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The Implications of Using E-Modules For Improving Teachers' Pedagogic Competence In The International Border of Indonesia-Malaysia

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ABSTRACT

Purpose of the study: The purpose of this study is to describe the application and implications of the use of PjBL-based teaching modules on the pedagogic competence of the trainee teachers.

Methodology: The research method used is a qualitative approach in descriptive form. The research data was obtained by interviewing informants, namely teachers who participated in the training from State High Schools in Beduai, Sekayam and Entikong Districts. Data processing techniques are data reduction, data presentation and conclusion drawn.

Main Findings: The results show that the implementation of the use of e-modules in learning in several schools in border areas can provide benefits in improving the quality of learning processes and outcomes, although there are still some challenges in its implementation. The use of e-modules in learning makes a real contribution to efforts to improve teachers' pedagogic competence, especially in the use of technology and the internet in supporting the learning process in the classroom.

Novelty/Originality of this study: The researcher intends to test the implications on the pedagogic aspects of teachers who use e-modules as a learning medium in Border Area High Schools in Beduai District, Sekayam District and Entikong District, Sanggau Regency. This sub-district was chosen because it is the outermost sub-district in West Kalimantan, the western region which is directly adjacent to Malaysia.

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1. INTRODUCTION

During the Covid-19 pandemic, the Ministry of Education and Culture made a policy on Learning from Home (BdR) to anticipate the spread of the coronavirus. [1]-[3] . This learning from home policy makes teachers have to develop the right strategies and materials to be shared online [4]-[6]. Teachers are advised to create content that contains detailed information and procedures that are easy to understand and help students understand the material well [7]-[9]. Teachers must also use digital media such as learning applications and various kinds of educational games, digital platforms such as video conferencing to maintain interaction with students [3], [10], [11], [12]. This allows teachers to have direct discussions with students and ensure that they understand the material being delivered [13]-[15].

This transition exposed a digital divide: students in well-connected areas could adapt, but those in rural and border regions faced severe barriers. Indonesia's archipelagic geography causes major Internet and

infrastructure gaps in remote regions [16]-[18]. Border areas like West Kalimantan similarly lack reliable infrastructure. One study of an Indonesia–Malaysia border district notes schools there suffer from a lack of facilities and infrastructure, hindering access to education [19]-[21]. Many rural high-school students lack personal computers or smartphones, and many teachers lack confidence with digital tools [22], [23]. During school closures, roughly half of teachers in Borders Area not teaching every day (in virtual class) due to poor connectivity or students having no Internet [24], [25]. In practice, these teachers often ended up physically delivering worksheets to students with minimal instruction.

Together, these factors mean that distance learning is especially challenging for remote-area high schoolers, requiring careful attention to context in any digital-education intervention. One of the solutions to overcome this gap is to utilize electronic modules [23]-[25]. Modules are learning tools or means that contain materials, methods, limitations and ways of evaluating that are designed systematically and attractively to achieve the expected results [26]-[28]. A module is a learning teaching material whose content is relatively short and specific that is prepared to achieve learning objectives [29]-[31]. Modules as a teaching material have advantages when compared to package books [32]-[34]. The advantages lie in two-way communication, can be used for distance education and training, interactive and dialogical, the structure is clear, friendly and motivating, applying newly acquired knowledge and skills, the material is divided into small pieces, there is assignment and feedback [26], [29], [30]. A good module has several characteristics, namely self-instruction, self-contained, stand alone, adaptive, and user friendly [7], [24], [31]. Modules were initially made in printed form, but with the development of science and technology, modules are now being developed in electronic form (e-modules) [24], [26], [30].

After the Covid-19 pandemic, the use of learning technology continues to be used by teachers because it is considered to be able to increase effectiveness and efficiency in learning [35]-[37]. One of the learning technologies that continues to be used is electronic-based modules or e-modules. The use of e-modules is due to several conditions, namely; E-modules can be accessed by students outside of class hours so that students can learn independently, e-modules can be accessed repeatedly so that students can learn the material comprehensively, e-modules are interactive so that learning can be more enjoyable [23], [25], [26], [27].

