Spectrum of Engineering Sciences
ISSN (e) 3007-3138 (p) 3007-312X Volume 4, Issue 6, 2026

ENHANCING TEACHING AND LEARNING THROUGH GENERATIVE ARTIFICIAL INTELLIGENCE: BENEFITS, CHALLENGES, AND ETHICAL CONSIDERATIONS

[1]Awais Maqsood, [*2]Farhan Ali, [3]Muhammad Ilyas, [4]Muhammad Ilyas, [5]Abdul Basit Butt

[1]EE Deptt. SEN, University of Management and Technology, Lahore 54770, Pakistan
[*2]School of Computer and IT, Beaconhouse National University, P.O. Box 53700 Lahore Pakistan
[3]Department of software engineering, Superior University, Lahore 5400 Pakistan
[4]Department of software engineering, Gold campus, Superior University, Lahore 5400 Pakistan
[5]EE Deptt. SEN, University of Management and Technology, Lahore 54770, Pakistan
[1]awais.maqsood@umt.edu.pk, [*2]farhan32748@gmail.com, [3]muhammad.ilyas@superior.edu.pk, [4]developersai643@gmail.com, [5]abdul.basit.butt05@gmail.com

DOI:-

Keywords
GenAI, ChatGPT, Technology for Education, K–12 studies, Higher Education, Brainstorming, AI principle

Article History
Received: 13 May, 2026
Accepted: 04 June, 2026
Published: 06 June, 2026

Corresponding Author: *

Farhan Ali

Abstract
Generative AI has significantly transformed learning, teaching, and academic support since the release of OpenAI's ChatGPT in 2022. It is changing how students learn, how teachers teach and how support is provided in schools and universities. Generative AI helps students collaborate, improve creativity, solve problems, and learn independently, especially in subjects like mathematics, physics, and coding. It is also used to create quizzes, summaries, and personalized learning materials that make complex topics easier to understand. Research shows that these tools can improve academic performance, motivation, confidence, and creativity among students. However, concerns remain about cheating, plagiarism, privacy, and unequal access to technology. Because of these challenges, Generative AI should not replace teachers but should be used as a supportive educational tool. With proper teacher training, student awareness, and ethical use, Generative AI has strong potential to improve education and make learning more effective and accessible for everyone.

1. Introduction

GenAI is really helpful because it can change content to fit each student's needs. It gives students feedback. Helps them understand things right away. Some artificial intelligence systems use things, like text and sound and picture, video to help students understand ideas better. For examples GenAI can make learning fun and interactive[1]. This is because GenAI can do a lot of things that make learning fun for students. GenAI is a tool that can help students learn in a way [2]. GenAI can use text and sound and pictures and video to teach students ideas. This makes learning with GenAI a lot of fun for students. Students like to learn with GenAI because it's fun and interactive. GenAI is a tool for students to learn new things [1,2,3]. In this paper [4], more schools are using GenAI tools to support students and get them more involved in learning. This helps achieve the United Nations goal of ensuring everyone has access, to education. GenAI makes education more accessible and engaging for students. Research shows that artificial intelligence can actually help students participate more and do better in school by giving them support.

[10] For GenAI to work well in classrooms teachers need to know how to use the technology. They need training. Researchers have found that whether or not students and teachers use GenAI tools depends on a key thing. These include whether they think the tools will work well how easy they are to use, whether the school supports their use and whether people actually use them. GenAI tools like ChatGPT are becoming more important, in education. Genai is changing the way we learn. [4] Shared Metacognition and Cognitive Offloading are really important for learning with GenAI systems. When students work together. Think about what they know that is Shared Metacognition and it helps them learn more. Cognitive Offloading is when students use technology to help them with their school work so they do not get too tired or confused. [6] GenAI can really help students understand concepts by explaining things in a simple way making practice questions and giving them feedback that is just, for them. Teachers can also use GenAI to make lesson plans, quizzes and other things they need for class, which helps them have time and be better teachers.

[29] Some people think that GenAI is changing the way we learn in classrooms. Of just memorizing things students are learning to solve problems be creative and think critically. GenAI systems let students talk to computers in real time which makes learning more fun and helps them work alone. [8] Other people think that schools need to be careful when they use GenAI so it helps students learn without taking away the things that make us human like talking to each other working together and thinking for ourselves. GenAI should help learning, not replace it. Despite these benefits researchers have raised concerns about dishonesty, misinformation, bias, over-reliance on AI systems reduced critical thinking and privacy risks when it comes to GenAI. GenAI responses may look accurate. They can have incorrect or misleading information. So educational institutions must focus on implementation ethical GenAI policies, teacher training, GenAI literacy and continuous evaluation to ensure effective and safe integration of GenAI in education [3] [8][6] Overall GenAI is different from search engines because GenAI generates new content rather than just getting existing information. This creates a lot of opportunities for creativity, collaboration and personalized learning with GenAI. It also introduces challenges related to originality, academic integrity and responsible educational use of GenAI [9].

1.1 Background: Understanding Generative AI

Education has changed a lot with technology from the printing press to the internet and digital learning systems. GenAI is another change because it does not just store information GenAI also generates new responses, examples, explanations, quizzes, lesson plans and interactive materials.

This makes GenAI more adaptive and interactive than previous educational technologies, like other systems that came before GenAI [9].

