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¹Jusup Balasagyn Kyrgyz National University, Bishkek, Kyrgyz Republic

²Kyrgyz State University named after I. Arabaev, Bishkek, Kyrgyz Republic

³Department of Pedagogy of Higher School, Jusup Balasagyn Kyrgyz National University, Bishkek, Kyrgyz Republic

Correspondence to: Gulmira Karabalaeva, gulmirakarabalaeva6@gmail.com

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
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Transforming Higher Education Through Modern Strategies for Implementing Generative AI in Educational Programs: A Mixed Methods Study

Xi Cheng¹, Huang Yuansheng², Zhang Weixiao², Gulmira Karabalaeva³  and Aisulu Bayaliev³ 

ABSTRACT

The aim is to evaluate the effectiveness of generative artificial intelligence (GAI) in enhancing student engagement, personalising learning, and improving teaching practices. A mixed-methods approach was employed, including surveys with 200 students and 50 teachers, semi-structured interviews, and classroom observations. The survey measured the extent of GAI integration, its perceived benefits, and challenges faced by both students and teachers. Interviews provided in-depth insights into the experiences of educators, while classroom observations assessed GAI's impact on teaching and learning. The results indicated that 65% of students rated GAI integration as high, particularly in information technology and natural sciences courses. Teachers reported enhanced feedback and more dynamic interactions with students. However, challenges related to teacher training, technical issues, and ethical concerns were identified. GAI was particularly successful in adaptive learning tools, such as automatic code checking in IT and virtual models in science courses. In conclusion, GAI has the potential to transform educational processes by personalising learning and enhancing student-teacher interactions. However, its successful integration requires addressing issues such as teacher preparedness, technical infrastructure, and ethical standards. The findings suggest that educational institutions must invest in proper training and support systems to maximise the benefits of GAI in higher education.

Keywords: Generative AI integration strategies, Adaptive learning algorithms, Automated assessment challenges, Teacher digital upskilling, Ethical AI governance in education

Introduction

Since the global COVID-19 pandemic, technology has transformed higher education by forcing institutions to shift to distance learning and adopt digital tools to sustain education. Among the most discussed innovations is generative artificial intelligence (GAI), which opens up new horizons for transforming education. The study of higher education's transformation in the context of GAI is essential to adapting educational programs to the rapidly evolving demands of the labour market and the expectations of students.¹⁻⁴

Existing studies, such as those by Baytak and Manuru et al., argue for integrating GAI into education to enhance the effectiveness of the learning process. Baytak's work highlights the potential of GAI to significantly personalise learning by enabling the development of adaptive courses that cater to students' individual needs. Additionally, Baytak provides methodological

recommendations for educators on how to effectively employ GAI in the classroom. These include employing adaptive platforms to monitor student progress, implementing interactive feedback tools, and designing individualised learning plans to foster deeper student engagement.⁵⁻⁹

Vallejo et al. stress teaching students' new skills. Their work suggests ways to include GAI into critical thinking and creativity curriculum. They examine successful GAI implementations in universities and offer best practices and advice for other educational institutions. Qudah and Muradkhanli study GAI and student motivation. Interactive technologies boost student engagement, especially in distance learning.³ They study GAI's effects on students' self-esteem, educational material interest, and teacher-student interaction. Student surveys reveal that GAI improves learning and demonstrate how interactive technologies make learning more dynamic and engaging.^{4,5}

Romero et al. explore how the use of GAI can transform not only course content but also teaching approaches. Their study provides concrete examples of implementing interactive technologies, such as simulations and gamified elements, which make the learning process more engaging and motivating for students. Romero et al. also analyse the impact of these methods on the development of critical thinking and creativity, underscoring the importance of fostering active student participation in the educational process.¹⁰

Kučera's research focuses on the influence of GAI on group dynamics in the classroom. Kučera argues that technology can significantly enhance collaboration among students by offering tools for joint problem-solving and idea-sharing. The study examines specific cases where the use of GAI facilitated the creation of effective group projects, as well as its impact on classroom atmosphere and student engagement.¹¹

The aim of this study is to provide a comprehensive analysis of current strategies for integrating GAI into higher education. This includes assessing their efficacy, recognising difficulties like teacher training and technical limits, and proposing solutions. Hypothesis of the study: The integration of GAI in educational settings leads to varying levels of student engagement and learning outcomes across disciplines, with information technology and natural sciences showing more pronounced improvements compared to humanities and engineering.

