Teacher Professional Development for Integrating Generative AI in Education: Techno-Pedagogical Competencies, Practical Applications, and Challenges

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פיתוח מקצועי למורים לשילוב בינה מלאכותית גנרטיבית בחינוך: מיומנויות טכנו-פדגוגיות, יישומים מעשיים ואתגרים

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Abstract

This study investigates the integration of Generative Artificial Intelligence (GenAI) in education through a Teacher Professional Development (TPD) framework focused on building techno-pedagogical competencies. The research examines how teachers in Israel integrate GenAI tools into both lesson planning and student engagement, highlighting both benefits and challenges. Drawing on principles of techno pedagogy for effective technology integration in classrooms (Dexter,2005), this study examines the alignment of technological tools with pedagogical goals such as collaboration, prompt crafting and learner-centered approaches. This qualitative research combined semi-structured interviews and analysis of teacher-designed learning activities from 17 educators participating in a 30-hour TPD program yielding 291 analyzed statements across all data sources. Data analysis employed inductive coding, and a deductive approach based on techno-pedagogical frameworks that emphasize technology-enhanced learning design and digital pedagogy competencies. Findings reveal that teachers are extending traditional frameworks by acquiring GenAI-specific skills, including prompt crafting, ethical considerations, and previously unaddressed areas such as source reliability and responsible GenAI use. Teachers demonstrate growing confidence in applying GenAI, though they continue to face significant barriers including infrastructural limitations, restrictive policies, and administrative support variability, complicating GenAI's integration. The study underscores the importance of TPD programs that combine foundational pedagogical strategies with hands-on GenAI experience, equipping teachers with conceptual understanding and practical skills. This approach aims to foster sustainable GenAI literacy, helping teachers create adaptable, student-centered learning environments.

Keywords: Generative AI – GenAI, Teacher Professional Development – TPD, Techno-Pedagogical Competencies, GenAI in Education, Crafting Prompts, Educational Technology Integration, GenAI Implementation Challenges.

Introduction

Teacher's professional development (TPD) for integrating Generative AI (GenAI) in education presents unique challenges as teachers adapt to rapidly evolving technology (Tammets & Ley, 2023). While research exists on technology integration in education, studies on developing techno-pedagogical competencies for GenAI implementation remain limited.

Techno-pedagogy principles, as conceptualized through Dexter's (2005) **Educational Technology Integration and Implementation Principles (eTIPs)**, provide a framework for technology integration in K-12 education, strategically aligning technology with pedagogical methods to enhance teaching and learning outcomes (Dexter, 2005). The framework consists of six key principles: learning outcomes must drive technology selection; technology should provide added value to teaching and learning through collaborative activities, independent exploration, and personalized learning experiences; technology should assist in assessment of learning outcomes; schools must provide ready access to supported technology resources with convenient, flexible access and technical support to ensure practical classroom implementation; TPD should target successful technology integration, moving beyond basic operational skills to focus on instructional design, exploration of educational technology, and meaningful pedagogical implementation; and professional community should enhance technology implementation, providing a collaborative environment (Dexter, 2005). These principles are particularly relevant to GenAI integration, where teachers must strategically align technological tools with pedagogical goals while fostering student collaboration and independent learning (Mørch et al., 2023). The following Figure 1 illustrates Dexter's six principles, at both classroom and school levels.

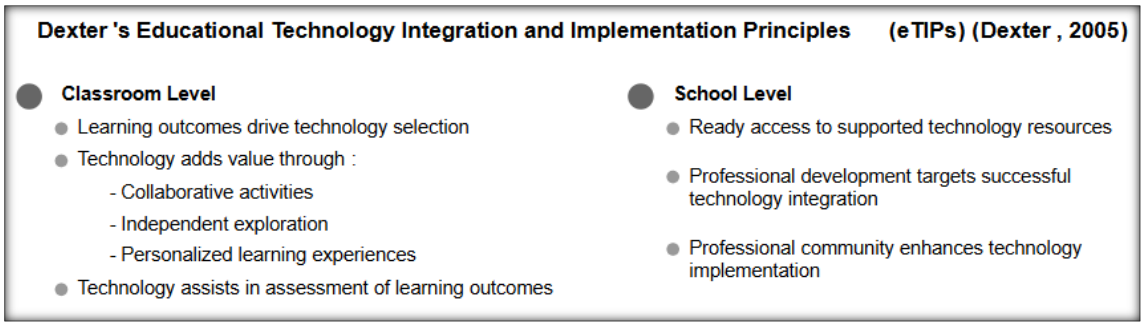

Figure 1: Dexter's principles of integration of education Technologies

Current GenAI implementation requires strategic alignment of technological tools with pedagogical methods to enhance teaching and learning outcomes (OECD, 2023). Teachers need support in developing essential competencies such as prompt crafting, critical thinking, and learner engagement strategies (Ding et al., 2024). This study examines how teachers in Israel integrate these techno-pedagogical principles to align GenAI with educational goals across various subjects, in elementary (n=7) and high-school (n=10) as well as the challenges encountered in this process.

