forth some issues that require improvement. Objectives were critiqued on grounds of repetitiveness and needing consolidation. Also, the directions for the prototype activities needed more specificity in the digital-physical dichotomy. These critiques are constructive, reframing the critiques as a positive opportunity for revision helps in reinforcing its constructive nature. Taking a picture of the prototype is the final step. Proof validation indicates that the module is credible and ready for classroom use in practical instruction. Proof validation indicates that the module is credible and ready for classroom use in practical instruction, and the outlined suggestions enhance its relevance and applicability.

CONCLUSION

This paper presented an explanation of the development and validation of the Inno-BlenDT module, an instructional innovation that integrates design thinking with blended learning for science education. The ADDIE model guided the entire process, encompassing the stages of Analysis, Design, Development, Implementation, and Evaluation. Validation of the module was conducted by eight experts in science education and educational technology. The validity results showed that the module possessed excellent content validity, with all items achieving perfect I-CVI and S-CVI/Ave scores. Further, the module demonstrated strong alignment with pedagogical principles, ensuring that its objectives, content, language, presentation, and usability were instructionally sound. This result also provided initial evidence indicating that the module had the potential to enhance students' science achievement, interest, and metacognition in learning challenging concepts such as electricity and magnetism. The researcher hopes that the detailed explanation of the module design and validation procedures will be beneficial to educators and researchers interested in developing similar instructional modules.

STATEMENT ON THE USE OF GENERATIVE ARTIFICIAL INTELLIGENCE

During the preparation of this manuscript, the researchers used ChatGPT (OpenAI) solely for language editing and improving the clarity of writing. No generative artificial intelligence tools were used to produce or interpret any scientific content. After using the tool, the authors carefully reviewed and revised the text as necessary and take full responsibility for the final content of this publication.

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