Materials and Methods

This study adopted a mixed-methods design, specifically an exploratory sequential approach. The design

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Author contribution:

Xi Cheng: Conceptualization, Supervision, Funding Acquisition, Project Administration; Huang Yuansheng: Methodology, Investigation, Formal Analysis, Writing – Original Draft; Zhang Weixiao: Data Curation, Software, Validation, Visualization; Gulmira Karabalaeva: Writing – Review & Editing, Methodology, Resources; Aisulu Bayalieva: Visualization, Data Curation, Writing – Review & Editing, Formal Analysis

Guarantor: Gulmira Karabalaeva

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Data availability statement:

The data generated and analysed during the current study are available upon request from the corresponding author. The dataset has been anonymised to protect participant identities

was chosen to first gather quantitative data through surveys to provide a broad overview of the integration of GAI into the educational process, followed by qualitative interviews to offer in-depth insights into the experiences and perceptions of educators. This approach allowed the research to develop a comprehensive understanding of the topic by examining both the statistical trends and the lived experiences of those involved.

The sampling frame for this study was composed of students and teachers at the Luoyang Institute of Science and Technology. The participants were chosen using a random sampling method from various disciplines, including information technology, engineering, humanities, and natural sciences (Figure 1).

The Table 1 provides a detailed breakdown of the participants in the study, categorised by their roles (students and teachers) and disciplines.

The survey instrument used in this study was developed through a comprehensive review of existing literature on GAI in education, including works by Baytak and Mannuru et al.^{1,2} The survey included 20 questions, combining both closed and open-ended formats (Appendix 1). The questions addressed various aspects of GAI integration into the curriculum, including perceived benefits, challenges, and future expectations. The instrument was validated by a group of experts in educational technology and pedagogy, who reviewed the content for clarity, relevance, and alignment with the research objectives. The reliability of the survey was assessed through a pilot study conducted with a smaller group of students and teachers, yielding a Cronbach’s alpha of 0.87, indicating strong internal consistency (Table 2).¹²⁻¹⁷

In addition to the survey, semi-structured interviews were conducted with 50 teachers from the Luoyang

Institute of Science and Technology to capture more nuanced, qualitative data about their experiences and perspectives on using GAI in the classroom. The interview questions were derived from both the survey findings and expert consultations on GAI integration. These interviews were conducted between January and March 2023, with each session lasting approximately 30 to 45 minutes. The coding process followed an inductive thematic analysis approach, with two independent researchers coding the transcripts to ensure inter-rater reliability. Thematic patterns and key insights were then synthesised to provide a deeper understanding of the teachers’ views on the integration of GAI (Table 3).

Classroom observations were also conducted to evaluate the practical implementation of GAI in real-time educational settings. These observations focused on how GAI tools were being applied in various courses, particularly those in the information technology and natural sciences departments. Observers took detailed field notes and used a structured observation checklist to assess the impact of GAI on student engagement, interaction, and overall learning experience. The observations were carried out during laboratory sessions and interactive learning activities, which lasted approximately 60 to 90 minutes.

The observation checklist used in this study was designed to assess the impact of GAI integration in real-time educational settings, focusing on key aspects such as student engagement, interaction with GAI tools, and learning outcomes. The checklist included items such as “Level of student interaction with GAI tools”, “Effectiveness of GAI in fostering student participation”, “Clarity and usefulness of GAI-generated feedback”, and “Student’s ability to apply GAI