Research Objectives and Questions

This study examines the framework of Techno-Pedagogical Principles, analyzing how teachers develop and apply these competencies through TPD to integrate GenAI effectively. It also explores challenges teachers face when using GenAI for lesson preparation and classroom applications. The research questions are:

1. Which techno-pedagogical principles and competencies do teachers acquire during TPD programs focused on integrating GenAI, and how are these principles reflected in their teaching and learning practices?
2. What challenges and barriers in the classroom level and the school level (Dexter,2005) do teachers encounter when applying these principles in educational settings?

Methodology

Participants and Context

The study involves 17 Hebrew-speaking teachers, across various subjects, in elementary (n=7) and high-school (n=10), with varied teaching experience and balanced gender representation. Participants undergo a 30-hour TPD program organized by the Ministry of Education [IL] and Pedagogical Center (Pisga), covering GenAI in education, digital pedagogy, and tools such as GenAI text and image generators. The TPD program was structured around three main components: AI fundamentals and educational applications, hands-on experience with text-to-text and text-to-image AI tools, and advanced AI tools such as Canva's Magic Studio with AI features for creating educational materials, presentations, and visual content. Throughout the program, teachers engaged in both synchronous online sessions and asynchronous learning activities, with practical workshops focusing on responsible AI integration, prompt crafting, and the development of AI-enhanced learning materials for their specific subject areas while developing pedagogical and technological competencies. Through hands-on application and peer sharing, teachers learn to integrate GenAI in ways tailored to their students' needs, reflecting on practical classroom implementations.

Research Instruments and Procedure

This study employed two research instruments: semi-structured interviews and analysis of teacher-designed activities. Seventeen interviews were conducted via Meet or Zoom videoconferencing 2-5 months after TPD program completion, allowing teachers time to implement and reflect on their learning. The 30–45-minute interviews explored participants' integration of GenAI into pedagogy, focusing on areas such as collaboration, critical thinking, prompt crafting, and student engagement as well as implementation challenges. The analysis of 15 learning activities developed during the TPD program provided systematic examination of how teachers applied GenAI tools in their pedagogical contexts. Each participant shared at least one learning activity, detailing the implementation process, technological tools used, and specific ways TPD contributed to the activity's development. These analyzed activities included lesson units using text-to-text AI for content adaptation and differentiated instruction, collaborative student projects utilizing multiple AI tools (text-to-image generation and Canva) for creative design tasks, and interactive educational materials combining AI-generated content with visual elements. These activities, developed across different subjects and grade levels, demonstrated teachers' application of TPD principles in transforming traditional teaching materials into AI-enhanced learning experiences. The data analysis combined inductive and deductive thematic analysis (Seidman, 2013) began with identifying emergent themes regarding GenAI integration in teaching, followed by systematic categorization using predefined theoretical frameworks. To ensure inter-rater reliability, 25% of the data was independently recoded by a second rater –

a specialist in educational technologies and qualitative research, with Cohen's Kappa coefficient of 0.82 indicating high agreement between the two raters.

Findings and Discussion

This study examines how teachers develop techno-pedagogical competencies through TPD while integrating GenAI into their teaching practices. Interviews conducted with 17 teachers and teaching material collected yielded 291 statements. The analysis encompassed 291 statements from two data sources: 258 statements from semi-structured interviews addressing both competencies and implementation challenges, and 33 statements from teaching materials documenting practical applications. The analysis reveals patterns in both competency development and implementation challenges, organized according to Dexter's (2005) framework and emerging GenAI-specific requirements.

Development and Application of Techno-Pedagogical Principles in GenAI Integration

Table 1 demonstrates the development of teachers' techno-pedagogical competencies, identified through both deductive analyses based on Dexter's (2005) framework and inductive analysis of emerging GenAI-specific competencies during TPD.

