From Design to Enactment: Examining GenAI Integration Patterns among High-School Teachers Through the SAMR Framework

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מתכנון ליישום: בחינת דפוסי שילוב בינה מלאכותית גנרטיבית בקרב מורי תיכון באמצעות מסגרת SAMR

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Abstract

The integration of Generative Artificial Intelligence (GenAI) into educational settings has altered teachers' professional responsibilities, necessitating frameworks for understanding how technology integration evolves in authentic classroom contexts. While the SAMR model distinguishes between enhancement and transformation in technology integration, research indicates that most GenAI activities concentrate at Augmentation levels, raising questions about what enables progression toward transformative integration. This study investigates how high-school teachers integrate GenAI tools following formal teacher professional development (TPD) and what factors are associated with different SAMR integration levels. Utilizing semi-structured interviews with 20 high-school teachers in Israel at two time points (immediately post-TPD and 7-8 months later), this mixed-methods study analyzed 181 documented GenAI activities. Data analysis combined thematic classification by integration level (Future Planning, Design of Learning Materials, Enactment with Students) and SAMR framework with quantitative chi-square analysis. Findings reveal two key patterns. First, GenAI integration varied substantially across pedagogical domains, with Teaching activities concentrating at Augmentation while Learning activities, where students directly engaged with AI tools, concentrated at Modification. Second, time elapsed since training alone did not significantly impact integration levels; rather, implementation approach was critical. Activities involving direct student engagement achieved Modification or Redefinition at substantially higher rates (73.6%) compared to teacher-centered design activities (18.4%). Theoretically, the study identifies SAMR pedagogical levels as a critical mediating factor in technology integration, challenging assumptions that time automatically drives transformative integration. Practically, findings suggest TPD programs should emphasize orchestrating meaningful student engagement with AI tools rather than focusing primarily on teacher-centered resource creation.

Keywords: Teacher Professional Development, Artificial Intelligence in Education, SAMR Framework, Educational Technology.

Literature review

The integration of Generative Artificial Intelligence (GenAI) has fundamentally altered teachers' professional responsibilities, necessitating frameworks for understanding how technology integration evolves in authentic classroom contexts (Kasneci et al., 2023). The SAMR model (Puentedura, 2012) provides such a framework for conceptualizing technology integration depth, distinguishing between enhancement (Substitution and Augmentation) and transformation (Modification and Redefinition), with each level representing increasingly advanced pedagogical integration. Recent empirical research applying SAMR to GenAI contexts reveals that higher-order integration remains relatively rare, with most documented activities concentrated at Augmentation levels (Shamir Inbal et al., 2024; Jiménez-García et al., 2024). This pattern raises critical questions about what factors enable progression toward transformative integration and why identical training produces such varied outcomes among teachers.

Research identifies internal factors (perceived usefulness, self-efficacy, pedagogical beliefs) and external factors (organizational support, professional learning communities) as critical enablers (Viberg et al., 2024; Yang et al., 2024). However, teachers face significant challenges translating AI capabilities into pedagogically sound implementations, particularly when designing innovative AI-integrated lessons (Ding et al., 2024; Kong & Yang, 2024). Teacher Professional Development (TPD) represents the primary institutional response. Recent scholarship emphasizes personalization, including differentiated learning paths, ongoing support, and institutional backing (Avidov-Ungar, 2024; Skantz-Åberg et al., 2022). Yet research documents substantial variability in outcomes, with identical programs producing divergent results (Luo et al., 2024) and facing challenges related to technical limitations, insufficient guidance, and inadequate structure (Sayag et al., 2025).

A critical gap exists in understanding GenAI integration following formal TPD. While most activities remain at enhancement levels (Shamir Inbal et al., 2024; Jiménez-García et al., 2024), longitudinal documentation across pedagogical domains is lacking. Moreover, despite documented challenges in moving from training to practice (Ding et al., 2024; Kong & Yang, 2024), implementation approaches enabling transformative integration remain unexplored. This study addresses this gap through longitudinal mixed-methods examination of GenAI integration patterns among high-school teachers following formal TPD. The study aims to identify not only how teachers integrate GenAI across pedagogical domains, but specifically, what factors enable transformative rather than enhancement-level integration. The study explores the following research questions:

RQ1: How do high-school teachers integrate GenAI tools into their professional practice following formal TPD across different pedagogical domains and SAMR levels?
RQ2: What factors are associated with different levels of GenAI integration following formal TPD?