E-module is a type of module in which there are text, images, graphics, animations, and also videos that can be accessed anywhere and anytime [3], [38]. With the e-module, students will understand the material better because the learning process developed is not only reading but using several methods. E-modules are expected to be one of the new learning resources for students, and can further improve students' understanding of concepts and learning outcomes [39]-[41].

E-modules provide collaborative solutions that cover four aspects, namely: scientific context, process, content, and attitudes [7], [42]. Increasing student understanding in the learning process optimally, requiring educators to foster fun interactions, this can combine the principles of education and entertainment, one way is to use interactive learning media [9], [23], [24], [43]. The use of learning media such as interactive e-modules in the learning process, allows teaching materials to be modified to be more interesting [29], [44], [45].

However, there are still teachers who have not used e-modules as a learning medium due to the lack of training provided to them [46]-[48]. Therefore, the researcher intends to test the implications on the pedagogic aspect of teachers who use e-modules as a learning medium in Border Area High Schools in Beduai District, Sekayam District, and Entikong District, Sanggau Regency. This sub-district was chosen because it is the outermost sub-district in West Kalimantan, the western region which is directly adjacent to Malaysia. This research was carried out after training activities on the same subject with a similar topic.

Our study focuses on high school teachers in the Indonesian region bordering Malaysia (West Kalimantan). This local context is important because border districts like Sanggau are both culturally distinct and resource-poor. Research in these areas highlights chronic shortages: for instance, schools in Sekayam report severe facility and infrastructure deficits. Students and teachers there face the same connectivity and resource issues described above, compounded by the fact that neighboring Sarawak (East Malaysia) has much higher educational investment [19], [49], [50], [51].

Given these conditions, we emphasize teachers' pedagogical competence in our methodology. Pedagogical competence the ability to design, implement, and evaluate effective learning is widely recognized as central to education quality [48], [52], [53]. In Indonesia, improving teacher pedagogical skills is a national priority, since weak pedagogy contributes to lower student achievement. Focusing on teacher competence is methodologically justified because an educator's skills determine how well they can leverage new media (like e-modules) under constraints [54]-[56]. Notably, existing government training modules have often been found outdated or irrelevant to current needs. By studying how electronic modules affect teachers' pedagogical practice, we can directly assess whether these tools help bridge the gap between limited resources and effective teaching [23], [26], [27].

Prior studies of Indonesian digital learning have documented various strategies (e.g. apps, video conferencing), but few specifically address e-module use among high school teachers in remote border areas [16], [19], [22]. In fact, a recent review notes that most "smart education" research concentrates on urban/suburban settings with ample infrastructure [57]-[59]. It highlights that remote schools face unique hurdles inadequate

Internet, very few available teachers, low digital literacy which are often overlooked. Moreover, there is little empirical evidence on how to adapt e-learning tools to such socio-geographic contexts. This gap underscores the urgency and novelty of our work. As students in remote, low-income regions lose more ground during crises, it is urgent to find practical solutions. Our study is novel because it examines existing electronic modules (across all subjects) at the high school level in a Malaysia–Indonesia border district a setting rarely studied. We will use teacher interviews and classroom observations to evaluate these e-modules' impact on teachers' pedagogical competence. By targeting this under-researched context, the research will illuminate how to enhance teacher quality and learning equity in Indonesia's digitally divided frontier regions.

2. RESEARCH METHOD

This study employed a qualitative descriptive design to explore how teachers develop and implement teaching modules. Qualitative descriptive research focuses on providing a comprehensive summary of events and answering questions of who, what, where, and how [60]-[62]. This straightforward, naturalistic approach is well-suited to educational settings where the aim is to describe participants' perspectives and experiences without imposing a theoretical framework. In line with standard practice, semi-structured interviews were used as the primary data collection method, allowing participants to elaborate on their experiences in detail.