Table 1. Development of Techno-Pedagogical Competencies Through TPD

Techno-Pedagogical Competencies Acquired in TPD n=141 interview statements	**Representative Quote**
Sub-category 1.1: Core Techno-Pedagogical Competencies (Based on Dexter, 2005) (n=73)	
Learning Outcome Alignment (selecting and applying appropriate technology for pedagogical goals) (n=24)	"They challenged me when they moved me to special education, and I needed to adjust the material to a different level. So, I used AI. I told it, "take this material and adapt it for kids of a certain age with a lower skill level." (T5)
Value-Added Technology integration (collaboration and independent learning) (n=49)	.."we had a learning unit on the topic of Ruberg's machine... in pairs, they created with AI a sort of machine in an image" (T1) "Independent self-learning -that's really my main goal when using GenAI, for the learner to know how to be independent in their learning." (T2)
Sub-category 1.1: GenAI-Specific Competencies (n=68)	
Critical Thinking and Source Comparison Between Different GenAI Engines (n=28)	".. you need to self-monitor…you ask the AI... but under no circumstances can you rely on it entirely... if it mentions a specific article, you need to check that the article exists, go and read it…to exercise self-monitoring." (T7). "You have to review… simultaneously with two search engines to compare them." (T8)

Prompt Crafting and Refinement (n=28)	"What really helped me in the training was refining the prompts. I think that's the key. That's what teachers need to be taught—how to write prompts correctly, how to fine-tune them, because that's what helps you achieve better results." (T2)
Teaching about AI safety and ethical use (n=12)	"We are learning with my class about the dangers found in improper use of GenAI tools such as copying, spreading false information, privacy issues." (T1)

While Table 1 demonstrates teachers' acquired competencies, Table 2 illustrates how these competencies are applied in practical teaching contexts, revealing the transformation of understanding into classroom practice.

Table 2. Implementation of Techno-Pedagogical Competencies in Teaching Materials Gathered After TPD.

Teaching and Learning Materials n= 33 statements	**Representative Quote**
Sub-category 2.1: Core Techno-Pedagogical Applications (Based on Dexter, 2005) (n=20)	
Learning outcome alignment (n=15) • Lesson Planning and Adaptation (n=6) • Student Collaboration Activities (n=6) Independent Learning Design (n=3)	"The lesson unit—I had Claude read the material summary and asked it to create a lesson plan for me, and this is the result. I added the images and made small content corrections." (T7) "I emphasized that they worked together in a group, learning how to phrase their requests through trial and error, and they were actively involved in designing their class symbol using GenAi to create a picture." (T9) "They used the GenAI feature on Canva to make their own invitations" (for an event we were learning about) (T3)
Time and Resource Efficiency (n=5)	"I worked on preparing the unit (three double lessons) and it only took me an hour." (T8)
Sub-category 2.2: GenAI-Specific Applications (n=13)	
GenAI tool Integration for Classroom Activities (n=9)	"You need to log in to Canva… and then search for an app called 'Magic Media.' …specifying the type of image you want to create, style, and size… you'll find 'Share'."
Prompt Crafting Implementation (n=4)	"The kids wrote the prompt in English, and we got four images that we liked but weren't quite right. I asked them to refine the prompt. They did this four times until we ended up with four great images, from which we chose one."

Analysis of the findings reveals key patterns in teachers' development and application of techno-pedagogical competencies. Core competencies based on Dexter's (2005) framework emerged strongly in learning outcome alignment (n=24) and value-added technology integration (n=49), demonstrating teachers' ability to strategically incorporate GenAI into their pedagogical practice. While Dexter's eTIPs framework provides a foundational structure for technology integration, our findings align with Mørch et al.'s (2023) emphasis on adaptive teaching yet indicate a need to expand these principles for GenAI-specific requirements, especially in prompt crafting (n=28) and critical source evaluation (n=28). Teachers effectively applied these competencies in their learning activities (Table 2), particularly through lesson planning adaptations (n=6) that align with Tammets and Ley's (2023) emphasis on meaningful technology integration. The emergence of GenAI-specific competencies as a distinct category suggests that traditional techno-pedagogical frameworks require expansion to fully support the unique affordances and challenges of GenAI. This is particularly evident in practical applications such as lesson planning adaptation, collaborative activities and independent learning designs (Table 2, n=15). These findings underscore the importance of providing teachers with both the technical skills and pedagogical strategies to effectively harness GenAI in their practice (OECD, 2023).

Challenges and Barriers

While incorporating GenAI in education is promising for enhancing teaching and learning practices, there are significant challenges that need to be addressed to ensure effective and sustainable integration. The following challenges emerged as teachers attempted to implement the GenAI integration strategies and skills developed during the TPD program in their classroom practice.

Table 3 demonstrates the complex barriers teachers encounter when implementing GenAI in educational settings.

