GENERATIVE AI-ENHANCED STEM EDUCATION: EXPLORING CHALLENGES, OPPORTUNITIES, AND TEACHER PERSPECTIVES IN TAIWAN'S SECONDARY SCHOOLS

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ABSTRACT
STEM-based learning is widely recognised for fostering interdisciplinary skills and preparing students for real-world challenges. Taiwan's secondary technology education emphasises hands-on learning, problem-solving, and creative design, encouraging students to explore technological applications through design projects and material processing. This approach strengthens students' theoretical knowledge and equips them with practical skills essential for engineering and design careers.
However, STEM instruction in Taiwan heavily depends on technology teachers, who face challenges integrating cross-disciplinary content while maintaining effective student assessment. Many educators have adopted generative artificial intelligence (GenAI) tools to reduce lesson preparation time and enhance curriculum design. Yet, GenAI remains underutilised in student performance evaluation, where it could offer more insights into students' creative processes and problem-solving strategies.
This study employs a quantitative survey to investigate how technology teachers in Taiwan incorporate GenAI in STEM education and where they acquire related knowledge. Data from 67 teachers of students aged 13–15 reveal that (1) 44% primarily use GenAI for lesson planning and content generation, while only 8% apply it to assess student performance; (2) Teachers gain GenAI knowledge mainly through university workshops, education conferences, and online platforms; and (3) Online platforms significantly support GenAI-based student evaluation. By expanding GenAI's use in creative design assessment, educators could better align STEM education with industry expectations, fostering enhanced design thinking, innovation, and engineering competencies.

Keywords: Stem-based learning, generative AI, teacher perspectives on AI, assessment

1 INTRODUCTION
Science, Technology, Engineering, and Mathematics (STEM) education has gained global recognition for fostering interdisciplinary problem-solving skills and preparing students for real-world challenges [1]. In Taiwan, secondary technology education integrates STEM principles through hands-on learning and creative design projects, enabling students to explore engineering applications and material processing [2]. This approach strengthens theoretical foundations while cultivating practical skills essential for future careers in technology, design, and engineering.
Despite its benefits, STEM instruction in Taiwan places a significant burden on technology teachers, who must design cross-disciplinary lessons that integrate science, mathematics, and engineering while maintaining effective student assessment. Traditional assessments mainly focus on final project results, often neglecting essential elements like creativity, problem-solving, and design thinking [3]. With increasing demands on educators, new technological tools, such as generative artificial intelligence (GenAI), offer potential solutions to streamline teaching and assessment processes.
In recent years, GenAI has gained attention for its ability to assist educators in lesson planning and curriculum development [4]. Many teachers have adopted AI-driven tools to ease workload pressures, yet their use remains largely limited to course design rather than student evaluation. The potential of GenAI to assess student performance—especially in creative and engineering-based projects—remains underexplored. Effective assessment is crucial for aligning STEM education with industry needs, ensuring that students develop not only technical skills but also the capacity for innovation and critical thinking.

This study investigates how secondary technology teachers in Taiwan integrate GenAI into STEM instruction and examines the primary sources from which they acquire knowledge about these tools. By analysing the extent to which teachers use GenAI for student assessment, this research highlights the challenges and opportunities in expanding AI-driven evaluation methods. Strengthening GenAI's role in assessment could enhance STEM education's ability to develop industry-relevant skills, bridging the gap between academic preparation and workforce expectations.

2 DEFINING STEM EDUCATION AND GENAI

STEM education is an interdisciplinary approach that combines different subjects to develop students' analytical and practical skills. It fosters problem-solving, critical thinking, and hands-on learning, preparing students for real-world applications. In Taiwan, STEM education at the secondary level is typically implemented by technology teachers through the "Living Technology" curriculum, which emphasises hands-on design projects and engineering tasks to foster both theoretical understanding and practical application. However, the effectiveness of these programs is often undermined by conventional assessment methods—such as written tests and teacher-led evaluations—that prioritise factual recall over critical thinking and interdisciplinary problem-solving [5]. Moreover, there is a lack of standardised assessment tools aligned with national curriculum goals, and limited teacher training in evaluating higher-order competencies [6]. These limitations make it difficult to accurately assess the integrated learning outcomes that STEM education seeks to promote.