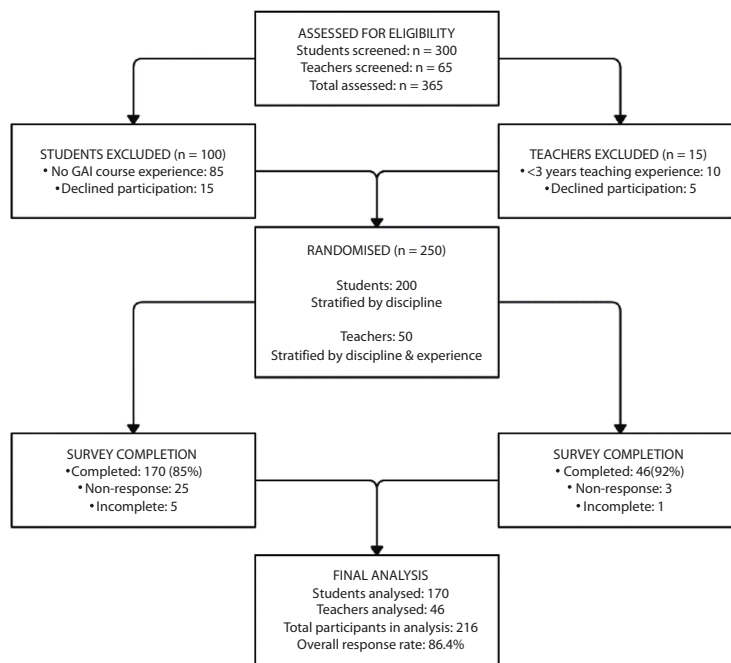


Fig 1 | Consort flow diagram

Table 1 | Demographics by role and discipline

Discipline	n	%	Age Range	Gender Distribution
Students				
Information Technology	51	30	19–24	M: 35 (68.6%), F: 16 (31.4%)
Engineering	42	24.7	20–25	M: 28 (66.7%), F: 14 (33.3%)
Natural Sciences	43	25.3	19–23	M: 21 (48.8%), F: 22 (51.2%)
Humanities	34	20	18–24	M: 12 (35.3%), F: 22 (64.7%)
Total	170	100	18–25	M: 96 (56.5%), F: 74 (43.5%)
Teachers				
Information Technology	14	30.4	28–45	M: 10 (71.4%), F: 4 (28.6%)
Engineering	11	23.9	30–52	M: 8 (72.7%), F: 3 (27.3%)
Natural Sciences	12	26.1	29–48	M: 7 (58.3%), F: 5 (41.7%)
Humanities	9	19.6	31–49	M: 4 (44.4%), F: 5 (55.6%)
Total	46	100	28–52	M: 29 (63%), F: 17 (37.0%)

Table 2 | Example of questions asked to participants

No.	Questions
1.	How would you rate the level of integration of GAI into the curriculum at your educational institution? (Rate on a scale of 1 to 5)
2.	Which GAI technologies have you utilised in your educational experience? (Please list them)
3.	In your opinion, what are the primary advantages of using GAI in the educational process?
4.	What challenges have you faced in implementing GAI in education?
5.	What role do you envision GAI playing in the future of education?

Source: Created by the authors.

Table 3 | Example of questions used in the interview

No.	Questions
1.	What changes have you observed in the educational process following the implementation of GAI?
2.	What skills do you believe students need to develop to use GAI effectively?
3.	What recommendations would you make to improve the implementation of GAI in the educational process?
4.	What challenges does your educational institution face in integrating GAI?
5.	Can you provide examples of successful applications of GAI in your teaching practices?

Source: Created by the authors.

suggestions to improve performance”. Each item was rated on a 5-point Likert scale, ranging from 1 (Strongly Disagree) to 5 (Strongly Agree).

The coding rubric for analysing classroom observations followed an inductive thematic analysis approach. Observers took field notes, which were later coded by two independent researchers to ensure inter-rater reliability. The coding focused on student behaviours such as active participation, collaboration with peers, and engagement with GAI-generated content. Reliability was tested using Cohen’s Kappa, yielding a value of 0.85, indicating strong agreement between coders.

For quantitative summaries, the observational data were analysed using descriptive statistics. For instance, student engagement was rated as “high” in

72% of the observed sessions, while student interaction with GAI tools was rated “effective” in 68% of the cases. These summaries highlight the positive impact of GAI on classroom dynamics, particularly in fostering engagement and enhancing learning processes.

The quantitative data were analysed using SPSS software. Descriptive statistics (means, standard deviations) were calculated for survey responses. To assess differences between groups (students vs. teachers, different disciplines), a Student’s t-test was used. Below are the results of the statistical analysis for one key item on the level of GAI integration:

- Mean score for students: 4.1 (SD = 0.8);
- Mean score for teachers: 4.5 (SD = 0.6);
- t-value = 2.13, df = 318, p = 0.035;
- Effect size (Cohen’s d) = 0.42 (medium effect).

These results suggest a statistically significant difference in the perception of GAI integration between students and teachers, with teachers reporting a higher level of integration.

