

Generative AI-Assisted Competitive Microlearning Strategy: Development and Validation of the Plomp Model in Classroom Teacher Education in Finland

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ABSTRACT

Background. The rapid adoption of generative artificial intelligence (AI) in education has created challenges in designing responsible and adaptive learning strategies. Meanwhile, competitive elements in gamified learning remain debated due to inconsistent effects on learner engagement.

Purpose. This research aimed to develop and evaluate a generative AI-assisted competitive microlearning strategy for improving instructional media development skills among Finnish Luokanopettajakoulutus (Class Teacher Education) students.

Novelty. This study introduces a novel instructional design that integrates generative AI, microlearning, and optional quality-based competition. Unlike conventional competitive gamification approaches, the proposed strategy recognizes learner differences by examining whether competition produces varied outcomes across learning groups

Method. Using the Plomp development model, the study involved 79 undergraduate students from four parallel classes. Data from expert validation, practicality questionnaires, and product assessments were analyzed using Aiken's V and descriptive statistics.

Results. The strategy achieved high validity (Aiken's V = 0.87) and strong practicality (83.1% student response; 85.9% lecturer response). Variation in competition participation (41–62%) indicated different effects among learner groups.

Conclusion. The findings contribute an adaptive AI-assisted microlearning framework that balances innovation, learner diversity, and educational equity in teacher education.

KEYWORDS : Generative AI; Co-creation; Instructional Media; Microlearning; Optional Competition; Teacher Education

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INTRODUCTION

The increasing demand for flexible, accessible, and personalized learning environments has accelerated the development of innovative instructional approaches worldwide. One emerging trend is the growing adoption of microlearning, which emphasizes concise, focused, and contextually relevant learning units to support learners' needs in diverse educational settings. Over the past decade, research and practical implementation of microlearning have expanded significantly, not only in corporate training environments but also within formal education systems,

reflecting its potential to enhance learning flexibility and engagement (Díaz Redondo et al., 2021). The convergence between flexible learning models and microlearning approaches has created a new educational landscape characterized by shorter learning cycles, digital integration, and learner-centered experiences. However, despite its increasing adoption, the implications of this transformation for future educators remain insufficiently explored, particularly regarding how prospective teachers understand, design, and implement emerging learning strategies in authentic educational contexts (Cabbeke et al., 2025; Tondeur et al., 2025).

Finland provides a relevant context for examining this phenomenon more closely (Schaffar & Wolff, 2024). Unlike many countries still in the policy development phase, the Finnish Ministry of Education and Culture, together with the Finnish National Agency for Education (EDUFI), began developing official recommendations for the use of AI in education starting in 2024, covering levels from early childhood to adult education (Ji et al., 2024). This move continues a tradition of AI literacy pioneered by Finland long before: in 2018, the University of Helsinki, in collaboration with the technology company Reaktor, launched Elements of AI, a free and bold course packaged in short modules (Tupasela, 2025). Initially, the course targeted one percent of the Finnish population before expanding to the European Union level, with over 660,000 participants worldwide.

However, this readiness policy must be read in conjunction with the distinctive character of the Finnish education system, which has historically minimized competition and ranking among students, prioritizing trust, equality, and teacher professionalism over standardized testing and market competition (Becher, 2024; Ehren, 2023). These characteristics make Finland a relevant and cautious location for research seeking to test AI-assisted competitive microlearning strategies in the education of primary school teacher candidates.

Research on generative AI in pre-service teacher education still focuses on literacy and self-efficacy, with little attention paid to the quality of creative work produced. Generative AI can enhance pre-service teacher reflective skills through digital storytelling, but did not examine competitive elements as a design variable (Wei et al., 2025). That mastery of generative AI does not automatically improve critical thinking without an appropriate learning framework (Cong-Lem & Thuy-Dung, 2026). Involving researchers from the University of Helsinki and the University of Oulu found that the use of generative AI improves pre-service teacher academic achievement through shared metacognition, but did not address microlearning formats or competitive elements. All three highlighted the same gap: no studies have yet combined microlearning, competition, and generative AI as co-creators specifically for the creation of pre-service teacher learning media this gap underpins the importance of this development strategy.

