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Psychological impacts of AI use on school students: a systematic scoping review of the empirical literature

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Abstract

This systematic scoping review aimed to collate evidence assessing associations between AI use and psychological outcomes (including cognitive, emotional, and behavioural responses to these intelligent systems) for school students from preschool (age <5 years), primary school (age 5–11 years), middle school (age 12–14 years), to high school (age 15–18 years). Original empirical studies were identified in seven reliable databases (Scopus, Web of Science, PubMed, PsycINFO, ScienceDirect, IEEE, and ERIC), resulting in 189 eligible studies. From these, we have identified 24 relevant studies reporting students' hands-on experiential learning outcomes on AI use. Findings revealed that the use of AI in schools can have both positive and negative impacts on the psychological well-being of students. Increased engagement, cognitive achievement, self-efficacy, learning autonomy, and decreased frustration are among the benefits of this strategy; nevertheless, over reliance, anxiety, stress, social isolation, unstable mental health, and moral dilemmas including privacy, bias, and justice are among its drawbacks. Overall, the psychological impacts of AI use among school students are multifaceted, context-dependent and across grades. By carefully considering the design, implementation, and ethical decorum of AI in school education, teachers and policymakers can maximise its benefits by mitigating potential risks in practicing technology enhanced learning.

Keywords: Artificial intelligence, Psychological impacts, School students, AI-driven learning, Student well-being

Introduction

Digitisation enhances access to information, collaboration, and communication, necessitating individuals to improve autonomous skills and digital literacy, particularly in AI technology, for equal opportunities in life and work. AI is a significant technological advancement in the digital age, impacting and disrupting various aspects of human life (Casal-Otero et al., 2023). The versatile utilisation of AI and its fast development have raised both hope and fear (UNICEF, 2021).

AI in Education (AIEd) has started revolutionising our earlier stands on learning, instructional strategies, administering schools, or predicting students' learning status through automated operations (Saqr et al., 2023). Education 4.0, a concept encompassing the fourth industrial revolution, is transforming education through disruptive technologies like AI, the Internet of Things, and 3D printing, similar to their impact in other human interaction areas (Noor et al., 2024). A series of past studies have recommended incorporating AI literacy in compulsory education curricula to enhance students' awareness of AI and at the same to make them responsible future citizens (Tlili et al., 2023; Vartiainen et al., 2021).

Technology significantly influences human minds and brains, shaping our thinking, information processing, and interactions with the world, balancing benefits and drawbacks. The parents of today's 'digitods' frequently support teens' media use and digital literacy (Brito et al., 2018). This exposure to digital technologies from an early age can lead to potential health issues due to disproportionate screen time or inappropriate media use (Marciano et al., 2021). The Convention on the Rights of the Children (CRC) provides the seven basics for child-centred AI policies with "supporting children's development and well-being" as the foremost (UNICEF, 2021, p.31). AI-enabled devices are transforming our lives, impacting our psychological health, especially in school students during their sensitive developmental stage, requiring further research (Chen & Zhang, 2019).

This study investigates the impact of AI on students' psychology deconstructing the construct into cognitive functioning, emotional regulation, and behavioural change aiming to contribute to policy directives for the more intelligent use of AI in schools. It seeks to expand knowledge, guide policy decisions, and improve students' well-being in the digital age. To that end, we formulated the following research questions for this investigation:

1. What are the cognitive impacts arising from AI use, such as perception, attention, memory, language, problem-solving, reasoning, and cognitive load?
2. What are the emotional responses triggered by AI use involving trust, fulfilment, joy, fear, anxiety, and autonomy?
3. What are the changes in students' behaviour brought forth by the incorporation of AI in school including social interactions, isolation, and communication styles?
4. How do these psychological impacts vary across students of different school levels?

Research background

The 21st-century youth have unprecedented access to digital technologies, leading to a multifaceted digital generation with novel digital environments. AI is the most recent extension of this trend transforming various fields, including medicine, psychology, science, and public policy (Shoufan, 2023). Scientists are optimistic and anticipate AI reaching human levels by 2029, crucial for Industry 4.0 (Rohovnin, 2024).