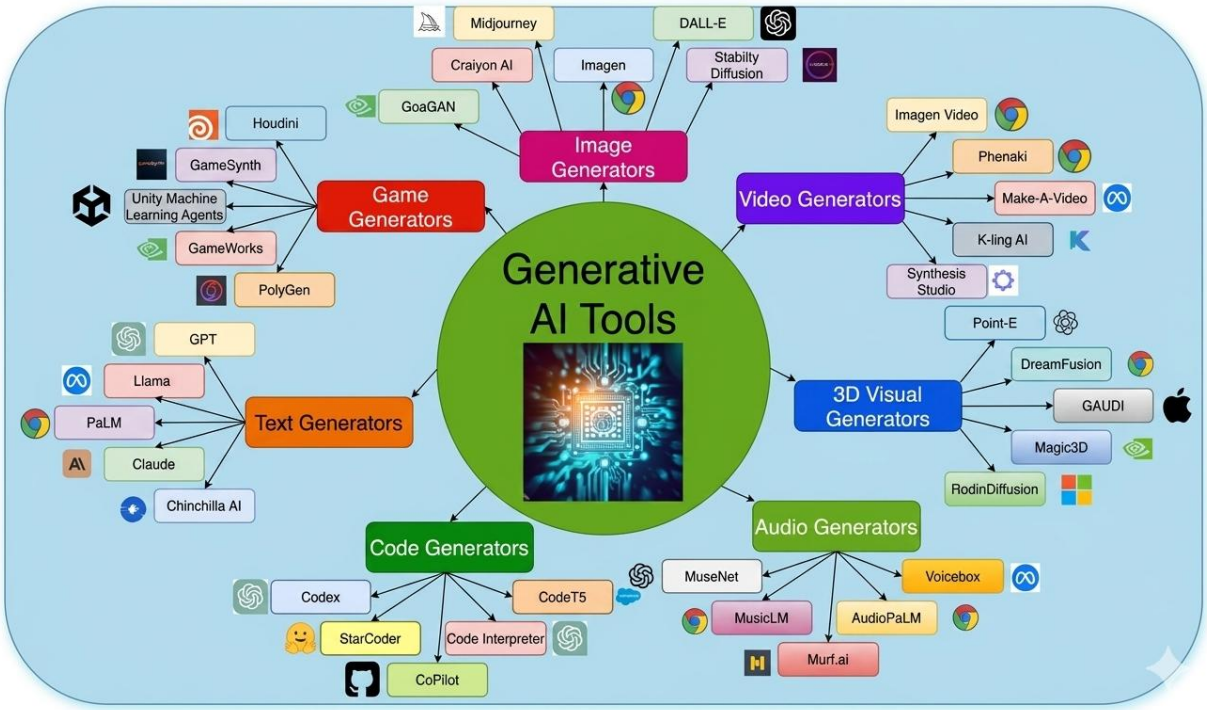

Figure 1: Overview

This figure shows AI tools usage in generators

2. Literature Review

2.1 Generative AI and Educational

Generative Artificial Intelligence or GenAI for short is really changing the way we learn in schools and universities. This technology is making education better by giving students personalized help and making learning fun. GenAI tools are like teachers that help students one on one. They also make learning more interactive which keeps students interested and helps them learn more. The GenAI tools, like ChatGPT are really changing the way that teachers teach and students learn. This is a deal. The GenAI tools are making it possible for teachers to give each student the help that the students need. The GenAI tools are also helping teachers have time to focus on other things, which is great for the teachers and the students. The GenAI tools, like ChatGPT are doing a lot of things, for teachers and students. This means that teachers can teach better and students can learn more [10].Some studies looked at how GenAI's used in schools from kindergarten to high school. They found that these tools are helping teachers plan their lessons create tests and make learning materials. This is helping teachers reach all their students, the ones who learn differently [11].

Using GenAI in schools is also getting students ready for a future where they will be using technology all the time. It is teaching them about technology, how to use it and how to be creative with it [12]. A lot of researchers are now looking into how GenAI can be used in education. Since ChatGPT came out more and more researchers are studying how GenAI can be used to help students and teachers, in universities and colleges. They want to know how it can help students learn better and how it can support teachers in their work.2.2 ChatGPT and GenAI in STEM **Education [37].[38] Some people looked** at how eleventh-grade students used ChatGPT and they found out that when teachers used ChatGPT to help them teach the students did better in school they were more interested in learning. They participated more in class.They participated more in class. [13] Other people studied what happens when students use intelligence like GenAI to learn programming and solve problems. They found out that students who used GenAI systems like ChatGPT were really good, at solving problems they thought critically and they did well in school.

[14] Research findings also showed that ChatGPT positively improved students' thinking abilities, learning experiences, and educational productivity. Researchers emphasized the growing importance of AI technologies in modern

educational activities and learning environments. [15] Some studies showed that GenAI is really helpful in group learning and customized education. Teachers have a hard time changing their teaching ways and keeping good teaching methods when using AI in classrooms. They have to adapt to tools.[16] A study, in education found that GenAI helps with simulation learning and makes it easier for students to understand tough concepts. GenAI is useful here. It supports learning in a way.

2.3Technology Acceptance and Learning Performance

When we talk about the Unified Theory of Acceptance and Use of Technology 2 we have to consider a thing. Performance Expectancy is what students think about GenAI tools. They believe that GenAI tools can really help them do better in school and learn more [4].

Then there is Effort Expectancy which's about how easy it is to use these AI technologies. We also have Facilitating Conditions which is all about the support we get from schools and technology to use AI in the classroom. Research has shown that when students use AI tool they have a time learning. They do better in school. They are also better at solving problems. Something called Shared Metacognition helps students work together and think about what they're learning. It helps them understand things better by talking about it with each other [17]. GenAI tools are also good because they help students remember things. This is called Cognitive Offloading. It means that students can use technology to help them so they do not have to remember everything. This is really helpful. It makes a big difference in how well students do, in school. Studies have found that when students use GenAI tools and Cognitive Offloading it really helps them achieve their goals [4].

2.4 Teachers' Perspectives and Professional Development

Lots of research showed that teachers had thoughts about ChatGPT.

Teachers really liked using ChatGPT. They used it for a lot of things. For examples ChatGPT was useful for making lesson plans. It was also very helpful for students. Teachers liked that ChatGPT could help students when they need it [18]. They also had some worries.

- These worries included things like:
- Was it okay to use AI?
- How would it affect students work?
- What would it mean for education on?

ChatGPT could make teaching simpler. It also brought up questions about what's right and what is wrong. Teachers also thought about how ChatGPT would change how students learn.

They also thought about how to make sure students used ChatGPT in an honest way, with ChatGPT.

Teachers' and Students' Use of AI Tools in Education

[19] Research found that teachers and students, like using Artificial Intelligence tools for math writing. They think it helps them be more creative and engaged. It also makes learning fun and interactive. The research also says that teachers need to learn more about Artificial Intelligence. They need training to understand how to use these tools properly.[20] For example Lu and other people found that Artificial Intelligence tools can help teachers become better at their jobs. These tools can make teachers feel more confident and help them think about what they're doing.

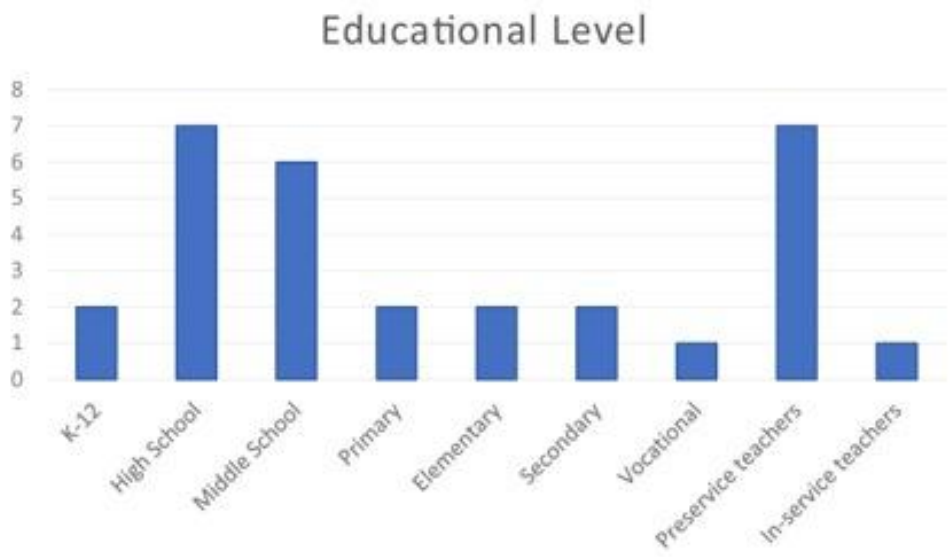

Figure 2

shows how people are using Artificial Intelligence tools more and more in education. This includes things like helping with teaching writing papers and learning in the classroom

2.5 Challenges and Ethical Concerns of GenAI

There are challenges and concerns with GenAI. Despite its benefits researchers have identified concerns about academic dishonesty, misuse, misinformation and reduced critical thinking among students [1] [3]. Many experts say that using AI much can actually hurt how well students learn and come up with their own ideas, in school [10]. Schools need to make sure people use GenAI in a way that's helpful not hurtful. They must make rules. Teach students and teachers about GenAI and keep an eye on how it is used all the time. Researchers say that schools and universities should:

- Have rules for using GenAI
- Teach teachers about GenAI
- Have a plan for using GenAI

This will help us get the most out of GenAI for education and avoid problems, with privacy, plagiarism and bias [8][9] Overall GenAI is an educational tool that can improve teaching and learning. However, its successful integration requires awareness of ethics, responsible use and continuous evaluation to support education systems that focus on human needs. GenAI has the potential to transform education. We need to use GenAI and think about what we are doing.

