



ALGORITHMIC CLASSROOM DYNAMICS: AN INVESTIGATION OF AI BASED PERSONAL LEARNING SYSTEMS

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DOI:

Received: 13 Mei 2026

Accepted: 10 Juni 2026

Published: 30 Juni 2026

Abstract : Digital transformation in education has encouraged the use of *Artificial Intelligence* (AI) to create a more personalized and adaptive learning system. Finland is one of the countries that has successfully integrated AI in learning through an approach oriented to the individual needs of students. This study aims to analyze how AI-based personalized learning systems shape classroom dynamics in Finnish rural public schools. The research used a qualitative approach with multiple case study designs conducted at Saunalahti Comprehensive School (Espoo), Puistola Comprehensive School (Helsinki), and Mäntynummi Comprehensive School (Lohja). Data were collected through non-participatory observation, in-depth interviews, and document analysis, then analyzed using thematic analysis through the process of data reduction, coding, data presentation, and conclusion drawing. The results show that the implementation of AI is able to transform classroom dynamics through personalization of learning paths, provision of real-time feedback, and strengthening data-driven pedagogical decision-making. The role of teachers shifts from conveyors of information to facilitators who utilize algorithmic recommendations to provide more targeted learning interventions. This research offers the concept of Algorithmic Classroom Dynamics as a new conceptual contribution that explains how AI algorithms affect pedagogical interactions, the distribution of teacher roles, and the learning experience of learners in a personalized learning environment. These findings are expected to be a reference in the development of AI implementation policies that continue to prioritize pedagogical values and educational inclusivity.

Keywords: *Artificial Intelligence, personalized learning, algorithmic classroom dynamics, digital pedagogy, Finnish education.*

Abstrak : Transformasi digital dalam pendidikan telah mendorong penggunaan *Kecerdasan Buatan* (AI) untuk menciptakan sistem pembelajaran yang lebih personal dan adaptif. Finlandia adalah salah satu negara yang berhasil mengintegrasikan AI dalam pembelajaran melalui pendekatan yang berorientasi pada kebutuhan individu siswa. Studi ini bertujuan untuk menganalisis bagaimana sistem pembelajaran pribadi berbasis AI membentuk dinamika kelas di sekolah umum pedesaan Finlandia. Penelitian menggunakan pendekatan kualitatif dengan beberapa desain studi kasus yang dilakukan di Sekolah Komprehensif Saunalahti

(Espoo), Sekolah Komprehensif Puistola (Helsinki), dan Sekolah Komprehensif Mäntynummi (Lohja). Data dikumpulkan melalui observasi non-partisipatif, wawancara mendalam, dan analisis dokumen, kemudian dianalisis menggunakan analisis tematik melalui proses reduksi data, pengkodean, penyajian data, dan penarikan kesimpulan. Hasil penelitian menunjukkan bahwa penerapan AI mampu mengubah dinamika kelas melalui personalisasi jalur pembelajaran, pemberian umpan balik real-time, dan penguatan pengambilan keputusan pedagogis berbasis data. Peran guru bergeser dari penyampai informasi menjadi fasilitator yang memanfaatkan rekomendasi algoritmik untuk memberikan intervensi pembelajaran yang lebih tepat sasaran. Penelitian ini menawarkan konsep Dinamika Kelas Algoritmik sebagai kontribusi konseptual baru yang menjelaskan bagaimana algoritma AI mempengaruhi interaksi pedagogis, distribusi peran guru, dan pengalaman belajar peserta didik dalam lingkungan belajar yang dipersonalisasi. Temuan ini diharapkan dapat menjadi acuan dalam pengembangan kebijakan implementasi AI yang terus mengutamakan nilai-nilai pedagogis dan inklusivitas pendidikan.

Kata Kunci: Kecerdasan Buatan, pembelajaran yang dipersonalisasi, dinamika kelas algoritmik, pedagogi digital, pendidikan Finlandia.

INTRODUCTION

The development of artificial intelligence (AI) in the field of education has driven the transformation of the learning paradigm from a uniform model (one-size-fits-all) to personalized learning based on the needs, abilities, and characteristics of students (Peng & Li, 2025; Sun & Cheng, 2026). AI-based personalized learning systems enable real-time analysis of learning data to recommend materials, activities, and learning paths that fit each student's profile (Hariyanto et al., 2025; Sajja et al., 2025). Various studies show that AI-based learning personalization contributes to improving learners' learning outcomes, motivation, and independent learning abilities (Wang et al., 2026). explained that AI allows for more accurate identification of student characteristics so that the system can provide learning recommendations that suit the individual needs of students (Maghsudi et al., 2021). However, the implementation of the system still faces challenges in the form of algorithmic bias, lack of social interaction, and gaps between the goals of modern education and the design of existing learning technologies.