The target population was teachers from four schools in Sanggau Regency (SMAN 1 Entikong, SMAN 1 Sekayam, SMAN 2 Sekayam, and SMAN 1 Beduai) who had participated in training on developing PjBL (Project-Based Learning) -based teaching modules. A purposive, saturation sampling strategy was employed: all eligible teachers were invited to participate, and data collection continued until no new themes emerged [63]-[65]. The final sample comprised 20 teachers. Key characteristics of the participants were: a) All teachers had between 5 and 10 years of teaching experience, ensuring that each had substantial classroom experience with comparable tenure; b) All had completed recent training on the PjBL module development; among them, five teachers had additionally attended prior general training on developing teaching modules, providing some variation in expertise; c) The sample included teachers from diverse subject backgrounds. No drop-outs occurred, as data saturation was achieved with the full group of 20. The use of saturation sampling (continuing data collection until no novel information is gained) ensured the sample size was adequate and aligned with qualitative best practices.

Data were gathered through a combination of methods to capture a rich picture of teachers' experiences. The primary technique was face-to-face, semi-structured interviews. An interview guide (research instrument) with open-ended questions was developed to probe teachers' experiences with module development and implementation. Each interview was conducted individually and audio-recorded with participants' permission. In addition, field observations were conducted: researchers observed participants teaching PjBL activities and taking notes on behaviors and contextual factors, using an observation protocol. These observations supplemented interview data and helped triangulate findings. Immediately after each interview, recordings were transcribed verbatim. The transcription ensured that the exact wording and nuances were captured for analysis [63], [66]. Throughout the data collection process, detailed field notes and reflexive memos were kept to document settings, nonverbal cues, and the researcher's insights. After initial analysis of an interview, a follow-up member-checking session was arranged via Google Meet: preliminary transcripts or summaries were shared with the participant, who was asked to confirm accuracy and clarify any points [67]. This step helped validate the data in real time and allowed participants to elaborate or correct information.

Following Miles and Huberman's model, data analysis proceeded in iterative phases of coding and theming [54]. First, all interview transcripts were read repeatedly, and open coding was applied to label key concepts and incidents in the data (data reduction). Codes were created inductively to stay close to participants' language. Next, codes were grouped into broader categories and themes by examining patterns and relationships among codes. This process involved constant comparison within and across cases. A sample of transcripts was coded independently by two researchers to enhance reliability; discrepancies were discussed until consensus was reached. As themes emerged, data were organized into matrices and charts (data display) to visualize how themes related to each research question. Finally, researchers drew conclusions by synthesizing the displayed data, checking that interpretations were supported by multiple data points. Conclusions were iteratively verified against the raw data and through discussions among the research team. The analysis steps can be summarized as:

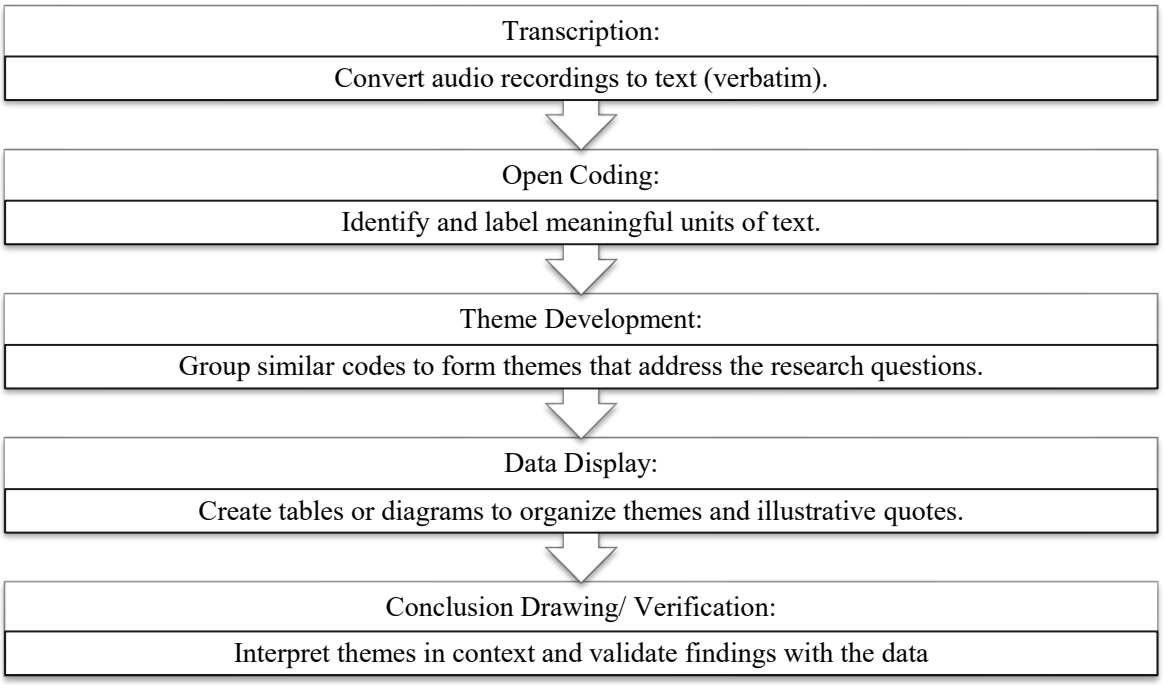

Figure 1. Analysis Step

This systematic approach ensured that the final thematic framework was grounded in the data and answered the study's objectives.

To enhance credibility, the study used multiple validity strategies. Method triangulation was applied by combining interviews with classroom observations, allowing cross-verification of teachers' reported practices against observed behavior [63]. Source triangulation was inherent in sampling diverse teachers (from different schools and with/without prior training) to compare perspectives. The research team also engaged in investigator triangulation: multiple researchers independently coded data and reviewed each other's findings, reducing individual bias. Moreover, member checking was performed during Google Meet sessions: participants reviewed interview summaries and helped confirm that the researchers' interpretations accurately reflected their views [67]. These techniques are recognized methods to improve trustworthiness in qualitative research [63], [67]. Finally, the criterion of data saturation (no new information from participants) was monitored as a form of credibility check [63]. An audit trail of raw data, coding notes, and analysis memos was maintained to support dependability and allow external review if needed.

The research process incorporated digital tools to facilitate data collection and validation. Interviews and member-checking sessions used video-conferencing (Google Meet) when necessary, providing a flexible way to reach participants and confirm transcripts remotely. Audio recordings were captured on digital devices for high-quality sound; recordings were stored securely in cloud drives. Transcription was done using a combination of professional transcription software for initial text and manual revision to ensure accuracy. All data were organized using digital folder systems. Additionally, Google Forms were used administratively to collect preliminary participant information and scheduling preferences. Overall, technology streamlined the research workflow: it enabled efficient data capture (audio recording), organization (digital documents), and collaborative validation (video calls and online document sharing). These digital methods did not alter the qualitative nature of inquiry but enhanced rigor by ensuring detailed, verifiable records of the process.

3. RESULTS AND DISCUSSION

3.1. Pedagogical Practices Before E-Module Integration

Before introducing e-modules, teachers in the border-region high schools reported largely traditional, teacher-centered instruction. One teacher at SMA Negeri 2 Sekayam explained, "*I used to rely on printed textbooks and my lecture slides; students just listened quietly*." Another noted that lessons felt "monotonous" without multimedia or hands-on activities. In this context, teachers depended on limited resources and conventional methods: lesson plans and class discussions were centered on the teacher, with little opportunity for student exploration. These accounts suggest that prior pedagogical competencies were confined to content delivery (CK-

PCK) and lacked dynamic technological integration. Students were often passive, and teachers had minimal tools for active learning or real-time assessment.