The use of GenAI must be carefully considered to ensure that it supports human-centered education systems [1].

3. Methodology

3.1 Research Design and Review Approach

The researchers used two methods to study Generative Artificial Intelligence in education. They did a review of the literature and they also did some quantitative research. The systematic review helped them to collect and evaluate the findings from different studies in a very organized way. This way of doing research is really good for finding out what is happening with technology in education what we still need to learn. How teachers are using new methods to teach students [1][21]. The researchers made sure to follow some rules to make their systematic review very clear and trustworthy. They used guidelines from PRISMA and Kitchenham to do this. They looked at academic papers from big databases, like Scopus and Web of Science to see how Generative Artificial Intelligence is being used in schools and universities [22].

The papers they reviewed talked a lot about Generative Artificial Intelligence models. How they can be used in education. They also discussed the bad things about using Generative Artificial Intelligence in schools how ready schools are to use it and how to use it in a responsible way. The researchers looked at the technical sides of using Generative Artificial Intelligence in modern schools and universities and how it can be used to help students learn [9][8][6].

3.2 Data Collection and Selection Criteria

The people doing this study looked for articles that used GenAI tools in places where people learn. They looked at studies about kids in school older kids in school and people who want to be teachers. These groups are similar because they use technology in the way and they learn in the same way. They have a lot, in common when it comes to technology and learning [3].

They mostly looked at studies from 2022 to 2025 because that is when GenAI tools like ChatGPT started to be used a lot. They also looked at studies about using GenAI with pictures, sound and videos. When they searched for an article, they used words like GenAI, ChatGPT and K–12 Education. After looking through all the articles, they picked the ones that were most relevant to GenAI[1]. At first they found 58 articles in one place and 22,660 articles in another place. After getting rid of duplicates and articles that did not fit they had 30 studies left to look at closely and learn from GenAI and these studies. [22] The inclusion criteria focused on empirical journal articles that implemented GenAI tools in teaching and learning environments. Studies related to K–12 education, higher education, and preservice teacher learning were included because these groups shared similar educational and technological characteristics. The studies we picked had information about the year they were published what level of education they were for the GenAI tools that were used the things students did to learn how well the students did in school, things that were not right, with using GenAI and how GenAI is used in education [4].

3.3 The Quantitative Research Framework

[22] These studies looked at how using Generative AI Tool Usage affects Academic Achievement, in university students and preservice teachers. The research framework was based on the Unified Theory of Acceptance and Use of Technology 2 which looks at how people accept technology and how they use it in settings.

[4] The main things the research looked at were Performance Expectancy, Effort Expectancy, Facilitating Conditions and Use Behavior of Generative AI Tool Usage. These variables were used to evaluate students' perceptions, acceptance levels, and usage patterns of GenAI technologies in educational activities.[5] The studies mainly focused on preservice teachers because future educators are expected to integrate AI technologies into classrooms and teaching practices. The research also examined the mediating roles of Shared Metacognition (SMC) and Cognitive Offloading (COL) in improving learning performance through GenAI system. [25] When people work togethers they use Shared Metacognition, which means they think together learn from each other and solve problems during work. Generative AI Tool Usage also helps with Cognitive Offloading, which's when learners use technology to make their work easier and not have to remember so work easier and not have to remember so much.

3.4 Participants and Data Analysis

[4] Quantitative data were collected from 465 university students enrolled in five universities located in Wuhan, China. We picked the people who were easy to find. They got a questionnaire with a lot of questions that had answers from one, to seven. We sent it out at times so people would not just say what they thought we wanted to hear. This way the information we got was more accurate.

Table 1: *The table shows information about teachers who're about to start teaching, like their gender education level, grades and where they studied.*

Variable	Category	Frequency (f)	Percentage
Gender	Male	220	47.3%
	Female	245	52.7%
	Total	465	100%
Age	18–22 years	180	38.7%
	23–27	190	40.9%
	28 and above	95	20.40
	Total	465	100%
Background	Rural	150	32.3%
	Urban	315	67.7%
	Total	465	100%
Study Years	Year 1	120	25.8%
	Year 2	115	24.7%
	Year 3	130	28.0%
	Year 4	100	21.5%
	Total	465	100%
Education Level	Undergraduate	200	43.0%
	Masters	170	36.6%
	Doctoral	95	20.4%
	Total	465	100%
CGPA	Less than 2.00	50	10.8%
	2.00–3.00	140	30.1%
	3.10-4.00	275	59.1%
	Total	465	100%

[4] The data we collected was looked at using a method called Partial Least Squares Structural Equation Modeling or Partial Least Squares Structural Equation Modeling is also known as PLS-SEM. Hair and others said in 2021 that PLS-SEM is good, for understanding relationships testing ideas and studying ho people behave. Researchers did tests to check if their study was reliable and valid. They checked the reliability did validity testing analyzed the path coefficients and evaluated their hypothese. This helped them to look at the research plan and see how the different study factors relate to each other.

3.5 Ethical Considerations

[4] Ethical considerations were carefully maintained throughout the research process. Participants were informed about the objectives of the study, confidentiality was protected, and voluntary participation procedures were followed to ensure responsible research practices.[6] The reviewed studies also emphasized ethical AI integration, responsible educational use, academic integrity and institutional readiness as essential components of future AI-supported educational environments.

3.6 Research Questions

The combined review was put together using some questions to help guide the research. These questions were really important, to the review.

- What does Generative AI mean in educational contexts?

- What educational benefits can GenAI provide for students, teachers, and institutions?
- What risks and ethical challenges emerge from GenAI integration in education?
- What frameworks can guide responsible AI adoption in schools and universities?

What strategies can help educational institutions become AI-ready?

[24] [15] The analysis looked at the school subjects. It mainly focused on the following educational themes

- Personalized learning
- Creativity enhancement
- Collaborative learning
- Academic writing support
- Student engagement
- Ethical challenges
- Academic integrity concerns
- AI-supported teaching practices

GenAI is also used in Computer Science. It is used in college level Education too.