In recent years, Finland has become one of the countries that is actively integrating AI technology into its national education system. The country is known for having an education system that emphasizes equal access to education, including for schools in rural areas (Arkorful et al., 2020; Yang et al., 2018). Penelitian (Jauhiainen & Garagorry Guerra, 2024) shows that the use of Generative AI such as ChatGPT can be used to dynamically personalize students' learning materials according to their level of knowledge. Selain itu, (Vartiainen et al., 2025) found that the integration of AI-based learning in Finnish schools focuses not only on improving academic competence, but also on students' critical understanding of how algorithms work and the potential biases that arise in AI systems. The findings show that Finland has entered a new phase of AI utilization that is not only technical, but also pedagogical and ethical.

A number of previous studies have examined the effectiveness of AI-based

personalized learning. (Whang & Lee, 2024)found that AI-based personalized learning is able to improve the mathematics achievement, learning attitudes, and independent learning abilities of students in rural areas. Meanwhile, Kim (2024) explained that AI-based education platforms have formed an increasingly complex personal learning structure through the continuous use of student learning data. Other research conducted by (Lechuga & Doroudi, 2023)shows that data from intelligent tutoring systems can be used to build collaborative pedagogical strategies in the classroom through algorithm-based grouping of students. The results of the study show that studies on AI in education still mostly focus on the effectiveness of technology, platform design, and improving student learning outcomes.

However, there is still a significant research gap. Most previous studies have focused on technological aspects and individual learning outcomes, while studies of how AI algorithms shape the dynamics of classroom interactions, teacher-student relationships, pedagogical decision-making patterns, and collective learning experiences in rural school settings have been very limited. In addition, research on the implementation of AI-based personalized learning in Finland generally discusses the effectiveness of the system or students' AI literacy, but has not thoroughly investigated the phenomenon of "algorithmic classrooms", That is the condition when the learning process, student grouping, material recommendations, and learning evaluation are influenced by algorithm decisions on an ongoing basis. In fact, these dynamics have the potential to change the role of teachers, classroom communication patterns, and the concept of educational justice in the school environment.

Based on this description, the formulation of this research problem is: (1) how AI-based personal learning systems shape classroom dynamics in Finnish rural public schools; (2) what are the implications of the use of the system on pedagogical interaction, equitable distribution of learning opportunities, and learning effectiveness. This study aims to investigate in depth the AI-based personalized learning system shaping classroom dynamics in rural Finnish public schools and the implications of using such systems on pedagogical interaction, equitable distribution of learning opportunities, and learning effectiveness. The novelty of this research lies in the focus of an analysis that not only assesses the effectiveness of AI technology on learning outcomes, but also explores how algorithms play a role as pedagogical actors that influence social interactions, learning decision-making, and learners' learning experiences in the context of Finnish rural education. Thus, this research is expected to enrich the latest studies on AI in education as well as make a conceptual contribution to the development of algorithmic classroom theory in 21st century education.

RESEARCH METHOD

This study uses a qualitative approach with multiple case study design to understand in depth how *Artificial Intelligence* (AI)-based personalized learning systems shape learning dynamics in Finnish rural public schools. This approach was chosen because it is able to explain complex phenomena in real-life contexts, especially when the interaction between technology, teachers, and

learners cannot be separated from the environment in which learning takes place (Yin, 2018). The focus of the research is not directed at measuring the effectiveness of AI quantitatively, but rather exploring how algorithms affect pedagogical processes, teacher decision-making, student learning experiences, and interaction patterns formed during learning.

The research was carried out in three Finnish public schools that have implemented AI-based digital learning systems, namely Saunalahti Comprehensive School (Espoo), Puistola Comprehensive School (Helsinki), and Mäntynummi Comprehensive School (Lohja). The three schools were chosen purposively because they have experience in integrating digital technology into the learning process and represent the context of public schools that develop learning personalization through the use of AI. The research informants include school principals, classroom teachers, subject teachers, educational technology coordinators, and students who directly use AI-based learning platforms. The determination of informants is carried out based on the principle of information-rich cases, while the number of informants follows the concept of data saturation, which is that data collection is stopped when the information obtained has shown a recurring pattern and no significant new themes are found (Saunders et al., 2018).