As the demand for high-quality STEM education continues to grow in Taiwan, there is an urgent need to explore more adaptive and authentic evaluation models that match the interdisciplinary goals of STEM instruction. Emerging technologies like GenAI offer promising potential to address this gap by enhancing assessment through personalised feedback, automated scoring, and semantic analysis of student responses. Studies suggest that current applications of GenAI in Taiwan remain focused primarily on curriculum design, while its use in student assessment is still underdeveloped [7]. Leveraging GenAI for formative assessment, rubric generation, and real-time learning analytics could significantly improve the validity, consistency, and efficiency of STEM evaluation practices.

To realise this potential, it is essential to equip teachers with the skills and knowledge necessary to effectively apply AI-driven evaluation tools. Successful implementation will depend on adequate professional development that empowers educators to integrate GenAI into their assessment practices for broader and more sustainable adoption.

Teachers' adoption of digital tools is shaped by their training and learning experiences. Those who receive structured professional development or collaborate with peers are more likely to implement innovative teaching strategies [8][9], whereas self-directed learners often apply technology in a more limited scope [10]. In Taiwan, technology teachers' familiarity with GenAI influences its classroom implementation, but its application in assessment remains limited. Currently, little research has explored why teachers hesitate to adopt GenAI for assessment. This study investigates whether their learning pathways and access to AI-related training influence adoption. Investigating this relationship can help identify strategies to enhance teacher training and expand the role of GenAI in student assessment.

In summary, while STEM education in Taiwan has embraced hands-on learning and interdisciplinary teaching, assessment methods remain largely traditional, limiting the evaluation of essential STEM competencies. While GenAI presents a promising solution, its application in student assessment remains underdeveloped. Examining how teachers learn and integrate GenAI can provide insights into expanding its role in STEM evaluation. The following chapter details the research methodology employed to investigate technology teachers' learning pathways and the factors influencing their application of GenAI in STEM assessment.

3 RESEARCH METHODOLOGY

3.1 Research questions and method of inquiry

This study seeks to address two key research questions: firstly, through which channels do teachers acquire knowledge about GenAI, and secondly, how do teachers integrate GenAI into their STEM-based teaching practices? A quantitative research approach was employed using a web-based survey to efficiently collect data from junior high school technology teachers in Taiwan. This approach was chosen due to its ability to efficiently reach a broad and diverse group of educators, ensuring accessibility and cost-effectiveness while allowing for the collection of data from teachers across different regions [11].

3.2 Research design and implementation

This study collected data over two months to investigate the sources from which teachers learn about GenAI and its integration into STEM education. The survey included 12 questions addressing different dimensions of GenAI adoption. However, this study focuses on two questions directly aligned with its research objectives. A total of 67 valid responses were obtained through purposive sampling, including 11 novice teachers (less than three years of experience) and 56 experienced teachers (more than three years). These educators, committed to advancing technology education, were selected as representatives from various cities across Taiwan. As regional leaders in curriculum development and teacher training, they offer valuable insights into GenAI adoption and its integration into teaching practices.

The survey focused on two key questions. The first investigated how teachers learn to use GenAI in their teaching practice, allowing participants to select multiple sources, including professional development opportunities such as university-organised workshops, educational technology conferences, online learning platforms (e.g., Coursera, Udemy, edX), workshops held by technology and maker centres, online videos from social media platforms (e.g., YouTube, TikTok), online communities and forums, school-organised training sessions, and professional books and articles.

The second question examined where teachers apply GenAI in STEM-based education, also permitting multiple selections. The response options included lesson planning and design, creative content generation, student performance assessment, facilitating group projects, simulating experiments, enhancing problem-solving activities, and supporting personalised learning paths.