Based on this gap, this strategy is guided by the AI-TPACK framework an extension of TPACK that specifically describes how knowledge of AI technology, pedagogy, and content interconnect in the competencies of prospective teachers (Karataş & Ataç, 2025; Oved & Alt, 2025). To manage the risk of competitive elements posing a threat to Finnish creativity and non-competitive culture, conventional leaderboard approaches that publicly rank participants need to be avoided; recent studies have shown that such leaderboards actually decrease social engagement among learners, particularly those who dislike competition (Oved & Alt, 2025; Philpott & Son, 2022). Instead, this strategy adopts the principle of autonomous choice regarding the level of competition allowing students to choose for themselves how competitive they want to engage, rather than being forced into a single ranking system (Kosmützky & Meier, 2026). With this combination, generative AI is positioned as a co-creator limited to the ideation stage, microlearning becomes the representational structure, and competition is presented in the form of variance and quality of work rather than speed or public ranking.

This research aims to develop a competitive microlearning learning strategy assisted by generative artificial intelligence to improve the ability of students in the Class Teacher Education (Luokanopettajakoulutus) program in Finland in creating learning media.

Theoretical review

a. Laaja-alainen Osaaminen (Transversal Competence) and the Position of Learning Media in It

The Finnish national core curriculum POPS 2014 does not structure competencies based solely on subject matter, but rather through seven transversal competencies that cross subject boundaries (Inkilä, 2023). Two of these are most relevant to this study: monilukutaito (multiliteracy the ability to interpret and produce various forms of text and media) and tieto- ja viestintätekniologinen osaaminen (information and communication technology competencies). The ability to create learning media, therefore, is not simply an additional technical skill for prospective teachers in Finland, but rather a core competency explicitly required by the national curriculum. This framework serves as a legitimate basis for why this strategy is relevant to research in the Finnish context, rather than simply adopting a global trend without local curricular roots.

b. Phenomenon-Based Learning

Since the 2014 curriculum reform, Finland has guaranteed at least one multidisciplinary, phenomenon-based learning module (PhBL) per year for students aged 7- 16, allowing them to explore real-world phenomena across subject boundaries, rather than studying topics siloed by subject (Honkimäki et al., 2022; Mård, 2021). However, Schaffar and Wolff (2024) critically caution that the idea behind PhBL is not new it is removed from the long-standing traditions of constructivism, problem-based learning, and inquiry-based learning and risks atomizing knowledge if applied solely for the sake of measurability and policy accountability, rather than holistic understanding. This warning is relevant to the microlearning strategy in this study: breaking down the process of creating learning media into short units carries the same risk reducing the creative process to fragmented technical steps if not designed to maintain the coherence of overall understanding.

c. Microlearning Theory and Its Cognitive Foundation

Microlearning delivers material in short, focused units, in line with the principle of cognitive load theory, which explains the limited capacity of human working memory to process information simultaneously Sweller (Dolasinski & Reynolds, 2020). Information retention from these units is enhanced through speed, as explained by the forgetting curve principle (Sunny & Thamankar, 2025). Microlearning research and practice over the past decade. In the Finnish context, this principle should be read in conjunction with the critique in subsection 2.2: microlearning can be a coherent vehicle in the spirit of ilmiöpohjainen oppiminen if the short units remain connected to an overall phenomenon/project (creating a single learning medium), rather than isolated exercises without a common thread.

d. AI-TPACK in the Finnish Teacher Competency Framework

Technology as the basis for teaching competencies; its extension, AI-TPACK, describes how generative AI knowledge integrates into these competencies. Kim (2024) demonstrated the effectiveness of this framework in a teacher training program focused on AI-convergence education. In Finland, this framework is relevant, especially considering the official recommendations of the Finnish Ministry of Education and Culture and EDUFI on the use of AI in education, which began to be developed in 2024 (OKM, 2024), making AI-TPACK not just an academic framework but also aligned with current national policy directions.

e. Motivation, Competition, and Creativity Examined from the Spirit of Yhdenvertaisuus (Equality)