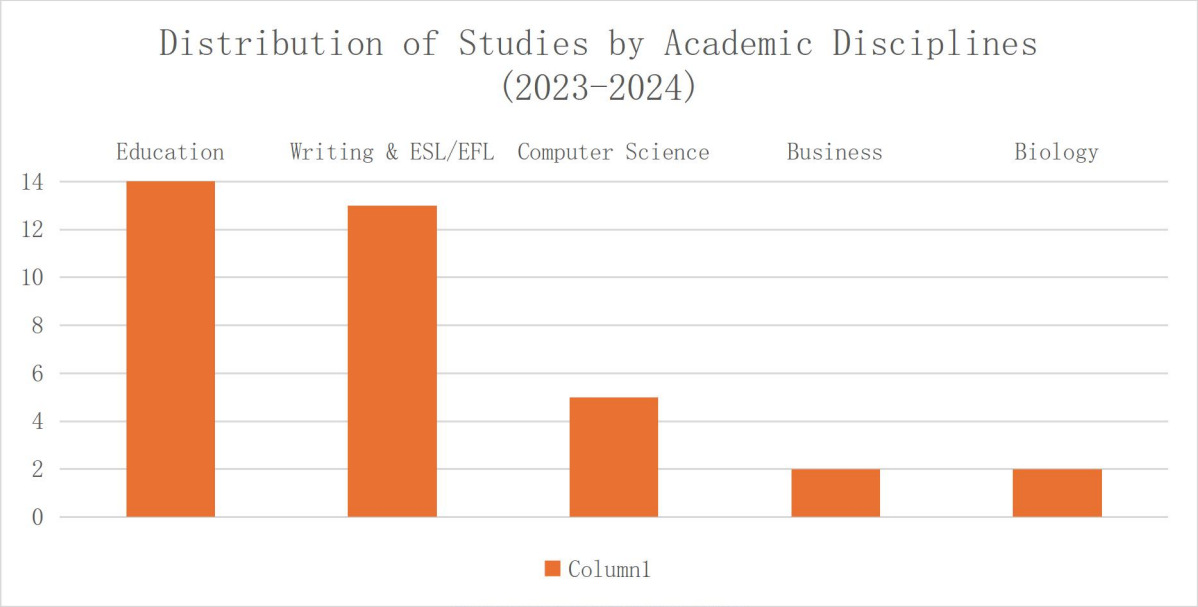

Figure 3:
shows how studies about GenAI are spread across areas like Education and Writing classes. This is for people who speak English as a language

3.7 Source Articles and Their Contributions

Source article	Main contribution to this combined paper
Article 1: Comprehensive review	Explains the types of GenAI models, the need for GenAI in education, applications, case studies, limitations and future research directions.
Article 2: ChatGPT/IDEE framework	Provides a responsible-use framework: identify outcomes, determine automation, ensure ethics and evaluate effectiveness.
Article 3: Opportunities, challenges and strategies	Adds educators' perspectives and school-level strategies such as professional development, guidelines, software access and AI literacy.
Article 4: K-Education	Tell GenAI impact in education system
Article 5: Higher education	Discuss the benefits and ethical challenges
Article 6: Sustainable education	Impact of GenAI on academic learn and their learning process

3.8 Methodological Summary

[1] [9] We did a study on Generative Artificial Intelligence in schools and universities. We wanted to see what it is about. We took a look at what Generative Artificial Intelligence can do for schools and universities and the issues it can create. We went through what other people had discovered about Generative Artificial Intelligence and we looked at some numbers to see what they showed us about Generative

Artificial Intelligence. This helped us make sure our findings were correct and easy to understand. By doing this we got an idea of what Generative Artificial Intelligence can do in elementary schools and colleges and what problems it might cause in these schools.

4. Discussion

[22] [1] The studies together show that Generative Artificial Intelligence or GenAI for short is now a big part of modern education that we cannot avoid. GenAI is really changing things. We can see this with how fast ChatGPT and other AI system are growing. More and more people are getting interested in using technology to help students learn in their own way be creative work together and get help with school work in both elementary school and college. [17, 20]. One of the things that GenAI does is help students learn in a way that is just right for them. Students can get help away like explanations and feedback on their work. They can also get summaries of what they need to know and help with their school work all based on what they need to learn. Some AI systems can even use pictures, sound and videos to help teach students in the classroom, which makes learning fun and interesting for GenAI and students. GenAI is making a difference, in education.

Geographical Distribution of GenAI Research in Education

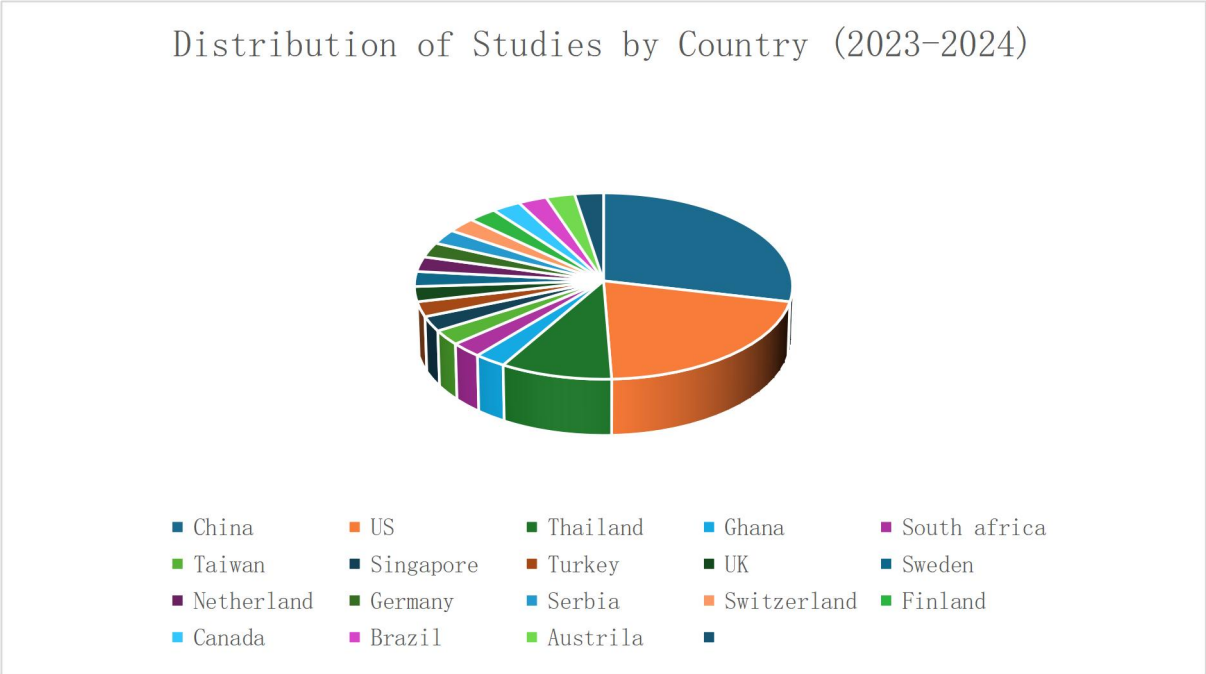

Figure 4:
The picture shows how GenAI educational research is spread across countries. China and the United States contributed the highest number of research publications, followed by Thailand and other developing educational regions.