3.2. Changes After E-Module Implementation

After implementing interactive e-modules, teachers observed notable changes in classroom dynamics and teaching practices. Many reported that lessons became more student-centered and engaging. For example, a science teacher commented, "*With the e-module loaded on tablets, students watch experiment videos and work through simulations themselves. My role shifted to guiding their exploration*." Teachers began using multimedia content, quizzes, and interactive exercises embedded in e-modules. One history teacher remarked: "Instead of just talking, I now have them answer questions and manipulate models in the module. They're more focused and ask more questions." These changes indicate that teachers adapted their instructional strategies: they integrated technology (playing videos, interactive quizzes) and encouraged collaborative group work via the e-module platform. Teachers also noted better classroom management through digital tools – for instance, posting assignments and tracking submissions online. One informant said that using a learning management interface (via the e-module) "*helped me see which students finished the task and who needs help, right away*." Overall, teachers' pedagogical approaches shifted toward active learning, aided by the flexibility and interactivity of e-modules.

3.3. Impact on Student Engagement and Outcomes

Teachers unanimously reported increased student motivation and engagement. In the e-module environment, students could learn at their own pace and repeat lessons as needed. A mathematics teacher observed: "My students seem more interested when they can click through the module and get instant feedback. They even study outside school hours." Many noted that weaker students especially benefited from the multimedia explanations and self-paced quizzes. As one teacher put it, "With e-modules, even shy students participate – they click to answer and aren't afraid to learn on their own." According to these interviews, the improvements in self-efficacy and performance align with prior findings: research has found that interactive e-modules significantly boost student confidence, motivation, and test scores [26], [40]. Importantly, teachers reported that collaborative e-module tasks (group projects or forum discussions within the platform) yielded the strongest positive effects on learning and critical thinking, echoing the literature that collaborative digital learning maximizes gains [24], [26], [68], [69].

3.4. Challenges and Contextual Constraints

Despite the benefits, teachers faced significant implementation challenges. The most common issue was unreliable internet and limited devices. "*Sometimes the connection drops, so students can't load the module*," lamented one teacher; another noted, "*Not all families have smartphones, so some students must use school tablets, which are few*." These infrastructure gaps reflect broader systemic issues: Indonesia's government acknowledges that border and disadvantaged areas especially lack stable connectivity [16], [57], [70], [71]. Teachers also cited a lack of formal training and occasional resistance. As one veteran teacher admitted, "*I was nervous to try the e-module at first – I barely know how to edit PowerPoint*." This digital literacy gap slowed adoption. Finally, teachers noted time constraints and administrative support as barriers: preparing engaging e-modules and managing online platforms required extra effort. Together, these challenges – connectivity, device access, and training – limited the full potential of e-modules in these border schools.

The findings suggest that thoughtfully designed e-modules significantly transformed teaching and learning in these remote high schools. The observed shift from teacher-led lectures to interactive, technology-enhanced learning illustrates the augmentation and modification stages of the SAMR model [72]-[74]. Rather than simply substituting digital for print (e.g. posting PDFs online), teachers created rich multimedia tasks and collaborative activities, indicating a move toward higher SAMR levels. This aligns with best practices: the SAMR framework emphasizes that effective tech integration involves redesigning learning tasks to add value [75]-[77]. In practice, teachers here went beyond substitution by embedding videos, quizzes, and group work into the e-module, thus leveraging technology to transform the learning process.

From the lens of TPACK (Technological Pedagogical Content Knowledge), these results show how teachers developed an integrated knowledge of content, pedagogy, and technology [78]-[80]. Initially, many teachers had strong Content Knowledge (CK) and Pedagogical Knowledge (PK) but limited Technology Knowledge (TK). Implementing e-modules required them to blend these domains: for example, adapting a chemistry lesson (CK) using an interactive simulation (TK) guided by collaborative learning methods (PK). As one teacher described, "I learned how to use a tablet app to demonstrate science experiments instead of just talking about them." This emergence of TPACK was context-specific: teachers negotiated technological affordances with curriculum demands [81]-[83]. The data suggest that successful e-module use depended on developing the Technological Pedagogical Content Knowledge that Mishra and Koehler define – integrating tech in ways that suit the subject matter and student needs [84]-[86].