Deci (1971) demonstrated that external imbalance can decrease intrinsic motivation, and Amabile (1982) reinforced this specifically in the context of creativity: a competitive atmosphere can decrease creative work compared to non-competitive conditions. This finding directly links to the principle of yhdenvertaisuus (equality) that underpins Finnish educational philosophy a system that has historically eschewed rankings and standardized testing among students (Messina, 2023). However, Okediji, Udofia, Ekong, Akpakpan, Udoh, Balogun, and Olagunju (2026) demonstrated that the impact of a competitive climate on creative performance is conditional, dependent on individual value orientations and ambitions making room for sensitively designed competition, not eliminating it entirely.

f. Human AI Co creation within the Boundaries of Monilukutaito

Human AI co creation refers to the collaborative process between generative AI and users in producing work, with a division of roles that must be maintained so as not to replace the user's cognitive processes. Wei, Wang, Koszalka, Lee, and Liu (2025) demonstrated that the involvement of generative AI in digital storytelling enhances prospective teachers' reflective abilities when designed within a three-dimensional framework of reflection. Reread through the lens of monilukutaito (subsection 2.1), the role of generative AI in this strategy is limited to that of an ideation partner sparking alternative ideas rather than as a producer of the final product, so that the multiliteracy competencies required by the curriculum are truly developed by students, not outsourced to an AI system.

g. Theoretical Development of the Human AI Supported Microlearning Strategy Based on Instructional Design and Joyce and Weil's Model Structure

The figure illustrates the theoretical development of the Human- AI Supported Microlearning Strategy through the integration of instructional design principles, Joyce and Weil's model structure, microlearning, generative AI, and optional competition. Instructional design provides the foundation for analyzing learner characteristics, aligning learning objectives, sequencing content, and designing assessment procedures. Joyce and Weil's framework is used to organize the strategy into five principal components: syntax, social system, principles of reaction, support system, and expected instructional and nurturant effects. Microlearning contributes short, focused, and sequential learning units, while generative AI functions as a bounded co-creator that supports students during the ideation stage without replacing their independent production process. The optional competition component is designed as a voluntary mechanism to encourage motivation and improve product quality without creating compulsory performance pressure.

The synthesis of these theoretical foundations produces a strategy characterized by curricular alignment with laaja-alainen osaaminen, structured microlearning delivery, limited use of generative AI during ideation, and quality-based optional competition. The strategy is implemented through seven learning stages: orientation, microlearning input, AI-assisted ideation, independent production, optional competition, presentation and feedback, and reflection. Its implementation is supported by student-centered and collaborative learning, lecturer facilitation, responsible AI safeguards, microlearning materials, digital platforms, and product-assessment rubrics. The expected outcomes include increased creativity, learner autonomy, responsible use of artificial intelligence, and improved quality of instructional media products, as measured through originality, pedagogical usefulness, and content appropriateness.