[8] [26] The studies that were looked at say that GenAI is not the answer to everything and it should not be stopped completely. How well GenAI works in education depends on how it is used in the classroom. [6] one thing that people are talking about is how teachers fit into classrooms that use GenAI. GenAI does not replace teachers it actually makes teachers more important. Teachers have to plan lessons look at what GenAI comes up with help students use GenAI in a good way and understand what students need to learn and how they are feeling.

GenAI can make things for the class[27]. Give good help but it is not good at knowing how students are feeling or what is going on in their life outside of class or what they need to do well in the future like a real teacher can. GenAI is not like a teacher because it cannot understand what students need to grow up and be successful, in the long run GenAI cannot do what a teacher does.[28] [29] These studies also showed that education needs to change how it assesses students. Since AI systems can write essays do tasks and give answers assessments should focus more on thinking critically being creative applying what is learned and real-life learning

experiences. Teachers play a role, in helping students. They can encourage students to speak up in class. They should also tell students to think about what they have learned and write it down. This helps students to join in class activities and share their thoughts. Teachers can encourage students to think about their ideas. Students can write down what they have learned. When students solve problems that make sense in life they understand what they are learning better. This way the goals of learning are clear. Make sense to the students. [30] GenAI can also greatly help make education more inclusive. Students who have a time with language or complicated ideas can get help with explanations and some extra things to practice with. The language and complicated ideas can be really tough for these students so they can get practice materials to make it easier, for them. Teachers who don't have time can create customized learning resources and adaptive content more easily.[6] However using GenAI for inclusion to work requires that everyone have equal access to technology, proper training and ongoing monitoring. If not done responsibly AI technologies might make the gap, between learners even wider. We have to make sure everyone gets a chance to use GenAI for their benefit. This way GenAI can help make learning more inclusive.

[31] The findings also show that it is very important to have parents, teachers and students work together when it comes to GenAI. When parents help and support their children it has an effect on the children motivation to learn their responsible use of GenAI and their overall digital learning experiences with GenAI.[32] [3] Researchers said that using AI systems much or without help might hurt student ability to think on their own. They also warned that it could affect how well students reason and be creative. This is because over-reliance on AI systems might make students not think critically. Students need to think and come up with new ideas. There are still concerns about plagiarism, misinformation, cheating, privacy risks and becoming too dependent on AI in settings.Therefore [33] ethical considerations must remain a priority when integrating AI into education. Using GenAI responsibly means being honest about getting help from GenAI. It is also about protecting people privacy and knowing that GenAI can be biased. We have to be careful when we use GenAI to teach and learn. Overall the studies that were looked at say that GenAI can really help make education better when we use it in a way. We need to have rules, about how to use GenAI in an ethical way. When we want to teach people about GenAI it is an idea to use GenAI in a careful way. Using GenAI to teach people about GenAI is an idea. We have to be very careful. We need to think about how we do this, with GenAI. Using GenAI to teach people about GenAI needs planning. When we do this with GenAI, we must get it right.

We have to make sure that people understand GenAI and its limits. GenAI can be very helpful. If we are not careful people might start to rely too much on GenAI.

So when we teach people about GenAI we have to teach them about GenAI strengths and weaknesses. [15,3] We have to teach them how to use GenAI in a way. That way people can get the most out of GenAI. They can use GenAI to learn and grow. They will also know when to trust GenAI and when not to. GenAI is here to help. We have to use it wisely. That is why we need to be careful when teaching people, about GenAI and GenAI. We should think a lot, about GenAI. How we use GenAI to teach people about GenAI. The best way to do this is to use GenAI in a way that's very thoughtful and careful. We should always think about GenAI and how it can help us teach people about GenAI. is because GenAI is a part of our lives now and we need to use GenAI in a good way. When we use GenAI to teach people about GenAI we have to be very thoughtful. We have to think about how we use GenAI and make sure we use GenAI correctly. We have to make sure that GenAI does not hurt the things about education. These things include understanding, being creative talking to each other being ethical and working with other people. GenAI should help us with these should help us with these things not hurt them.

We need to use GenAI in a way that protects the values of education including understanding, creativity, communication, ethics and social development and these values are very important, to GenAI and education [31]. Here is a python code according to this research work.

```
import pandas as pd
import matplotlib.pyplot as plt
data = {
```

```
    "Country": [
        "China", "USA", "Thailand", "Ghana",
        "South Africa", "Taiwan", "Germany",
        "UK", "Canada", "Brazil"
    ],
    "Studies": [12, 10, 6, 3, 3, 5, 4, 3, 2, 2]
}
df = pd.DataFrame(data)
print("Distribution of Studies by Country")
print(df)
plt.figure(figsize=(10,6))
plt.bar(df["Country"], df["Studies"])
plt.title("Distribution of GenAI Research in Education by Country (2023–2025)")
plt.xlabel("Country")
plt.ylabel("Number of Studies")
plt.xticks(rotation=45)
plt.tight_layout()
plt.show()
year_data = {
    "Year": [2023, 2024, 2025],
    "Publications": [8, 14, 11]
}
year_df = pd.DataFrame(year_data)
plt.figure(figsize=(8,5))
plt.plot(
    year_df["Year"],
    year_df["Publications"],
    marker='o',
    linewidth=2
)
plt.title("Growth of GenAI Research in Education (2023–2025)")
plt.xlabel("Year")
plt.ylabel("Number of Publications")
plt.grid(True)
plt.tight_layout()
plt.show()
```

5. Results

Growth of GenAI Research in Education

I found out that research on Generative Artificial Intelligence or GenAI in education is growing fast between 2023 and 2025. It seems like 2024 had the publications. I think this growth is happening because people over the world are getting more and more interested in AI-supported technologies especially after ChatGPT came out. Most of the studies focused on high school students and teachers which's really interesting. GenAI and AI are being used in new ways, in education [22]. Elementary school students and teachers who are already working got attention in research. Countries in Asia, China and Taiwan did the most studies on GenAI in education. The United States and Germany also did a lot of research. Countries, in Africa did not do studies [22].