Both survey questions allowed participants to select all applicable learning sources and applications of GenAI. Given the categorical nature of the responses, logistic regression analysis was conducted to examine the relationship between learning sources and teachers' adoption of GenAI in different instructional contexts.

4 RESEARCH FINDINGS AND DICUSSION

4.1 Sources of Learning GenAI

To understand where teachers acquire their knowledge of GenAI, survey data on learning resources were analysed. Figure 1 illustrates the distribution of learning sources, highlighting that online learning videos from social media platforms (39), school-organised training sessions (36), and online communities and forums (27) are the most frequently cited sources, while professional development courses and workshops organised by universities (17) and educational technology conferences and exhibitions (15) are less common. This suggests that informal, digital spaces play a key role in teachers' learning of GenAI applications. Similarly, Figure 2 presents the distribution of GenAI applications, revealing that teachers predominantly use GenAI for lesson planning and design (41 teachers) and generating creative content or projects (34 teachers), whereas its application in assessing student performance remains limited, with only 12 teachers reporting its use in this area. The comparison of these distributions suggests that while teachers have access to a variety of learning resources, their use of GenAI remains largely focused on curriculum design rather than student assessment.

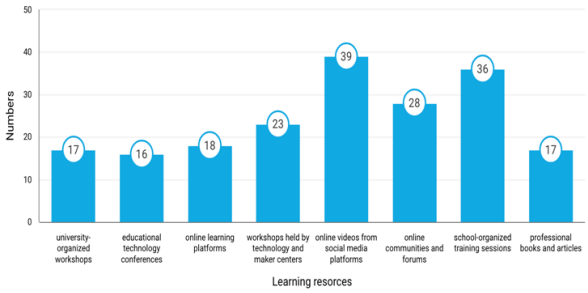

Figure 1. Teachers' learning resources for GenAI

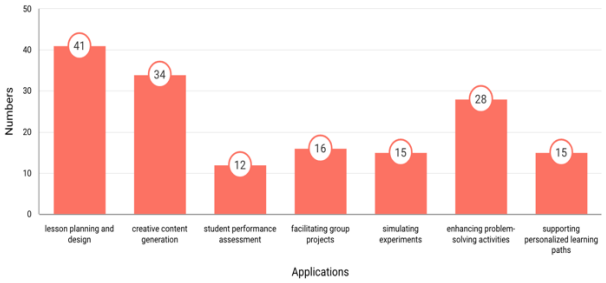

Figure 2. Applications of GenAI in STEM

4.2 Exploring the Relationship Between Learning Sources and Applications

After identifying the various sources from which teachers acquire knowledge about GenAI and examining how they apply it in their teaching, we conducted a logistic regression analysis to determine whether specific learning pathways were associated with different areas of GenAI application in STEM education. Our initial goal was to explore potential connections between learning sources and various instructional applications, without a predetermined focus on any particular area.

Table 1. Logistic Regression Results

Learning source	Coefficient (β)	Odds Ratio (OR)	Significance (p-value)
Professional Development Courses and Workshops (Universities)	0.49	1.64	$p< 0.05$
Educational Technology Conferences and Exhibitions	0.49	1.64	$P < 0.05$
Online Learning Platforms (Coursera, Udemy, edX)	0.71	2.04	$P <0.01$
Model accuracy	-	82.1%	-

The results indicated that most learning sources did not show a significant relationship with specific GenAI applications. However, online learning platforms such as Coursera, Udemy, and edX demonstrated a stronger association with the use of GenAI in student assessment. Professional development courses and workshops organised by universities, as well as educational technology conferences and exhibitions, both yielded an odds ratio of 1.64, suggesting a moderate positive effect on teachers' use of GenAI for evaluation. In contrast, online learning platforms had a comparatively higher odds ratio of 2.04, indicating that teachers who engage in structured, self-paced online learning are more likely to integrate GenAI into student assessment. The model's overall accuracy of 82.1% reinforces its predictive effectiveness in identifying factors that may contribute to teachers' likelihood of applying GenAI for assessment purposes.