The teachers' reports and observed outcomes connect strongly with existing research. Consistent with prior studies, interactive e-modules increased student engagement and outcomes [24], [25], [39], [42]. Our teachers' observation that collaborative features produced the largest learning gains mirrors who found that e-modules with group activities maximized student self-efficacy and achievement [26], [27], [40]. Similarly, the engagement described that students are publishers of their own work, resonates with analyses of high-SAMR practices where students become content creators [72]-[75]. Thus, these findings extend earlier work by showing that the benefits of e-modules (motivating learners, supporting self-paced study, fostering higher-order thinking) also apply in under-resourced border contexts.

The study highlights important implications for policy and practice. First, expanding infrastructure is crucial. As the national digital agenda notes, poor connectivity remains "a major barrier" in border areas [16], [19], [57]. Reliable internet and devices are prerequisites for e-module success. Second, teacher training in digital pedagogy should be prioritized . Building teachers' TK and PK so they can develop interactive e-module content will bridge competence gaps. Third, curriculum planners should incorporate e-modules into lesson design, enabling flexible, anytime learning. These steps not only improve immediate learning but also contribute to long-term goals: digital literacy and human resource development in border regions, as emphasized by education planners [51], [55].

The novelty of this research lies in its empirical focus on teacher pedagogical competence in under-resourced international border-area high schools, a context that remains underrepresented in prior digital education studies. While earlier research has largely emphasized student outcomes or urban settings, this study provides evidence that e-modules can function as a practical tool for teacher professional growth in frontier regions facing infrastructural and capacity constraints. The findings highlight that digital innovation, when aligned with contextual needs and supported by basic infrastructure and training, can contribute to educational equity by narrowing pedagogical gaps between urban and remote schools. At the same time, the study underscores the importance of sustained policy support, digital literacy development, and infrastructure investment to ensure the long-term impact of e-module integration. Overall, this research extends existing literature by showing how technology-enhanced pedagogy can be realistically developed and sustained in border-area secondary education contexts.

Thus, it can be said that, integrating e-modules has enhanced pedagogical practice and learning in these border high schools [87]-[90]. The approach exemplifies 21st-century teaching by combining technology with pedagogy (TPACK) and rethinking traditional instruction (beyond SAMR Substitution). With continued support, e-modules can help prepare students and teachers in remote areas for the digital era, fostering equity in education across the urban-rural divide.

4. CONCLUSION

This study demonstrates that the integration of e-modules in secondary schools located in the Sanggau Regency border area has substantially strengthened teachers' pedagogical competence and transformed classroom practices. Teachers shifted from predominantly teacher-centered instruction toward more interactive, student-centered learning supported by digital classroom management and assessment strategies. Through e-modules, teachers were able to design richer instructional strategies using multimedia, manage learning activities more systematically, and implement formative digital assessments that provided timely feedback. These changes indicate a meaningful development of teachers' technological, pedagogical, and content knowledge (TPACK), as technology was not merely added but integrated into pedagogy in ways that enhanced student engagement, autonomy, and learning effectiveness. From the perspective of the SAMR model, most practices progressed beyond simple substitution toward augmentation and modification, showing that e-modules enabled pedagogical redesign rather than superficial digitization. Future research should include larger samples and pre/post learning assessments to validate these findings. Finally, because technological access remains uneven, the positive effects reported may not be sustainable without systemic support.

USE OF ARTIFICIAL INTELLIGENCE (AI)-ASSISTED TECHNOLOGY

The authors declare that no artificial intelligence (AI) tools were used in the preparation, analysis, or writing of this manuscript. All aspects of the research, including data collection, interpretation, and manuscript preparation, were carried out entirely by the authors without the assistance of AI-based technologies.

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