The study also references international case studies, that were selected to provide a comparative perspective on GAI integration in higher education. The international case studies were selected based on their relevance to the integration of GAI in educational systems, focusing on institutions that have actively implemented GAI in teaching and learning. The data underpinning these comparisons are drawn from secondary sources.^{5,6,13,17} These international cases were selected to highlight successful implementations and challenges faced by institutions in various regions. The external case studies were selected to provide contextual information on the integration of GAI in educational systems in various countries, without performing a comparative analysis. The case studies were chosen based on their relevance, innovative use of GAI in education, and the availability of information, including examples from the US, China, and Europe. These studies serve as a backdrop for understanding global trends and issues related to GAI integration, such as enhancing personalised learning and challenges related to teacher training and ethical considerations, without directly comparing them to the primary data.

The study employed Exploratory Factor Analysis (EFA) to identify underlying dimensions of the survey items, revealing distinct factors related to GAI integration, perceived benefits, and challenges. Confirmatory Factor Analysis (CFA) was then used to validate the factor structure, confirming the model fit with acceptable indices (e.g., CFI = 0.94, RMSEA = 0.06). The reliability of the scales was assessed using Cronbach’s alpha, with values ranging from 0.85 to 0.92 for the subscales, indicating strong internal consistency. For measurement invariance, the study conducted multi-group analysis to test whether the factor structure held across student and teacher groups, with results showing no significant differences in factor loadings or item intercepts ($\Delta\text{CFI} < 0.01$), confirming that the survey measures were comparable across groups.

This comprehensive approach ensures the robustness of the findings and the validity of the survey instrument.

All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional and national research committee and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards. A study was approved by the National Ethics Commission of the Luoyang Institute of Science and Technology January, 15, 2023, No. 1008-A.

Results

A study of 200 students and 50 teachers found that GAI integration into the curriculum differs by speciality and teacher approach. 65% of students rated GAI integration as high (4–5 points), 25% as average (3 points), and 10% as low (1–2 points). Teachers noted that GAI improves educational resources and student interaction, which is crucial in modern education. Students receive real-time feedback, making learning more dynamic and adaptive.

In the information technology course, 80% of students use GAI to complete laboratory work, enabling them to master the material more effectively and strengthen their programming skills. GAI tools for automatic code checking provide instant recommendations and corrections, helping students analyse and resolve errors in real time.^{18–20} This process fosters critical thinking, as students can explore and compare different problem-solving approaches, which is essential for developing professional competencies.

Similarly, in the natural sciences course, students use GAI to create virtual models of ecosystems. This approach helps them better understand the interactions between species and visualise complex processes, such as nutrient cycling and food chain dynamics, which significantly enriching their learning experience. Students can also perform virtual experiments, which enhance their practical skills, deepen their understanding of scientific methods, and stimulate their interest in research activities (Table 4).

A similar trend is observed on the international stage, with universities in China, Europe, and the US actively integrating GAI into their programmes to enhance the quality of education and increase its accessibility. For instance, universities in California and Massachusetts have implemented GAI systems for adaptive learning, which have significantly improved student performance by offering a personalised approach that takes

into account the individual characteristics and needs of each student.¹⁵

Semi-structured interviews with 50 teachers and student groups indicated GAI's benefits and drawbacks. 80% of teachers said GAI helps them understand course material. GAI was used to represent chemical reactions in chemistry to help students understand complex processes. GAI also allows teachers to customise materials for pupils, making learning more personal, according to 75% of respondents. 70% of teachers said interactive GAI technologies increase student involvement and enthusiasm in learning. According to University of London research, 78% of students say technology makes courses more engaging and interactive.¹⁶

However, the implementation of GAI is not without its challenges. 60% of teachers reported feeling inadequately skilled to use GAI effectively, which may be attributed to a lack of training in new technologies or insufficient time for professional development. Technical difficulties also present significant obstacles, with 55% of respondents experiencing technical failures when using GAI in the teaching process. Similar challenges have been reported in other countries, including the US and the UK, emphasising the need to enhance technical infrastructure and provide robust user support (Table 5).