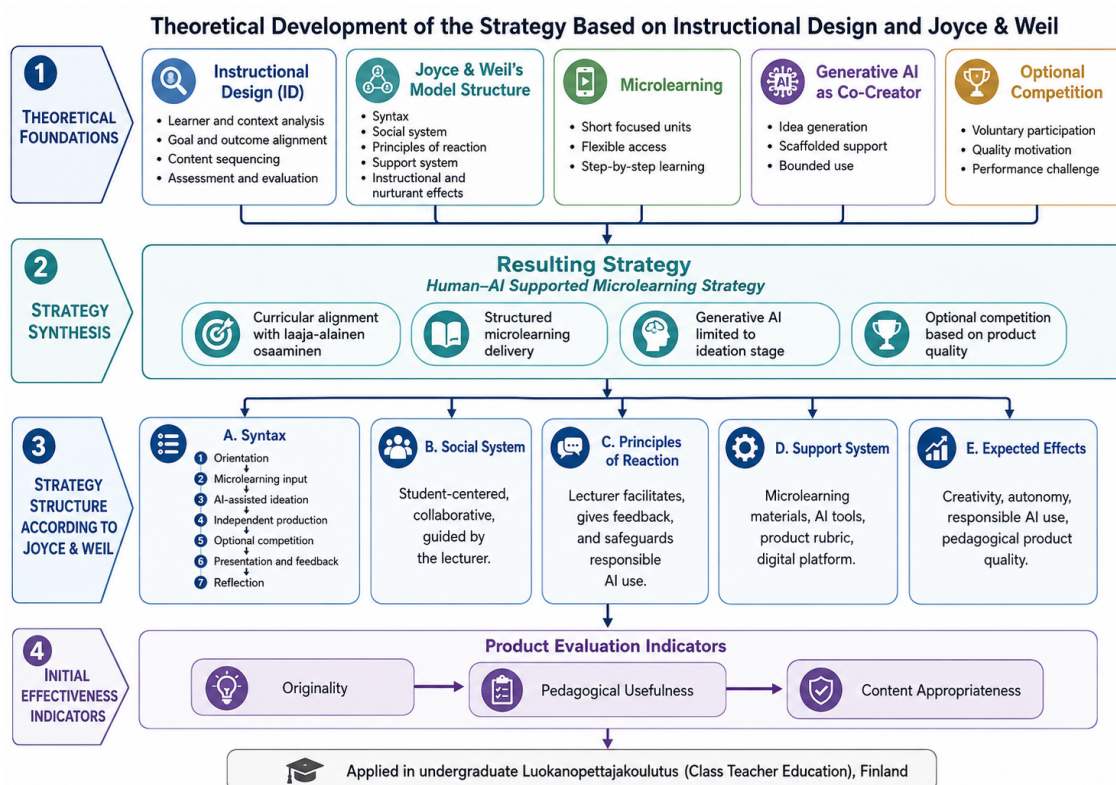


Figure 1. Theoretical Development of the Human- AI Supported Microlearning Strategy Based on Instructional Design and Joyce and Weil's Model Structure

RESEARCH METHODOLOGY

Research Type

This study uses a Research and Development approach, referring to the Plomp model, which consists of three main phases: preliminary research, prototyping, and assessment (Plomp & Nieveen, 2013). This model was chosen because the generative AI-assisted competitive microlearning strategy developed in this study requires an iterative design-validation-revision cycle before being declared suitable for use, rather than simply being tested for effectiveness in a single run.

Research Location and Subjects

This research was conducted within the Finnish Luokanopettajakoulutus (Classroom Teacher Education) undergraduate program, involving four parallel program study classes as field test subjects, with the following details:

Classes: Number of Students: Class A: 21, Class B: 19, Class C: 22, Class D: 17, Total: 79

These four classes were used as field test subjects to assess the practicality and effectiveness of the initial strategy after validation by experts, rather than as experimental and control groups for comparison.

Table 1. Characteristics of Field Test Participants

Class	Educational Context	Number of Students	Role in the Study
Class A	Undergraduate students in the Finnish <i>Luokanopettajakoulutus</i> (Classroom Teacher Education) program	21	Field test participants evaluating the practicality and effectiveness of the developed learning strategy
Class B	Undergraduate students in the Finnish <i>Luokanopettajakoulutus</i> (Classroom Teacher Education) program	19	Field test participants evaluating the practicality and effectiveness of the developed learning strategy
Class C	Undergraduate students in the Finnish <i>Luokanopettajakoulutus</i> (Classroom Teacher Education) program	22	Field test participants evaluating the practicality and effectiveness of the developed learning strategy
Class D	Undergraduate students in the Finnish <i>Luokanopettajakoulutus</i> (Classroom Teacher Education) program	17	Field test participants evaluating the practicality and effectiveness of the developed learning strategy
Total	Undergraduate students in Classroom Teacher Education program	79	Participants involved in the field testing phase

Development Procedure

Preliminary Research Phase

This included a needs analysis, literature review, and analysis of the Finnish curricular context (laaja-alainen osaaminen, ilmiöpohjainen oppiminen), as described in the background and theory section of the study.

Prototyping Phase

The generative AI-assisted competitive microlearning strategy was designed in the form of a prototype, including the structure of the microlearning units, the boundaries of the AI's role as a co-creator in the ideation phase, and an optional competition mechanism based on the quality of the work. This prototype was developed through an iterative cycle: initial plan → peer review → revision, before entering the expert validation phase.