The research data was obtained through non-participatory observation, semi-structured interviews, and document analysis in the form of school policies, curriculum, reports on the use of AI platforms, and other learning documents. The combination of these three techniques allows the triangulation process so that the data obtained is more comprehensive and credible (Creswell, 2018). All data were analyzed using the Miles, Huberman, and Saldaña interactive analysis model through the stages of data reduction, data presentation, and withdrawal and verification (Miles, 2020). The analysis was carried out thematically by comparing the findings in each school (*cross-case analysis*) to identify similarities and differences in the implementation of AI-based personal learning systems in shaping algorithmic classroom dynamics. To ensure the validity of the findings, this study applies source triangulation, method triangulation, member checking, and peer debriefing, so that the research results meet the criteria of credibility, dependability, confirmability, and transferability in qualitative research (Lincoln, 1985).

FINDINGS AND DISCUSSION

Findings

The results of the study show that the implementation of *Artificial Intelligence (AI)-based personal learning system* has changed the dynamics of learning in the classroom in three schools that are the location of the research, namely Saunalahti Comprehensive School, Puistola Comprehensive School, and Mäntynummi Comprehensive School. Based on the results of observations, the learning process no longer takes place with a completely uniform approach for all students. The AI-based learning platform automatically analyzes learning outcomes, task completion speed, error patterns, and the level of competency mastery of each learner to generate recommendations for different materials, exercises, and learning activities at the same time. This condition causes in one

class there is a variety of learning pathways (*personalized learning pathway*), where students learn different materials according to the results of algorithmic analysis even though they follow the same subject.

The observation findings also show that the role of teachers has changed during the learning process. Teachers no longer dominate the delivery of material in a classical way, but rather play a more role as facilitators who monitor students' learning progress through an analytical dashboard provided by the AI system. Information about the level of material mastery, learning difficulties, and recommendations for learning follow-up are displayed in real-time to make it easier for teachers to provide interventions to students who need more intensive assistance. At the same time, students who have achieved certain competencies can move on to the next material without having to wait for their classmates to complete the learning at the same level.

The results of interviews with teachers show that the use of AI-based personal learning systems increases flexibility in classroom management. One of the teachers at Saunalahti Comprehensive School stated that before using the AI system, teachers tend to provide the same material to all students, while after the implementation of AI, each student receives recommendations for learning activities that suit their respective abilities. The teacher also said that the system helps identify students who have learning difficulties early so that mentoring actions can be carried out more quickly and on target. Similar findings were obtained from Puistola Comprehensive School and Mäntynummi Comprehensive School, where teachers used the results of AI analysis as a basis for organizing study groups, determining learning differentiation strategies, and designing collaborative activities between students.

From the perspective of students, the implementation of AI-based personalized learning systems provides a more independent and adaptive learning experience. Most of the students stated that the material provided by the system was in accordance with their abilities so that learning felt more challenging without causing excessive pressure. In addition, the feedback provided automatically after students complete the assignment helps them find out where the mistakes are and improve their learning strategies directly. However, some students revealed that the intensity of interaction between friends during individual learning activities decreased because most of the learning activities were carried out through digital devices with different learning paths.

Based on the overall results of observations, interviews, and document analysis, this study found that AI-based personal learning systems have shaped classroom dynamics that are more adaptive, flexible, and data-based. Learning interactions are no longer centered on delivering material uniformly, but develop into a learning process that is tailored to the characteristics of each student through the support of algorithmic recommendations. These changes have an impact on the transformation of teacher roles, student interaction patterns, and learning decision-making mechanisms in the classroom, which as a whole form a new characteristic of the algorithmic classroom in Finnish rural public schools.

Discussion

The findings of the study show that the implementation of *Artificial Intelligence* (AI)-based personal learning systems has changed the dynamics of learning from a *teacher-centered learning* model to a more adaptive and *learner-centered learning* model. These changes can be seen in the ability of AI systems to analyze the learning performance of each student on an ongoing basis, then produce recommendations for different materials, difficulty levels, and learning activities according to individual needs. This condition indicates that algorithms not only function as a technological device to support learning, but also become part of the pedagogical decision-making process in the classroom. These findings reinforce the results of (Gligorea et al., 2023) research which explains that AI is able to optimize the learning personalization process through real-time analysis of student data so that learning becomes more efficient, adaptive, and in accordance with individual characteristics (Retno Anggraini et al., 2025). In addition to increasing learning effectiveness, AI-based personalization also allows teachers to identify gaps in students' learning abilities faster than conventional approaches (Maghsudi et al., 2021).