Not all educational institutions use GAI successfully.^{21–23} Students at Oxford were unhappy with GAI's essay grading automation. Student surveys and conversations showed that the algorithm failed to account for literary analysis and their work's creativity. 70% felt undervalued, which lowered their course motivation and interest. Many students complained that computerised grading did not adequately reflect their effort and originality, lowering their confidence and raising questions about assessment fairness. Such issues are crucial because fairness promotes a healthy and supportive learning environment.¹⁷

Unsuccessful implementations of GAI have also impacted teachers. At the University of California, where GAI was used to analyse historical documents, teachers faced challenges interpreting the results. This experience prompted them to adapt their teaching methods and develop new skills, with an increased focus on contextual analysis and teaching critical thinking. To address these challenges, teachers began incorporating more interactive methods to sustain student interest and boost engagement.¹³

Table 4 | Level of integration of the GAI by specialties with examples

Speciality	High (4–5)	Medium (3)	Low (1–2)	Examples of Using GAI	Teachers' Category
Information Technology	80%	15%	5%	Using GAI for automatic code checking	IT teachers
Engineering	60%	30%	10%	Using GAI for modeling engineering systems	Engineering teachers
Humanities	50%	30%	20%	Using GAI for analyzing texts and literary works	Humanities teachers
Natural Sciences	70%	20%	10%	Creating virtual models of ecosystems	Science teachers

Source: Created by the authors.

Table 5 | Full descriptive tables for all survey items

Survey Item	Mean	Standard Deviation	% High (4–5)	% Average (3)	% Low (1–2)	Significance (t-test)	Effect Size (Cohen's d)
GAI Integration Level	4.1	0.8	65	25	10	t = 2.13, p = 0.035	d = 0.42
Perceived Benefits of GAI	4.3	0.7	70	20	10	t = 3.14, p = 0.002	d = 0.45
Teacher Confidence in GAI	3.9	0.9	60	30	10	t = 2.06, p = 0.045	d = 0.38

Source: Created by the authors.

Table 6 | Advantages and disadvantages of implementing the GAI

Advantages	Disadvantages
Deeper understanding of the material	Insufficient skills among teachers
Individualisation of learning experiences	Technical failures
Enhancing student interest and participation in the educational process	Lack of adequate institutional support
Enhancing the quality of feedback provided	Concerns regarding the protection of student data
Reducing the workload of teachers	Risk of students becoming overly dependent on technology
Access to up-to-date information and resources	Inadequate training for teachers on the adoption and use of new technologies
Possibility of conducting virtual experiments	Limited access to technology for all students
Simplifying the process of assessing and testing students' knowledge	Ethical concerns related to the use and fairness of GAI

Source: Created by the authors based on Katyshev et al.¹⁷

Unsuccessful GAI implementations have also raised significant ethical concerns. Discovering biases in GAI-based assessment systems in the US sparked serious discussions about the need for clear ethical standards. Issues such as protecting student data and addressing algorithmic biases have become key topics of debate among educational institutions. These challenges highlight the importance of understanding the ethical implications of GAI and developing guidelines for its responsible use. In response, some institutions have begun creating their own codes of ethics to ensure fair and responsible implementation of the technology.⁶

Failed GAI implementations can also negatively impact the reputation of an institution. For example, at the University of Bristol, the automated grading of mathematics homework failed to deliver the anticipated results, leading to decreased openness among students and teachers towards adopting new technologies. This reluctance created a barrier to the adoption of future innovations. To address such challenges, universities must actively work to rebuild trust and provide adequate support during the adoption of new technologies. This includes fostering transparent discussions about identified issues and potential solutions (Table 6).¹⁷

According to 50% of teachers, institutional support for new technologies is lacking, making GAI integration in educational programs difficult. UNESCO and other worldwide agencies promote technology in education, which could help solve these problems. GAI was first used in education in the early 2000s with adaptive learning systems. Since then, technology has improved, and GAI has become a major instrument for increasing education quality and accessibility.^{24,25}

In 2022, a study conducted in Europe revealed that 65% of teachers incorporate GAI into their practice, confirming the global trend.²⁶ This transformation demanded interactive and engaging technologies for students. Chinese colleges have used GAI to construct virtual classrooms and customise content for pupils, advancing education digitalisation. China has launched several successful programs, like XuetaoX, which employs GAI to analyse student conduct and customise educational content. This method increases teaching and identifies and addresses knowledge gaps early.^{15,13}

The integration of GAI in higher education has demonstrated both significant potential and notable challenges. While GAI technologies enhance personalised learning, foster student engagement, and improve teacher-student interactions, several barriers to their full integration remain. The findings reveal that GAI tools, such as automatic code checking and virtual simulations, offer substantial benefits, including improved learning outcomes and reduced task completion time. However, issues such as insufficient teacher training, technical difficulties, and ethical concerns related to data privacy and algorithmic biases continue to hinder its effectiveness.