Methodology

This mixed-methods study utilized semi-structured interviews to examine how teachers integrated GenAI tools following participation in an AI-focused TPD program (Creswell & Poth, 2018). This approach captured the progression from initial intentions to classroom implementation.

Participants and Context

This study examined an entry-level AI-focused TPD program conducted by the Israeli Ministry of Education's Pedagogical Secretariat, implemented through multiple parallel courses across subject areas. The curriculum, designed by educational technology experts, was adapted by subject-area instructors to meet discipline-specific needs. Course sizes varied, ranging from approximately 30 to 60 participants per subject area, with hundreds of teachers participating across all courses. Each course comprised 30 hours of instruction delivered through both synchronous and asynchronous sessions. The curriculum covered fundamental GenAI concepts, text-to-text and text-to-image tools, GenAI applications in educational design software, and subject-specific implementations, emphasizing responsible AI use in education. The participants completed the program during spring-summer 2024.

From this broader sample, 20 high-school teachers were selected using purposive sampling to ensure representation across disciplines (sciences, humanities, social sciences). The participants represented varied career stages: early career (0-5 years, n=4), middle career (6-12 years, n=7), and late career (13+ years, n=9). Many held leadership roles such as subject-matter or pedagogical coordinators. The sample represented various geographic regions and socioeconomic contexts, with teachers in schools classified as high (n=8), medium-high (n=8), and medium-low (n=4) socioeconomic status. While a few participants had limited initial experience with AI tools, for the vast majority this TPD program served as their entry point into AI integration in education.

Research Tools and Procedure

This longitudinal study employed semi-structured interviews via Zoom videoconferencing at two time points. The first round occurred within three weeks of program completion (spring-summer 2024), and the second 7-8 months later (winter 2025), examining sustained implementation patterns. Each interview lasted 40-60 minutes and explored participants' TPD experiences, GenAI tool use, and implementation of AI-enhanced activities. All interviews were recorded and transcribed for analysis. Twenty high-school teachers participated in both interview rounds.

Data analysis followed a mixed-methods approach combining qualitative and quantitative methods. Qualitative data from semi-structured interviews were analyzed using inductive thematic analysis and deductive content analysis (Fereday & Muir-Cochrane, 2006). Activities were classified by the SAMR framework (Puentedura, 2012), distinguishing between enhancement levels (Substitution and Augmentation) and transformation levels (Modification and Redefinition), and categorized by implementation level: Future Planning (conceptual ideas not yet developed), Design of Learning Materials (resources for teacher or student use), and Enactment with Students (direct application in learning environments). Coded activities were then quantified, and chi-square tests for independence assessed **changes over time** between rounds in SAMR distribution and associations between implementation levels and SAMR levels. Qualitative analysis provided representative examples illustrating how teachers implemented GenAI tools across different SAMR levels and implementation approaches. To ensure inter-rater reliability, 25% of the data was independently analyzed by a second rater, with Cohen's Kappa coefficient of 0.81 indicating substantial agreement between raters for SAMR classification.

Findings and Discussion

This study examined GenAI integration patterns among 20 high-school teachers following formal TPD, analyzing 181 documented activities across two interview rounds conducted 7-8 months apart (Round 1: N=91, Round 2: N=90). The first section examines how teachers integrated GenAI tools across different pedagogical domains and SAMR levels (RQ1), mapping the breadth of integration across teaching, learning, and assessment contexts. The second section investigates what factors are associated with different levels of GenAI integration (RQ2), analyzing both temporal progression and implementation approaches. The analysis reveals that while teachers engaged with GenAI across multiple pedagogical domains, the critical differentiating factor for achieving transformative integration was not time elapsed since training, but rather the level of implementation—specifically, whether activities involved direct student engagement.

The Pedagogical Landscape: Mapping GenAI Integration

To understand how teachers integrated GenAI tools into their professional practice, we mapped their pedagogical activities across three core domains: **Teaching**, **Learning**, and **Assessment**. This classification provides a comprehensive view of how GenAI integration manifests across the full spectrum of pedagogical practice. Table 1 presents the distribution of all coded activities across these pedagogical domains and SAMR levels.