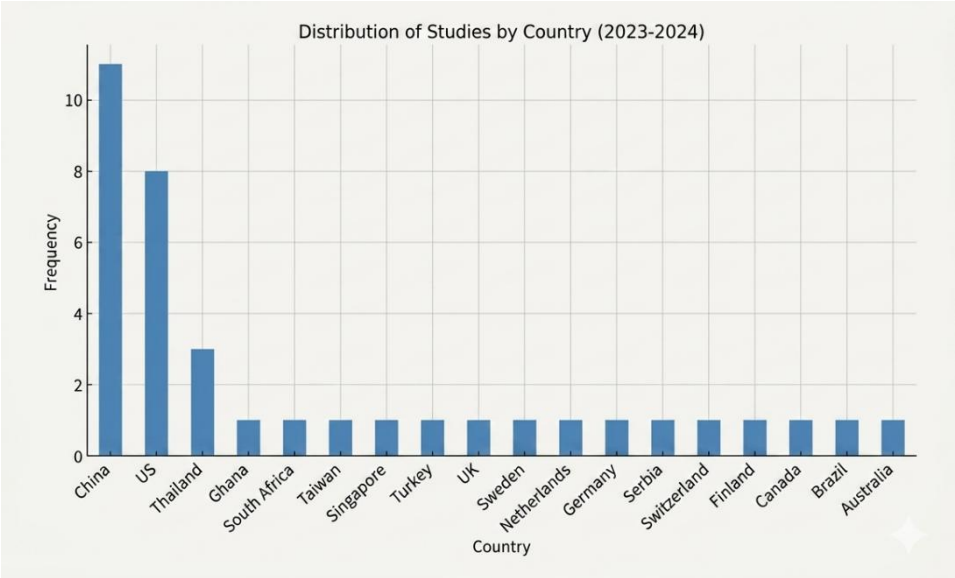

Figure 5:
The picture shows which countries are working on Gen AI for education. China and the United States are the two countries leading Gen AI research.

5.2 Applications of GenAI in Teaching and Learning

[22] [9] I found that GenAI is used a lot in subjects, like Mathematics and Physics. GenAI is really helping in these areas. China is doing a lot of work on GenAI and the United States is also doing a lot of work on GenAI. GenAI educational research is being done in ways. Mathematic and Physics are two subjects where GenAI is used a lot. These are the areas where GenAI is commonly used to help with teaching and learning. GenAI is really useful for Mathematics and Physics because it helps people understand these subjects better. The use of GenAI, in Mathematics and Physics is very helpful. The people doing this research looked at GenAI applications in teaching and learning activities for STEM subjects. They found that GenAI is very helpful for Mathematics and Physics. GenAI is making a difference, in these areas. Other subjects such as English language learning, History, programming, engineering, medicine, and geography were also explored.

[3] [25] ChatGPT became the most widely used GenAI tool across educational studies because of its ability to provide instant feedback, explanations, summaries, and academic support. Some researchers also combined ChatGPT with DALL·E, GitHub Copilot, Canva, and multimodal AI systems to support interactive educational activities using text, image, audio, and video resources.

[17] The studies further highlighted that GenAI can personalize learning experiences by adjusting explanations, feedback, examples and learning paths according to students' individual needs. Students were able to ask questions and get help with language skills and writing through computer systems that used intelligence. They could also get help with school work.[8] For teachers GenAI was like a helper when it came to planning lessons. It assisted with making lesson plans, quizzes and worksheets. It also helped with activities for the classroom and comments to give students feedback. This made things easier for teachers. Teachers did not have to work much. The teachers had time to focus on the students and the classroom became a more interesting place because of this. Teachers were able to make the classroom a fun place for students to learn.

5.3 Opportunities for Teaching and Learning

[17] The best results, from the studies I looked at showed that GenAI can make learning more tailored to each student. It can change explanations, examples and feedback to fit what each student needs.AI systems can also adjust learning paths to match how each student learns best.

This helps the education can become more flexible and fun. GenAI helps make education fit each student needs and learning styles.[3] [23] ChatGPT is really popular because it gives you answers away. It also gives you a summary of what you need to know explains things in a way that's easy to understand and helps you with your school work. There are tools like DALL·E, GitHub Copilot and multimodal AI systems that are useful for learning too. These tools use things, like text, pictures, sound and videos to help you learn. [9] Many students used GenAI tools in subjects like math, physics and programming. These, tools were especially helpful in areas such as engineering and medical education.AI-generated explanations and visuals made it easier for students to grasp concepts. Simulation also played a role in helping students understand abstract ideas more effectively. In subjects like Mathematics, Physics, programming, engineering and medical education GenAI tools were really helpful. The people who created GenAI tools did a job of making hard ideas easier to get.