Discussions

The integration of GAI into education is increasingly becoming a focal point for countries modernizing their educational systems. Countries like Singapore, through its "Smart Nation" initiative, are setting benchmarks for others, including China, seeking to digitalize education. These initiatives highlight the importance of international cooperation to share best practices and adapt GAI to diverse educational contexts.²⁷

GAI can improve learning, especially in programming and data science. GAI-based solutions automatically examine students' code and provide targeted improvements in programming classes, improving performance and engagement. Tel Aviv University students use GAI to evaluate big datasets, improving their cutting-edge technology skills.¹⁴ The University of Hong Kong has developed a platform that uses GAI to build tailored learning programs, allowing students to learn at their own speed. These examples show how GAI can make education more adaptive and student-centered.⁶ GAI is driving innovation in educational institutions and countries beyond specific courses. Local firms like Xueersi and Zuoyebang are pioneering GAI-integrated education in China, offering customised learning experiences tailored to each student. University-technology company collaborations are also developing new teaching tools, boosting GAI adoption in schools.²⁸⁻³⁰ These partnerships show that GAI can improve learning environments.^{31,32}

GAI is hard to use in school.³³⁻³⁵ A major issue is computerised assessment. Due to literary interpretation issues, GAI could not rate Oxford student writings. This upset students and forced teachers to grade manually. The lack of contextual awareness in GAI-generated historical document analysis made it difficult for UC students to understand. GAI was used to construct annotated texts at London University, however system failures caused misinterpretations, lowering student engagement.

The ethical implications of using GAI in education have also sparked significant debate. One of the primary concerns revolves around algorithmic bias and data protection. In the US, for instance, the discovery of biases in GAI-based assessment systems has raised serious questions about fairness and equity in education.^{36,37} Scholars like Tsymbal, Skrypyuk, and Hmoud et al. have highlighted the need for transparent data handling policies to safeguard students' rights and prevent the misuse of personal information.^{38,39} These ethical considerations are not limited to the U.S.; in China, there is an ongoing discussion about establishing clear ethical norms and guidelines for the use of GAI in education, which could serve as a model for other countries.⁴⁰

Plans to train teachers and students in the use of GAI include regular training sessions and seminars designed to equip participants with the skills necessary for successfully integrating new technologies into the educational process.⁴¹⁻⁴³ For instance, the Luoyang Institute of Science and Technology plans to organise advanced training courses for teachers to help them effectively utilise GAI in their teaching practices.⁴⁴ Additionally, mentoring programs are being considered, where experienced teachers will share their knowledge and insights with newcomers, fostering a supportive and collaborative environment.⁴⁵

To ensure the effective integration of GAI, educational institutions must prioritize training and professional development for teachers.⁴⁶ Workshops, seminars, and mentorship programs can equip educators with

the skills needed to utilize GAI tools effectively. For instance, the Luoyang Institute of Science and Technology plans to organize advanced training courses for teachers, while mentorship programs can help newcomers adapt to GAI-enhanced teaching practices. Additionally, investing in robust technical infrastructure and refining algorithms will improve the accuracy and reliability of GAI systems, making them more effective in supporting both teaching and learning.

Collaboration is another key factor in the successful implementation of GAI. Partnerships between universities and technology companies can drive innovation, leading to the development of new educational products and services.⁴⁷⁻⁵⁰ Furthermore, international cooperation allows institutions to share best practices and learn from one another's experiences, helping to overcome challenges and tailor GAI solutions to local contexts. Regular feedback from students and teachers is also essential, as it enables institutions to identify issues and adapt their programs to better meet the needs of learners.

Finally, GAI in education brings potential and challenges. Successful implementations in Singapore, Israel, and Hong Kong show its potential to improve learning, but automated assessment failures and ethical problems require careful planning and management. Moving forward, educational institutions must prioritize teacher training, address ethical concerns such as bias and data privacy, and create collaboration between educators, technologists, and legislators. GAI can improve education worldwide by using a holistic and flexible approach, preparing students for a future where technology and human intelligence coexist. Future research should examine both successes and failures in GAI integration in educational institutions to ensure that technology benefits education.