Table 1. Distribution of Activities by Pedagogical Domain and SAMR Level

Pedagogical Domain	Substitution	Augmentation	Modification	Redefinition	Total
Teaching	10	48	8	8	**74**
Learning	2	14	43	9	**68**
Assessment	5	21	11	2	**39**

The distribution reveals distinct integration patterns across pedagogical domains and SAMR levels. **Substitution activities** (9.4% of total activities) represented direct replacement of existing practices without functional improvements. In Teaching contexts, teachers used AI to generate lesson plans that replicated traditional planning processes, though one biology teacher noted the AI "gave me a truly nice lesson plan with few ideas I hadn't thought of" (T9B-R1). In Assessment contexts, AI-generated test questions often required substantial human revision to achieve appropriate cognitive complexity. When students used AI as a direct search engine replacement in Learning contexts, outcomes were frequently problematic, with one teacher reporting "shocking" results (T5B-R1). These limitations align with concerns about difficulties in translating AI capabilities into pedagogically sound implementations (Ding et al., 2024; Kong & Yang, 2024).

Augmentation activities constituted the largest category (45.9% of total activities), representing functional improvements over existing practices. **Teaching** activities concentrated primarily at this level (64.9% of Teaching activities), suggesting teachers used GenAI predominantly to enhance existing instructional practices. Teachers leveraged AI for enhanced brainstorming, with one civics teacher describing: "I asked it to give me ideas for a civics text influenced by other fields... I simply got a whole world of options" (T11C-R1). In Learning contexts, students used AI to overcome language barriers when reading academic articles. As one teacher noted, students would "find the article, put it in ChatPDF and ask the tool to explain methodologies and findings," adding that this approach "really saved time" (T5B-R1). In Assessment contexts, AI enabled efficient creation of practice materials, such as converting informational text into fill-in-the-blank exercises (T5B-R1). These applications enhanced efficiency but did not fundamentally redesign learning tasks, consistent with findings that most GenAI activities concentrate at enhancement levels (Shamir Inbal et al., 2024; Jiménez-García et al., 2024).

Modification activities (34.3% of total activities) involved significant task redesign enabled by AI capabilities. A striking pattern emerged: Learning activities, where students directly engaged with AI tools, showed marked concentration at this level (63.2% of Learning activities), indicating more transformative integration when AI reached students directly. Students shifted from content creation to critical evaluation of AI outputs. One teacher designed an activity where students would "ask AI to prepare a summary... read the summary and check if it's appropriate... ask AI to write 10 multiple-choice questions with answers" (T8B-R2), moving from passive consumption to active assessment. Another literature teacher created a novel-specific chatbot: "I built a chatbot for students about the novel 'The life before us'... I finally felt some enthusiasm" (T19L-R2). In Assessment contexts, teachers fundamentally reconceptualized evaluation by allowing open AI access during exams, with one teacher designing a matriculation-format exam explicitly instructing: "you're allowed to use the computer... and I'm not blocking the internet" (T10L-R2), transforming assessment from factual recall to critical AI use. These activities illustrate how direct student engagement enables progression toward transformative integration (Viberg et al., 2024; Yang et al., 2024).

Redefinition activities (10.5% of total activities) enabled entirely new tasks previously inconceivable without AI technology. Teachers created novel interactive experiences that fundamentally reimagined pedagogical approaches. In Learning contexts, one biology teacher orchestrated a Socratic dialogue in which ChatGPT assumed the role of an expert cardiologist during a classroom lesson. The teacher described how the AI "asked us questions and we answered," noting that this interaction "really helped to break the routine" (T9B-R2). In Teaching contexts, teachers transformed content delivery by using AI to create dialogue videos where virtual characters discussed scientific concepts (T5B-R2). In Assessment contexts, teachers created meta-cognitive evaluation experiences where students compared their peer assessments with AI-generated evaluations (T11C-R2), prompting reflection on judgment itself. These activities exemplify transformative potential where technology enables previously impossible pedagogical approaches, representing the highest integration level that research identifies as relatively rare (Puentedura, 2012; Shamir Inbal et al., 2024). This mapping reveals significant variation in integration levels across pedagogical domains, with Learning activities showing notably higher transformative integration. The next section investigates what factors drive these differential integration patterns.

Integration factors: Time vs. Integration Approach

Analysis of activities classified according to the SAMR framework (Round 1: N=91, Round 2: N=90) revealed that temporal progression alone does not drive pedagogical transformation. Chi-square analysis showed no statistically significant difference in SAMR level distribution between interview rounds conducted 7-8 months apart (χ^2 (3) = 5.19, p = .158). **Table 2** presents the distribution across rounds. While descriptive patterns suggested shifts, a decrease in Augmentation activities (47→36) and increase in Modification activities (24→38), the overall distribution remained stable, challenging assumptions that sustained practice automatically produces higher-order integration. This finding aligns with research documenting substantial gaps between training participation and classroom implementation (Ding et al., 2024; Kong & Yang, 2024).