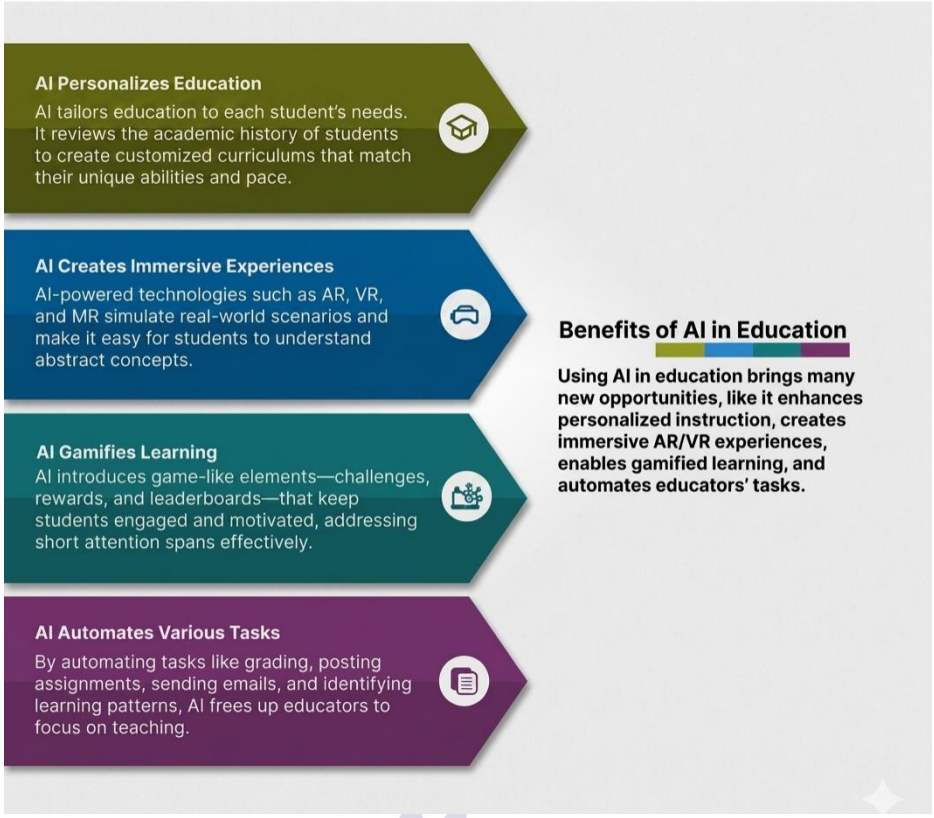

Figure 6: Benefits and Opportunities of integrating GenAI in education

The GenAI tools really helped make things easier to handle. For examples when it came to Mathematics and Physics the GenAI tools were super helpful. They made it a lot easier for students to learn and understand. The GenAI tools also helped out a lot in areas. They were useful in programming and engineering and medical education. The GenAI tools assisted students in understanding concepts and ideas in these fields. This was especially true in education and programming. They made it easier for students to learn about Mathematics and Physics and other subjects. The studies that were looked at also showed that GenAI is like a helper for teachers. GenAI helps teachers get ready for class by making lesson plans, worksheets and quizzes. It also helps teachers come up with comments to give to students. This makes things easier for teachers. They can focus more on talking to students and making sure they understand the work [8]. The studies also found out that GenAI is good for students. It helps students do better in school and work well with others. GenAI also helps students think about their learning and stay engaged, in class. When students work together and think together it is called Metacognition. GenAI is really helpful with something called Cognitive Offloading. This means that students do not have to think hard. They can learn things easily with GenAI. GenAI helps students learn better. It also helps students feel less stressed out when they are doing their school work. GenAI makes school work easier, for students. Students can learn more with GenAI. They do not get as stressed out. GenAI really supports students. This thing helps people learn in a way,5.4. Risks of GenAI [4, 17][6] [34]. Despite the things that GenAI can do for education the studies always point out some problems with using GenAI. GenAI systems can give information repeat the same mistakes that are, in the data they were trained on not understand what is going on in the classroom and make students less able to think for themselves if they rely too much on what GenAI says. GenAI can be a problem if students use it much and stop thinking critically.
[3] People who study this stuff are also saying that they are worried, about students cheating. They think it is not a thing when students copy work from other people. They think students might use Artificial Intelligence to do their school work and assignments.

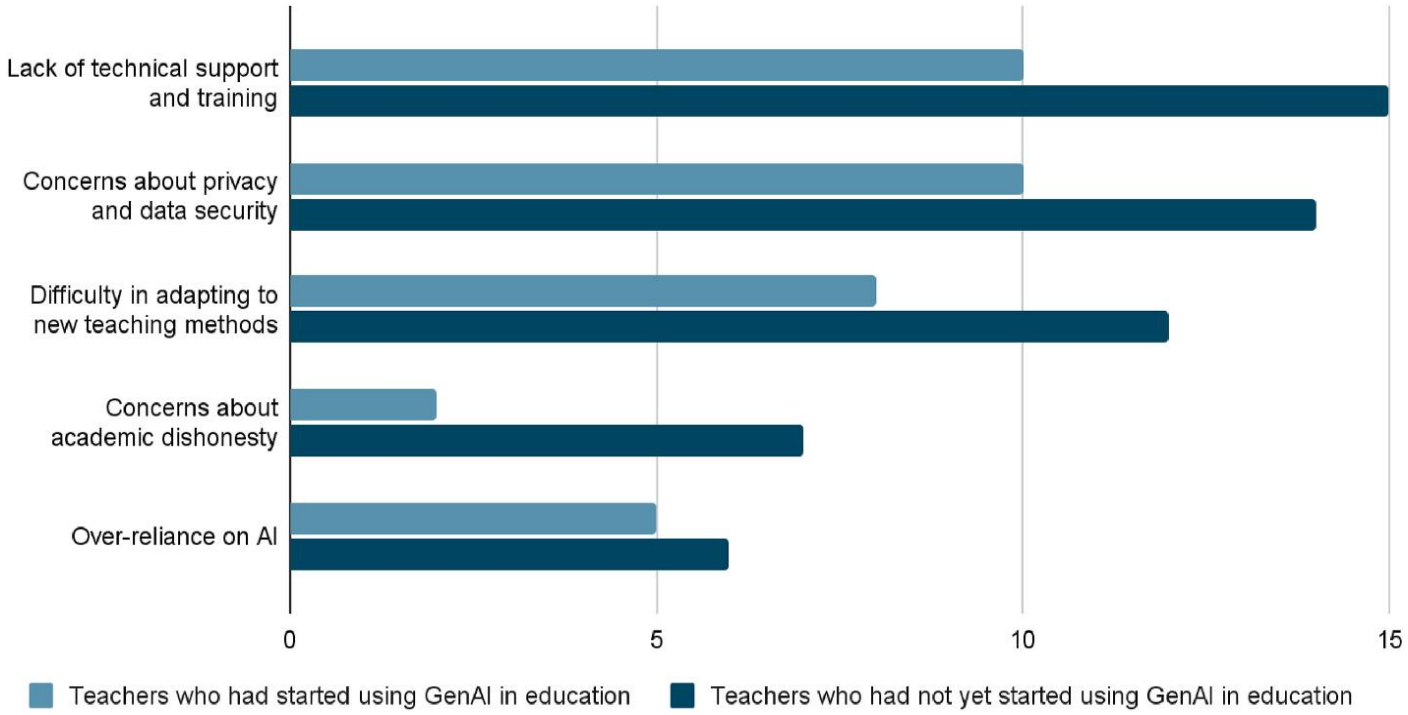

Figure 7: show the effect of becoming dependent GenAI

5.5 School Strategies for Responsible Integration

The studies showed that schools and universities need help before they can use Artificial Intelligence in classrooms. Some, ideas that were suggested included training for teachers to teach about Artificial Intelligence and making sure Artificial Intelligence tools work well [8][6]. Teachers also wanted rules from their schools about things, like copying work using Artificial Intelligence in a way testing students in new ways using Artificial Intelligence prompts responsibly owning ideas and keeping personal information safe [6].

One thing that the studies found is that Artificial Intelligence readiness is not about the technology. It is also about education and ethics. It is about how organizations work with Artificial Intelligence. Schools become ready for Artificial Intelligence when the people in charge give direction, teachers get the training they need students learn how to use Artificial Intelligence in a way and families know what is expected of them in terms of education [35].The picture shows the parts of schools that are ready for Artificial Intelligence, including training teachers having policies about ethics teaching people about Artificial Intelligence providing technical help using fair ways to test students and always checking how things are going. The studies also found out that it is very important to include parents, teachers and students when Artificial Intelligence is being added to schools. When parents support what is going on it helps students want to learn use technology in a way and have good experiences with digital learning [31].Overall, the studies said that to use General Artificial Intelligence in a way schools need to have balanced education policies teach ethics in the classroom always be checking on things and focus on the needs of people when they are teaching so that the good things, about Artificial Intelligence can be maximized and the bad things can be minimized [15].

6. Conclusion

The studies that were reviewed show that Generative Artificial Intelligence or GenAI for short has become an important technology in education today. GenAI tools like ChatGPT are very helpful for students and teachers because they support learning that is tailored to each student, planning lessons writing papers solving problems and getting students engaged in the classroom in both elementary school and college [22, 1,9]. The findings from these studies revealed that GenAI actually improves how well students learn, how engaged they are, how creative they are and how well they do academically all thanks to educational support

systems. Things like how students think GenAI will help them how often they use it how well they work together with others and think about their own thinking and how they use GenAI to help with tasks all have a positive effect on learning [4].However, these studies also pointed out some challenges, like cheating on school work risks to student privacy relying too much on GenAI getting bad information and not being able to think critically. So, schools need to make sure they are using GenAI in a way by having rules to follow, training teachers and teaching students about GenAI [36,5]. Overall, GenAI should be used to help students learn not replace teachers or make students think they do not need to learn on their own. Teachers are still very important for guiding students checking how well they are learning and making sure everyone is following educational practices. GenAI should support learning, like the kind that happens in a classroom, with a teacher rather than replace it [30,33].Finally, future research should look at how GenAI can be used with children how to make sure all students can use it what the long-term effects of using GenAI are and how to use different GenAI tools in a big classroom setting. This will help us understand how GenAI can best be used to support students and teachers in education [22].