Assessment Phase

Validity testing the prototype was assessed by subject matter experts (pedagogy/curriculum) and media/learning technology experts using a Likert-type validation sheet. Practicality testing the prototype was piloted on a limited basis, then on a larger scale in four classes, with student and lecturer feedback data collected. Initial effectiveness testing conducted by assessing the learning media products produced by students in the fourth grade using a creativity and media quality assessment rubric.

Data Analysis Techniques

Validity was analyzed using Aiken's V-index, with a threshold of ≥ 0.80 as the validity criterion, consistent with common practice in educational development research (Aiken, 1985, as applied to various recent development studies). Practicality was described descriptively percentages of questionnaire responses. Initial effectiveness was described from the rubric scores for the learning media products in the four classes, reported descriptively per class, given that this design was not a comparative experiment.

RESULT AND DISCUSSION

The prototype of a generative AI-assisted competitive microlearning strategy was validated by three experts a criteria expert, an instructional media expert, and an educational AI expert using Aiken's V index, a coefficient that calculates the ratio of rater agreement to the maximum possible agreement and is widely used in educational development research to test the content validity of instruments and products (Aiken, 1985). Referring to the general categorization of this index, a V value ≥ 0.80 is declared high validity, a value of 0.40- 0.80 is declared moderate validity, and a value < 0.40 is declared invalid (Penfield & Giacobbi, Jr., 2004). The validation results in Table 2 show that the four assessed aspects obtained an average Aiken's V of 0.87, which is in the high validity category and exceeds the recommended threshold.

Table 2. Results of the Prototype Strategy Validity Assessment

Assessed Aspect	Validator 1	Validator 2	Validator 3	Mean Aiken's V	Validity Category
Alignment with <i>laaja-alainen osaaminen</i> (transversal competence)	0.88	0.85	0.90	0.88	High
Structure and sequencing of the microlearning units	0.92	0.90	0.87	0.90	High
Clarity of the limitations placed on the role of generative AI as a co-creator	0.83	0.80	0.85	0.83	High
Quality-based optional competition mechanism	0.90	0.88	0.86	0.88	High
Overall Mean				0.87	High

These findings indicate that the four core components of the strategy curricular alignment, instructional delivery structure, governance of the AI role, and competition design were consistently judged to be feasible and valid by all three experts. None of the assessed aspects fell within the moderate- or low-validity categories. The lowest score was recorded for the limitations imposed on the role of generative AI ($V = 0.83$). This result suggested that the boundaries of AI use required further clarification to ensure that the technology supported rather than replaced students' independent creative processes. Accordingly, the prototype was revised based on the validators' qualitative feedback, as summarized in Table 3.

Table 3. Prototype Revisions Based on the Validators' Qualitative Feedback

Component	Condition Before Revision	Validator Feedback	Condition After Revision
Access to generative AI during the production stage	Students were permitted to access generative AI throughout the entire creative and production process.	Unrestricted access could reduce students' engagement in independent thinking, problem solving, and creative production.	Access to generative AI was limited to the ideation stage. During the production stage, students were required to develop and complete their work independently.
Timing of the competition-option selection	The competition option was selected at the beginning of the learning session and could not be changed.	The mechanism needed to provide greater flexibility because students might reconsider their participation after understanding the task requirements and learning process.	Students were allowed to activate or deactivate the competition option at any point during the learning session before final submission.

The practicality test was conducted across four parallel undergraduate classes in the *Luokanopettajakoulutus* (Class Teacher Education) program, involving a total of 79 students. Practicality data were obtained from both students and course instructors, focusing on three principal dimensions: ease of use, clarity of instructions, and the suitability of the time allocated for implementing the strategy.

Table 4. Practicality Test Results by Class

Class	Number of Students (n)	Student Practicality Score (%)	Instructor Practicality Score (%)	Practicality Category
A	21	84.2	87.0	Highly Practical
B	19	81.5	85.5	Practical
C	22	86.7	88.2	Highly Practical
D	17	79.8	83.0	Practical
Mean/Total	79	83.1	85.9	Practical to Highly Practical

Practicality scores varied across classes within the range of 79.8- 86.7% for student assessments, with Class D recording the lowest scores and Class C the highest. This pattern was consistent across both data sources (students and lecturers), indicating that variations in practicality were more related to individual class characteristics than to bias from the assessor source.