Table 2. Distribution of SAMR Levels in Round 1 vs. Round 2

SAMR Level	Round 1	Round 2	Total
Substitution	10	7	17
Augmentation	47	36	83
Modification	24	38	62

The critical differentiating factor emerged as implementation approach. Activities were categorized as *Future Planning* (conceptual ideas not yet developed), *Design of Learning Materials* (resource creation), or *Enactment with Students* (direct classroom application). Chi-square analysis revealed a significant association between integration level and SAMR level (χ^2 (6) = 53.57, p < .001). Specifically, 73.6% of *Enactment with Students* activities (39 of 53) achieved Modification or Redefinition levels, compared to only 18.4% of *Design of Learning Materials* activities (16 of 87). Table 3 presents this distribution.

Table 3. Distribution of Activities by Integration Level and SAMR Level

Implementation Level	Substitution	Augmentation	Modification	Redefinition	Total
Future Planning	0	15	18	8	**41**
Design of Learning Materials	15	56	12	4	**87**
Enactment with Students	2	12	32	7	**53**
Total	**17**	**83**	**62**	**19**	**181**

The pattern is striking: 73.6% of Enactment with Students activities (39 out of 53) achieved Modification or Redefinition levels, compared to only 18.4% of Design of Learning Materials activities (16 out of 87). Conversely, 81.6% of Design activities remained at Substitution or Augmentation levels. This dramatic difference suggests that direct student engagement serves as the mechanism enabling progression to transformative integration levels. The finding extends research showing that most GenAI activities concentrate at Augmentation levels (Shamir Inbal et al., 2024; Jiménez-García et al., 2024) by identifying the specific factor - student-facing integration that enables movement beyond enhancement. The difficulty teachers face in translating AI capabilities into pedagogically sound integration (Ding et al., 2024; Kong & Yang, 2024) may stem not from insufficient technical knowledge but from inadequate transition from teacher-centered design to student-centered enactment. The transformative potential of GenAI manifests most fully when students directly interact with AI tools in authentic learning contexts.

While the aggregate analysis identified integration level as the key factor driving transformative integration, this pattern masks considerable individual variance. The 73.6% success rate for student-facing activities represents an average that obscures different trajectories among teachers. Understanding what enables some teachers to successfully transition to integration with students while others face persistent barriers, warrants further investigation.

Conclusions

This study examined GenAI integration patterns among high-school teachers following formal TPD, analyzing how integration levels manifest across pedagogical domains and what factors are associated with different SAMR levels. Analysis of 181 documented activities across two interview rounds revealed two key findings. First, GenAI integration varied substantially across pedagogical domains, with Teaching activities concentrating at Augmentation levels while Learning activities, where students directly engaged with AI tools, concentrated at Modification levels. Second, while temporal progression alone did not significantly impact integration levels, the level of integration emerged as the critical differentiating factor. Activities involving direct student engagement achieved transformative integration levels at substantially higher rates than teacher-centered design activities.

Theoretically, this study extends the SAMR framework by identifying implementation approach as a critical factor in technology integration. The findings suggest that transformative integration depends not merely on tool capabilities or temporal familiarity, but on the pedagogical approach to integration, specifically, the degree of direct student engagement with AI tools. This challenges assumptions that time and exposure automatically drive progression toward higher-order integration. **Practically**, these findings indicate that TPD programs should emphasize orchestrating meaningful student engagement with AI tools rather than focusing primarily on teacher-centered resource creation. The path to transformative integration runs through authentic classroom integration with students.

Limitations and Future Research

This study's findings are limited by its focus on high-school teachers in Israel who participated in an entry-level AI-focused TPD program. Reliance on self-report data may introduce biases like social desirability or recall inaccuracies. Future research should broaden the scope to include teachers from diverse educational levels and cultural contexts, as well as integrate instruments for collecting behavioral data such as classroom observations Investigating individual factors that enable or prevent successful transition from teacher-centered design to student-centered enactment could provide deeper insights into pathways toward transformative integration. Additionally, examining how different TPD program designs specifically support this transition could inform more effective professional development models.