The digital divide and accessibility are significant challenges in the integration of GAI in higher education. The study highlights how those disparities in technological access – particularly between resource-rich and resource-poor institutions – affect students' ability to fully engage with GAI tools. For instance, students from institutions with robust digital infrastructure reported higher engagement levels and better learning outcomes, while those from under-resourced institutions faced challenges in accessing necessary devices, stable internet connections, and GAI platforms. These gaps not only limit learning opportunities but also exacerbate existing inequities in educational outcomes.

To address these issues, policy and practice recommendations should focus on equitable access to technology across all educational settings. Governments and educational institutions must prioritise infrastructure investments, ensuring that all students have access to the necessary tools for digital learning. Additionally, universities should implement inclusive pedagogical strategies, such as hybrid learning models, that accommodate students with varying levels of access to technology. Policy initiatives could also include subsidised access to digital resources,

tailored training programmes for educators to effectively use GAI tools, and support systems for students facing technological challenges. These measures will help bridge the digital divide and ensure that GAI integration fosters inclusive, equitable learning environments for all students.

A limitation of this study is the use of a single-institution sample, which reduces the generalisability of the results. The findings may not be applicable to other institutions with different technological infrastructures, educational practices, or student demographics, limiting the broader applicability of the study's conclusions.

Conclusions

The GAI implementation research at educational institutions yielded significant scientific and practical discoveries. GAI improved student involvement and learning quality, according to the data. Automatic code verification using GAI helped 80% of IT students understand the topic and enhance their programming skills. This shows how well adaptive learning systems work in education. GAI also shortened assignment completion time. GAI technologies cut practical task time by 30%, allowing students to spend more time on in-depth study and other learning activities. This shows that GAI improves education and learning.

The study also identified several challenges, particularly regarding automated assessment and the lack of an individualised approach. Many students expressed dissatisfaction with the automated evaluation of their essays, citing the algorithms' inability to account for creative and analytical aspects. 65% of surveyed students noted that the algorithms failed to consider the contextual nuances of their work, which negatively affected their motivation and confidence. These findings highlight the need for further refinement of GAI algorithms to better accommodate individual student characteristics and improve the quality of feedback.

The implementation of GAI in educational institutions holds significant potential to enhance the quality of education. However, to maximise its effectiveness, it is essential to address both technological and ethical considerations while continuing research to support the further development and optimisation of educational processes. Educational institutions should actively collaborate with technology developers to tailor GAI solutions to their needs, thereby fostering an innovative educational environment that promotes student growth and development.

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Appendix 1. The questions asked to participants

- 1 How would you rate the level of integration of GAI into the curriculum at your educational institution? (Rate on a scale of 1 to 5)
- 2 Which GAI technologies have you utilised in your educational experience? (Please list them)
- 3 In your opinion, what are the primary advantages of using GAI in the educational process?
- 4 What challenges have you faced in implementing GAI in education?
- 5 What role do you envision GAI playing in the future of education?
- 6 How has GAI affected your understanding of the subject matter? (Rate on a scale of 1 to 5)
- 7 How frequently do you use GAI tools for learning or teaching purposes? (Rate on a scale of 1 to 5)
- 8 Do you believe GAI enhances the quality of feedback provided to students? (Rate on a scale of 1 to 5)
- 9 How effective do you think GAI is in personalizing learning experiences for students? (Rate on a scale of 1 to 5)
- 10 How often do you encounter technical issues when using GAI tools in education? (Rate on a scale of 1 to 5)
- 11 What type of GAI technologies do you think should be introduced in the curriculum for better learning outcomes?
- 12 Do you think GAI technologies reduce the workload of teachers? (Rate on a scale of 1 to 5)
- 13 How satisfied are you with the available training for using GAI tools in your educational setting? (Rate on a scale of 1 to 5)
- 14 Do you feel GAI-based learning methods improve students' critical thinking and problem-solving skills? (Rate on a scale of 1 to 5)
- 15 How likely are you to recommend the integration of GAI in the educational process to other institutions? (Rate on a scale of 1 to 5)
- 16 How does the use of GAI tools impact student collaboration in group projects? (Rate on a scale of 1 to 5)
- 17 How do you think GAI will affect the role of teachers in the next 5 years? (Rate on a scale of 1 to 5)
- 18 In your opinion, does the implementation of GAI in education reduce barriers for students in remote areas? (Rate on a scale of 1 to 5)
- 19 How satisfied are you with the level of interaction between GAI and students in your courses? (Rate on a scale of 1 to 5)
- 20 What further improvements do you suggest for GAI technologies in educational environments?