One possible explanation for this trend is that structured learning environments, particularly online courses, might provide teachers with more systematic and sustained training, which could enhance their confidence and ability to implement GenAI in student evaluation. Compared to one-time workshops or conferences, structured online learning could offer more interactive components, continuous feedback, and applied practice, making it a potentially more effective mode of professional development.

This interpretation aligns with Desimone [12], who emphasised that sustained, content-focused, and structured professional development programs tend to be more effective in transforming teachers' instructional practices compared to short-term or fragmented training sessions. Likewise, Korthagen [13] suggested that professional learning experiences incorporating real-world applications and reflective practice are more likely to have a lasting impact on teachers' instructional behaviour. Given these insights, further research is needed to explore whether structured learning environments play a more significant role in fostering the application of GenAI in assessment compared to less structured, informal learning methods.

4.3 Key Finding: Online Learning Platforms and Student Assessment

A deeper examination of the statistical results revealed that among all learning channels, online learning platforms had the most significant impact on the use of GenAI for student assessment. However, the overall low adoption rate of GenAI in assessment suggests several key areas for further investigation. The strong influence of online learning platforms in supporting GenAI-based assessment suggests that more targeted training efforts should focus on equipping teachers with the skills to integrate AI into evaluation methods.

To address this limitation, future research could explore why teachers hesitate to adopt GenAI for student assessment, focusing on identifying specific barriers and designing interventions to enhance its practical implementation. Investigating how different training formats—such as structured online courses, certification programs, or informal learning through online communities—impact teachers' ability to integrate AI into assessment practices would be valuable. Additionally, developing AI-integrated assessment models could be a crucial next step. Research could explore how AI-driven tools provide real-time feedback, support competency-based evaluation, or enhance formative assessments in STEM education. Understanding how AI can assist in designing more effective and scalable student assessment frameworks would help broaden its applications beyond lesson planning and creative content generation.

These findings contribute to the broader discourse on AI integration in education, reinforcing the need for a structured approach to teacher training that aligns with the evolving technological landscape of STEM education. Future research should explore how different training methodologies impact teachers' long-term adoption of GenAI and its effectiveness in enhancing student learning outcomes.

5 CONCLUSIONS

This study investigated how secondary technology teachers in Taiwan adopt Generative AI in STEM education. The findings show that GenAI is primarily used for lesson planning and content creation,

while its application in student assessment remains limited. This indicates that teachers largely perceive GenAI as a tool for instructional support rather than for integrated evaluation.

Importantly, the study found that teachers who engage with structured learning platforms—such as formal online courses—are more likely to explore GenAI's potential in assessment. In contrast, those relying on informal resources tend to limit its use to content generation. These insights underscore the importance of structured learning environments, which appear to facilitate teachers' ability to learn and integrate GenAI into both instructional and assessment practices.

6 FUTURE RESEARCH AND LIMITATIONS

As an exploratory study, this research primarily relied on self-reported data to understand teachers' practices and perceptions of GenAI in STEM education. Future studies should further investigate the factors that influence teachers' willingness to adopt GenAI for student assessment, particularly in relation to their learning experiences and access to structured support.

While the findings suggest that structured learning environments may support broader GenAI applications, future research could explore how different types of structured learning environments influence teachers' ability to apply GenAI in assessment. As GenAI continues to be used for instructional content creation, evaluating the quality and relevance of the generated materials is also becoming an important area of concern. In this context, developing assessment frameworks specifically designed to evaluate the quality and instructional relevance of GenAI-generated content in STEM education is also necessary. Future work should focus on validating such frameworks to ensure teachers can evaluate and apply GenAI-generated content that aligns with learning goals and curriculum standards.

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