References

Avidov-Ungar, O. (2024). The Personalized Continuing Professional Learning of Teachers: A Global Perspective (1st ed.). Routledge. https://doi.org/10.4324/9781003424390

Creswell, J. W., & Poth, C. N. (2018). Qualitative inquiry and research design: Choosing among five approaches (4th ed.). SAGE Publications.

Ding, A.-C. E., Shi, L., Yang, H., & Choi, I. (2024). Enhancing teacher AI literacy and integration through different types of cases in teacher professional development. Computers and Education Open, 6, 100178. https://doi.org/10.1016/j.caeo.2024.100178

Fereday, J., & Muir-Cochrane, E. (2006). Demonstrating rigor using thematic analysis: A hybrid approach of inductive and deductive coding and theme development. International Journal of Qualitative Methods, 5(1), 80–92. https://doi.org/10.1177/160940690600500107

Jiménez-García, E., Orenes-Martínez, N., & López-Fraile, L. A. (2024). Rueda de la Pedagogía para la Inteligencia Artificial: adaptación de la Rueda de Carrington. RIED-Revista Iberoamericana de Educación a Distancia, 27(1), 87–113. https://doi.org/10.5944/ried.27.1.37622

Kasneci, E., Seßler, K., Küchemann, S., Bannert, M., Dementieva, D., Fischer, F., Gasser, U., Groh, G., Günnemann, S., Hüllermeier, E., Krusche, S., Kutyniok, G., Michaeli, T., Nerdel, C., Pfeffer, J., Poquet, O., Sailer, M., Schmidt, A., Seidel, T., ... Kasneci, G. (2023). ChatGPT for good? On opportunities and challenges of large language models for education. Learning and Individual Differences, 103, 102274. https://doi.org/10.1016/j.lindif.2023.102274

Kong, S.-C., & Yang, Y. (2024). A human-centred learning and teaching framework using generative artificial intelligence for self-regulated learning development through domain knowledge learning in K–12 settings. IEEE Transactions on Learning Technologies, 1–13. https://doi.org/10.1109/TLT.2024.3392830

Luo, Z., Abbasi, B. N., Yang, C., Li, J., & Sohail, A. (2024). A systematic review of evaluation and program planning strategies for technology integration in education: Insights for evidence-based practice. Education and Information Technologies. https://doi.org/10.1007/s10639-024-12707-x

Puentedura, R. (2012). The SAMR model: Six exemplars. http://www.hippasus.com/rrpweblog/archives/2012/08/14/SAMR_SixExemplars.pdf

Sayag, M. S., Blau, I., & Avidov-Ungar, O. (2025). "We need more than tools": Examining AI-focused professional development challenges through the DigCompEdu AI supplement framework. In

D. Olenik-Shemesh, I. Blau, N. Geri, A. Caspi, Y. Sidi, Y. Eshet-Alkalai, Y. Kalman, & E. Rabin (Eds.), Proceedings of the 20th Chais Conference for the Study of Innovation and Learning Technologies: Learning in the Digital Era. The Open University of Israel. https://www.openu.ac.il/chais2025_heb_and_eng_web/344/

Shamir-Inbal, T., Levi, L., & Blau, I. (2024). The use of artificial intelligence to promote changes in teaching and learning processes. EDULEARN Proceedings. https://doi.org/10.21125/edulearn.2024.0064

Skantz-Åberg, E., Lantz-Andersson, A., Lundin, M., & Williams, P. (2022). Teachers' professional digital competence: An overview of conceptualisations in the literature. Cogent Education, 9(1), 2063224. https://doi.org/10.1080/2331186X.2022.2063224

Viberg, O., Cukurova, M., Feldman-Maggor, Y., Alexandron, G., Shirai, S., Kanemune, S., Wasson, B., Tømte, C., Spikol, D., Milrad, M., Coelho, R., & Kizilcec, R. F. (2024). Teachers' trust and perceptions of AI in education: The role of culture and AI self-efficacy in six countries. British Journal of Educational Technology, 55(1), 223–245. https://doi.org/10.1007/s40593-024-00433-x

Yang, Y., Xia, Q., Liu, C., & Chiu, T. K. F. (2024). The impact of TPACK on teachers' willingness to integrate generative artificial intelligence (GenAI): The moderating role of negative emotions and the buffering effects of need satisfaction. Education and Information Technologies, 29(5), 6389–6413. https://doi.org/10.1016/j.tate.2024.104877