Assessed using a rubric designed to evaluate the instructional media products developed by the students. The assessment focused on three indicators: originality, pedagogical usefulness, and content appropriateness. Each indicator was rated on a four-point scale, ranging from 1, representing the lowest level of performance, to 4, representing the highest level of performance.

Table 5. Rubric Scores for Student-Developed Instructional Media Products by Class

Class	Originality	Pedagogical Usefulness	Content Appropriateness	Mean Score
A	3.10	3.40	3.30	3.27
B	2.90	3.20	3.00	3.03
C	3.30	3.50	3.40	3.40
D	3.00	3.10	3.20	3.10

To specifically test the impact of the Optional competition element, the most distinctive component of this strategy, the data was disaggregated by student participation choices.

Table 5. Comparison of Product Scores Based on Participation in the Optional Competition

Class	Participated in Competition (%)	Did Not Participate (%)	Mean Product Score: Competition Group	Mean Product Score: Non- Competition Group
A	62	38	3.35	3.12
B	47	53	3.10	2.98
C	58	42	3.44	3.33
D	41	59	3.05	3.14

The data in Table 5 show a heterogeneous pattern across classes: in Classes A, B, and C, the groups that chose to participate in the competition recorded higher average product scores than the non-competition group (a difference of 0.11- 0.13 points). However, this pattern reversed in Class D, where the non-competition group actually recorded slightly higher scores (3.14 compared to 3.05). The level of participation in the optional competition itself varied quite widely, from 41% (Class D) to 62% (Class A), indicating that the decision to participate in the competitive element was not uniform despite identical strategies across the four classes.

DISCUSSION

Validity as Evidence of the Convergence of the AI-TPACK Framework with Local Curricular Contexts

The high validity scores across all tested aspects (mean 0.87) provide an initial indication that the AI-TPACK framework (Kim, 2024) can be coherently operationalized within a very specific curricular context the Finnish laaja-alainen osaaknata without losing its theoretical legitimacy. This is not a trivial finding: most AI-TPACK applications in the literature so far have been tested in generic AI convergence education contexts (Joy Prakash Deb & Dr. Firdous Ahmad Sofal, 2026) or in non-Nordic populations (Shrestha & Yi, 2026), thus opening the argument that

the framework has broader cross-cultural curricular adaptability than previously demonstrated. However, the lowest score actually appeared in the aspect of the boundaries of the role of generative AI (0.83) not by chance, but rather a reflection that the validators still view the boundary of “AI as a co-creator of ideation” as an area that is not yet fully established conceptually, in line with the warning, the involvement of generative AI in creative tasks requires an explicit demanding framework, not the assumption that “more AI help is always better” (Grewal et al., 2024; Ward, 2023).

Does Optional Competition Really Solve the Gamification Dilemma?

This is where this study’s most forward-thinking contribution lies, and where the most incisive scientific inquiry needs to be addressed. The literature on leaderboards and competitive elements in education is sharply divided. Found that integrating leaderboards into formative assessments for engineering students significantly improved achievement and engagement supporting the optimistic view that competition is a valid motivational lever (Cigdem et al., 2024). That leaderboards decreased student social engagement, particularly in groups that did not value competition (Do et al., 2024). These two studies are equally credible, both using robust quasi-experimental designs, but come to conflicting conclusions.

This study’s findings the non-uniform pattern in Table 5, where competition is associated with higher product scores across three classes but reverts to Class D do not resolve this conflict unilaterally, but rather offer a structural construct for why this evolution occurred. The wide variation in optional competition participation rates (41- 62%) across classes receiving identical strategies suggests that the impact of competition on performance is not a universal effect of its design, but rather an interaction effect between the design and the composition of individual orientations within the group a proposition that directly reinforces and argument about the importance of competitor autonomy, summary of the context that competitive climate interacts with personal value orientations, rather than having a uniform effect (Popa et al., 2026).