References

1. Qian, Y., *Pedagogical applications of generative AI in higher education: A systematic review of the field.* TechTrends, 2025: p. 1–16.
2. Houston Jackson, D., *An interdisciplinary look at generative ai impacts on workplace communication, learning, and planned organizational change models.* 2025.
3. Crompton, H. and D. Burke, *The educational affordances and challenges of ChatGPT: State of the field.* TechTrends, 2024. **68**(2): p. 380–392.
4. Iqbal, J., et al., *Generative AI tool use enhances academic achievement in sustainable education through shared metacognition and cognitive offloading among preservice teachers.* Scientific Reports, 2025. **15**(1): p. 16610.
5. Holmes, W. and I. Tuomi, *State of the art and practice in AI in education.* European journal of education, 2022. **57**(4): p. 542–570.
6. Ng, D.T.K., E.K.C. Chan, and C.K. Lo, *Opportunities, challenges and school strategies for integrating generative AI in education.* Computers and Education: Artificial Intelligence, 2025. **8**: p. 100373.
7. Lo, C.K., K.F. Hew, and M.S.-y. Jong, *The influence of ChatGPT on student engagement: A systematic review and future research agenda.* Computers & Education, 2024. **219**: p. 105100.
8. Su, J. and W. Yang, *Unlocking the power of ChatGPT: A framework for applying generative AI in education.* ECNU Review of Education, 2023. **6**(3): p. 355–366.
9. Mittal, U., et al., *A comprehensive review on generative AI for education.* Ieee Access, 2024. **12**: p. 142733–142759.
10. Kasneci, E., et al., *ChatGPT for good? On opportunities and challenges of large language models for education.* Learning and individual differences, 2023. **103**: p. 102274.
11. Yuwono, E.I., et al., *Co-creation in action: Bridging the knowledge gap in artificial intelligence among innovation champions.* Computers and Education: Artificial Intelligence, 2024. **7**: p. 100272.
12. Culverhouse, R., *OpenAI and how it can benefit K-12 education*, in *Artificial Intelligence Applications in K-12*. 2024, Routledge. p. 38–55.
13. Gong, X., Z. Li, and A. Qiao, *Impact of generative AI dialogic feedback on different stages of programming problem solving.* Education and Information Technologies, 2025. **30**(7): p. 9689–9709.
14. Liao, J., et al., *Scaffolding computational thinking with ChatGPT.* IEEE Transactions on Learning Technologies, 2024. **17**: p. 1628–1642.
15. Mohebi, L., *Empowering learners with ChatGPT: Insights from a systematic literature exploration.* Discover Education, 2024. **3**(1): p. 36.
16. Preiksaitis, C. and C. Rose, *Opportunities, challenges, and future directions of generative artificial intelligence in medical education: scoping review.* JMIR medical education, 2023. **9**(1): p. e48785.
17. Baidoo-Anu, D. and L.O. Ansah, *Education in the era of generative artificial intelligence (AI): Understanding the potential benefits*

of ChatGPT in promoting teaching and learning. Journal of AI, 2023. **7**(1): p. 52–62.
18. Hays, L., O. Jurkowski, and S.K. Sims, *ChatGPT in K-12 education.* TechTrends, 2024. **68**(2): p. 281–294.
19. Song, Y., et al., *Elementary school students' and teachers' perceptions toward creative mathematical writing with Generative AI.* Journal of Research on Technology in Education, 2026. **58**(3): p. 615–637.
20. Lu, J., et al., *Supporting teachers' professional development with generative AI: The effects on higher order thinking and self-efficacy.* IEEE transactions on learning technologies, 2024. **17**: p. 1267–1277.
21. Zawacki-Richter, O., et al., *Systematic review of research on artificial intelligence applications in higher education–where are the educators?* International journal of educational technology in higher education, 2019. **16**(1): p. 39
22. Alfarwan, A. *Generative AI use in K-12 education: A systematic review.* in *Frontiers in Education*. 2025. Frontiers Media SA.
23. Risko, E.F. and S.J. Gilbert, *Cognitive offloading.* Trends in cognitive sciences, 2016. **20**(9): p. 676–688.
24. Owan, V.J., et al., *Exploring the potential of artificial intelligence tools in educational measurement and assessment.* Eurasia journal of mathematics, science and technology education, 2023. **19**(8): p. em2307.
25. Lee, G., et al., *Multimodality of ai for education: Towards artificial general intelligence.* IEEE Transactions on Learning Technologies, 2025.
26. Dwivedi, Y.K., et al., *Artificial Intelligence (AI): Multidisciplinary perspectives on emerging challenges, opportunities, and agenda for research, practice and policy.* International journal of information management, 2021. **57**: p. 101994
27. Siemens, G., et al., *Human and artificial cognition.* Computers and Education: Artificial Intelligence, 2022. **3**: p. 100107.
28. Rudolph, J., S. Tan, and S. Tan, *ChatGPT: Bullshit spewer or the end of traditional assessments in higher education?* Journal of applied learning & teaching, 2023. **6**(1): p. 342–363.
29. Malik, P., *The role of artificial intelligence in education: opportunities and challenges.* International Journal of Scientific Research in Engineeringa and Management, 2024.
30. Shen, Y., et al., *ChatGPT and other large language models are double-edged swords.* 2023, Radiological Society of North America. p. e230163.
31. Han, A., et al. *Teachers, parents, and students' perspectives on integrating generative AI into elementary literacy education.* in *Proceedings of the 2024 CHI Conference on Human Factors in Computing Systems*. 2024
32. Valcea, S., M.R. Hamdani, and S. Wang, *Exploring the impact of ChatGPT on business school education: Prospects, boundaries, and paradoxes.* Journal of Management Education, 2024. **48**(5): p. 915–947.
33. Yan, L., et al., *Practical and ethical challenges of large language models in education: A systematic scoping review.* British Journal of Educational Technology, 2024. **55**(1): p. 90–112
34. Shen, Y., et al., *ChatGPT and other large language models are double-edged swords.* 2023, Radiological Society of North America. p. e230163.
35. Chiu, T.K., *The impact of Generative AI (GenAI) on practices, policies and research direction in education: A case of ChatGPT and Midjourney.* Interactive learning environments, 2024. **32**(10): p. 6187–6203.
36. Knox, C., *Meritocracy in authoritarian states: bureaucrats' perceptions in Central Asia.* Transforming Government: People, Process and Policy, 2026: p. 1–25.
37. Sharma, D.M., et al., *Integrating generative AI into K-12 curriculums and pedagogies in India: Opportunities and challenges.* Facilitating global collaboration and knowledge sharing in higher education with generative AI, 2024: p. 133–161.
38. Alneyadi, S. and Y. Wardat, *ChatGPT: Revolutionizing student achievement in the electronic magnetism unit for eleventh-grade students in Emirates schools.* Contemporary Educational Technology, 2023. **15**(4): p. ep448.