Table 3. Challenges in integrating AI tools in education

Interviews n= 117 interview statements	**Representative Quote**
Sub-category 3.1: Core Implementation Barriers (Based on Dexter, 2005) (n=95)	
Learning outcome alignment barriers (n=34) • Teacher implementation for GenAI tools (n=20) • Academic integrity and assessment challenges (n=14)	"How do we integrate this into the curriculum in a way that's not just a nice add-on to learning, but something truly meaningful? How do we handle this, so it doesn't interfere with our students' thinking processes? I feel like we're not there yet… Nobody's telling us what we should be doing." (T6) "It's clear we lack the tools to handle this. When a student copied everything from AI, I explained it was plagiarism, like copying from an article, but I couldn't prove it. Right now, no one really knows how to manage this or make it part of meaningful learning. I don't have a way to assign work and ensure students aren't just copying answers from GenAI." (T5)
Technology infrastructure barriers (n=36)	".. an issue of having enough devices. Not all schools have enough computers or tablets, and in many schools, the internet

• Device limitations (n=7) • Technical difficulties (n=19) • Costly tools (n=10)	connection just isn't fast enough to make this work properly." (T1) "The school's bandwidth can't handle many users at once. The computer lab is a mess…login issues, and the laptops are either broken or not charged. It's discouraging for teachers. Kids have to share computers, often two or three per device, and I sometimes have to bring my own laptop." (T7) "There are tools, but without payment, they're very limited… when my students used Ruby Bot for images, they quickly hit the limit—5 images without an email, 10 with it. They were so excited and used up their quota fast, so I had to switch to a different tool." (T3)
TPD and Environmental support (n=25) • Administrative support issues (n=11) • Staff resistance to change (n=14)	"The school administration, subject coordinator, grade-level coordinator – they're not interested at all. As far as they're concerned, I teach, and they don't care what I do in my lessons. They're just not interested." (T8) ".. not all teachers are on board with this whole thing… Old teaching methods – it always takes time for them to change." (T6)
Sub-category 3.2: GenAI-Specific Barriers (n=68)	
Prompt Crafting Challenges (n=10)	"The biggest challenge is learning to write the right prompt to get the desired result. Teaching kids how to do it was really tough—they had to keep adjusting things just to search for images with AI. It's not as simple as using Google, and it was really hard." (T2)
Content Reliability Concerns (n=5)	"Everything has become so easy with it - creating completely fake images or completely fabricated material. It can be amazing, but it can also be a really harsh and harmful tool." (T4)
Policy Restrictions for GenAI Use (n=18)	"Since I teach in an elementary school, there are a lot of… restrictions about what we can expose the students to. Therefor it hasn't really changed anything in my teaching methods..." (T3)
Attitudes Toward GenAI (n=35) • Fear of AI (n=12) • Staff Negative Reactions (n=17) • Student Negative Reactions (n=6)	"Teachers are really scared of this whole AI thing. You just mention AI and they immediately put up this wall, they don't want to hear about it. 'What, soon I'll be talking to robots? Like, am I not good enough? I'm a teacher with plenty of experience!'" (T2) "And other teachers are really worried, saying 'No, students will cheat, we need to run away from this, we need to shut it down, not allow it…" (T8) "Those who weren't interested, well, I didn't push them. I've actually encountered students who flat-out said they don't want to deal with AI because they feel it's making their brain cells deteriorate." (T8)

Table 3 shows complex barriers teachers encounter when implementing GenAI in educational settings. The analysis reveals two distinct categories of barriers: core implementation barriers based on Dexter's (2005) framework (n=95) and emerging GenAI-specific barriers (n=68). The core implementation barriers align with Dexter's (2005) framework, including learning outcome alignment challenges (n=34), technology infrastructure barriers (n=36), and TPD and environmental support issues (n=25). These findings parallel Law's (2024) observations about infrastructural challenges in GenAI integration. While the TPD provided strategies for GenAI integration teachers show to particularly struggle with implementation tools (n=20) and academic integrity concerns (n=14), reflecting the need for strategic planning and clear pedagogical objectives (Dexter, 2005). Despite the TPD's focus on GenAI skills, GenAI-specific barriers present unique challenges, particularly in prompt crafting (n=10), content reliability (n=5), and policy restrictions (n=18). Staff attitudes toward GenAI emerged as a significant concern (n=35), with teachers expressing fear (n=12) and resistance to change (n=17). These findings align with Ng et al.'s (2023) emphasis on addressing both technical and attitudinal barriers in technology integration.

Conclusions and Recommendations

This study highlights how TPD empowers teachers to implement techno-pedagogical practices, particularly with GenAI. Findings reveal that teachers are extending Dexter's framework to include GenAI-specific skills such as prompt crafting, ethical considerations, and unaddressed areas like source reliability and responsible GenAI usage. This evolution in techno-pedagogical frameworks is essential for GenAI-driven education. Challenges remain, including infrastructure limitations, academic integrity, and administrative support. Addressing these barriers in TPDs is crucial for sustainable GenAI integration. Findings underscore the need for TPD frameworks that combine hands-on GenAI experience with pedagogical strategies while addressing systemic and staff-related challenges.

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