In other words, this study has the potential to offer a new synthesis of, (Alsaiani et al., 2026) both are correct in their respective contexts, as both examine competition as a mandatory and uniform element for all participants. When competition is optional as designed in this strategy the population naturally sorts itself into conditions that match individual orientations, so that the average class-level effect becomes a product of the composition of individual preferences, not a direct effect of the gamification design itself. This explains why Class D with the lowest level of competition participation (41%) actually exhibits a performance pattern that resembles the findings of while Classes A, B, and C with higher participation resemble the findings (Chang et al., 2025).

This may shift the broader perspective of educational gamification research from the question “does competition improve or decrease performance?” to “at what level of diverse participation does a class population achieve an optimal balance between competitive motivation and inclusive engagement?” This shift in question framing is consistent with the projected direction, in generative AI research in teacher education, moving away from simply proving binary effectiveness (effective/ineffective) toward mapping optimal personalization conditions. As a developmental study born at the intersection of microlearning, alternative learning, and generative AI as a co-creator, a gap that has not been explicitly explored in previous research literature has the potential to become an initial reference for similar development strategies not only in Finland, but also in countries with educational philosophies that both guarantee and avoid open competition, such as other Nordic countries.

CONCLUSION

This developmental research resulted in a generative artificial intelligence-assisted competitive microlearning strategy for Luokanopettajakoulutus students in Finland, with three key findings. First, the prototype strategy was found to be valid with a mean Aiken's V of 0.87, confirming that the AI-TPACK framework can be coherently integrated into the Finnish transversal competency curriculum without losing its theoretical legitimacy. Second, the strategy proved practical to implement, with practicality scores of 83.1% from students and 85.9% from lecturers, although the gap in perception between the two indicated the need for joint orientation before full-scale implementation.

Third, and most substantively, the optional competition design was shown to produce effects that depended on the composition of individual participation per class, rather than a uniform effect. This finding bridges the contradiction between the literature reporting positive (Cigdem et al., 2024) and negative (Michinov & Michinov, 2025) impacts of competitive elements in educational gamification. Theoretically, this study fills a gap at the intersection of three variables previously studied separately: microlearning, competition, and generative AI as a co-creator. It offers the novel proposition that the capital of competition serves as a balancing mechanism between motivational benefits and the risk of social exclusion, particularly in a pedagogical context that values equality like Finland. Practically, this strategy provides a concrete model that other elementary teacher education programs can adopt, provided they maintain a clear demarcation of the role of generative AI at the ideation stage to prevent the outsourcing of students' creative processes.

This study has fundamental limitations that limit the generalizability of its findings: the lack of a control group due to the parallel field trial design, the uneven sample size across classes, and the trial duration that was not able to capture the long-term effects of competition participation on sustained learning motivation. Further research with a controlled quasi-experimental design, a larger population, and a longitudinal duration is needed to causally test the capital of competition proposition presented in this study and to examine its applicability in teacher education contexts in countries with similar pedagogical philosophies.

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GENERATIVE AI AND AI-ASSISTED

During the preparation of this manuscript, the author utilized artificial intelligence (AI)-based tools to assist with language refinement, grammar checking, and the polishing of academic phrasing. The use of these AI tools was limited to enhancing the manuscript's clarity, readability, and linguistic quality. The author critically reviewed, verified, and revised all AI-generated output to ensure the accuracy, originality, and integrity of the content. The author bears full responsibility for the ideas, analysis, interpretation, and final version of this published work.

ETHICAL CONSIDERATIONS

This research was conducted in accordance with ethical principles applicable to research in the field of education. Ethical considerations were upheld throughout the research process, including voluntary participation, informed consent, the protection of confidentiality, and the responsible management of research data. Participants were informed of the research objectives and procedures, and their involvement was based on their willingness to participate. All collected data were used solely for research purposes and managed in a manner that protects the privacy and rights of the participants.

AUTHORS' CONTRIBUTION

Author 1: Conceptualization; Project administration; Methodology development; Validation; Supervision; Writing - review and editing.

Author 2: Conceptualization; Data curation; Investigation; Formal analysis; Writing - original draft preparation.

Author 3: Data curation; Investigation; Data validation; Supporting analysis; Manuscript review and editing

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