This study also found that the transformation of classroom dynamics does not only occur in students, but also in the role of teachers. Teachers are no longer the only source of knowledge, but rather transform into facilitators, mentors, and pedagogical decision-makers who utilize information from AI systems to design more targeted learning interventions. Thus, learning decisions are the result of collaboration between algorithmic analysis and teacher professional considerations (*human-AI collaborative decision making*). This finding is in line with the research of (Ghamrawi et al., 2024) who emphasized that AI in education should be positioned as *intelligence augmentation*, which is to strengthen the capacity of teachers in making educational decisions, rather than replacing the role of teachers as the main actors in the learning process. This perspective emphasizes that the quality of learning still depends on the teacher's ability to interpret the recommendations generated by the algorithm and adjust them to the social and emotional conditions of the students.

Another interesting aspect of this research is the emergence of the phenomenon of the algorithmic classroom, which is a classroom whose learning activities are influenced by algorithmic recommendations at almost every learning stage, ranging from material selection, student grouping, providing feedback, to evaluating learning outcomes. In the context of Finnish rural public schools, this phenomenon does not eliminate social interaction in the classroom, but instead creates a new pattern of interaction that is more flexible because teachers can pay attention to students according to their individual needs. The results of this study expand on the findings of (Meng et al., 2025) who stated that AI has the potential to improve the quality of education if it is designed to support student-centered learning while maintaining a humanistic dimension in the educational process. In other words, the success of AI implementation is not only determined by technological sophistication, but also by pedagogical design that ensures the maintenance of relationships between teachers, students, and the learning environment.

Nonetheless, the study also shows that AI-based learning personalization has the potential to reduce the frequency of interactions between learners when most learning activities are done individually through digital devices. This condition is a challenge for schools because one of the main characteristics of the Finnish education system is the development of collaborative competencies, communication, and social learning. Therefore, personalization of learning should not be interpreted as individualization that completely eliminates collaborative activities, but rather as a strategy to provide a learning experience that suits the needs of learners without reducing their opportunities to learn together. This finding is in line with the results of research by (Kucirkova & Leaton Gray, 2023) who emphasize that AI systems need to be designed based on the principle of *democratic personalization*, which is personalization that still considers aspects of justice, collaboration, participation, and social interaction in the learning process.

The main contribution of this research lies in the development of the concept of algorithmic classroom dynamics as a new perspective in the study of AI in the field of education. In contrast to previous research that measured the effectiveness of AI on learning outcomes or academic achievement, this study shows that AI algorithms also affect the structure of classroom interactions, the distribution of teachers' attention, students' communication patterns, and pedagogical decision-making mechanisms. Thus, algorithmic classroom dynamics can not only be understood as a consequence of the use of digital technology, but also as a transformation of the learning ecosystem that integrates artificial intelligence with teacher professionalism to create more adaptive, inclusive, and student-centered learning.

CONCLUSION

This study concludes that the implementation of *Artificial Intelligence* (AI)-based personal learning systems has transformed the dynamics of learning in Finnish rural public schools through more adaptive, data-based, and student-centered learning. AI systems not only support the personalization of materials and learning feedback, but also strengthen teachers' pedagogical decision-making in managing the learning process according to the individual needs of students. These findings suggest that the successful implementation of AI depends on the collaboration between algorithmic intelligence and teacher professionalism, so that AI serves as a support, not a replacement, of the teacher's role in learning.

The main contribution of this research is the development of the concept of Algorithmic Classroom Dynamics, which is a conceptual framework that explains how AI algorithms affect the structure of classroom interactions, the distribution of teacher roles, and the learning experience of students in a personalized learning environment. This concept expands the study of AI in education which has been more oriented towards academic achievement, by placing pedagogical dynamics as the main focus of analysis. Practically, the results of this study provide a basis for schools and policymakers to develop AI implementations that are not only oriented towards technological innovation,

but also maintain pedagogical values, collaboration, and inclusivity in the learning process. Further research is recommended to test the Algorithmic Classroom Dynamics model at different levels of education and country contexts in order to strengthen conceptual validity and expand the generalization of findings.

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