A series of studies have pointed out and stressed that the integration of AI in Education has the potential to enhance teaching and learning experiences, improve educational outcomes, and support the diverse needs of students in today's digital age (Ng et al., 2023; Park & Kwon, 2023). AI has numerous applications in school and child learning, including personalised learning platforms, AI-powered tutoring systems, virtual reality simulations, and AI-based grading systems. It also aids teachers in lesson planning, curriculum development, and identifying student needs (McClelland et al., 2023).

AI's use among school students raises concerns about its impact on cognitive, emotional, and behavioural domains, necessitating further investigation at various school levels. Cognitive functioning is crucial for academic achievement and learning. AI tools can enhance cognitive load management, information processing, and constructive learning by personalising experiences and providing real-time feedback (Uddin et al., 2023). However, concerns about cognitive overloading, reducing critical thinking, attentional biases, and over-reliance on technology need to be addressed (Martin et al., 2024).

Emotional regulation involves managing emotions effectively, including self-awareness, empathy, and social competence (Brackett & Rivers, 2014). AI systems can simulate human emotions, raising ethical concerns about authenticity, privacy, security, and loss of control (Rayhan & Rayhan, 2023). The 'self-determination theory' (Deci & Ryan, 1985) suggests AI can enhance motivation by providing personalised feedback and learning experiences (Xiao et al., 2020). AI tools can develop emotional intelligence by providing feedback and emotional support (Ali et al., 2021). Understanding emotional impacts is crucial for designing technology-enhanced learning systems.

The study of behavioural impacts of AI on human behaviour and societal implications is crucial. AI tools facilitate 'social learning' (Bandura, 1977), potentially changing habits and attitudes (Lai et al., 2023; Limone & Toto, 2022; Seo et al., 2021). Students' acceptance of AI tools is determined by their behavioural engagement, and understanding these changes is essential for effective technology-enabled learning.

Research gap

Despite the growing interest in AIEd, there remains a significant gap in understanding the psychological impacts of AI use on school students. Existing literature primarily discusses the cognitive and academic advantages of AI applications, but lacks empirical studies on psychological effects like stress, anxiety, self-esteem, ethical concerns, and social dynamics. Current research often lacks a comprehensive framework that considers the diverse range of AI technologies and their nuanced impacts on different age groups and educational contexts. Moreover, there is limited exploration of the long-term psychological outcomes and potential negative consequences of AI interaction, such as dependency on technology and reduced face-to-face social skills. This systematic scoping review aims to address these gaps by synthesising existing empirical evidence and identifying areas requiring further investigation to provide a holistic understanding of the psychological effects of AI on school students.

Significance of the study

The study will contribute to the literature of student well-being and technology enabled learning outcomes by synthesising empirical data on AI use, identifying potential benefits and challenges, highlighting ethical issues, and directing future research. In the end, the research backs the development of AI systems that mitigate possible hazards and foster constructive psychological growth.

Method

The study uses PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) methodology (Page et al., 2021) and Okoli's (2015) seven vital steps for this systematic review, including identifying purpose, drafting protocol, screening and searching, extracting data, evaluating quality, synthesising, and writing the review. The variability in the evidence base resulting from the different study procedures and outcomes of the studies under review necessitates the caveat that we did not conduct a meta-analysis. Choosing a scoping review (Peters et al., 2015) for the study of psychological impacts of AI use on school students allows for a broad exploration of the topic, accommodating the likely diversity in study designs, populations, and outcomes, which would be challenging to synthesise in a meta-analysis.

Step 1: Identify the purpose

The studies that have already been done on the application of AI in school education have been thoroughly reviewed by the authors. They aimed to gain a deeper understanding of the potential psychological impacts of AI use on school students to inform future development of AI-enabled teaching and learning in school and understand initial reactions with an attempt at better incorporation of AI into education.

Step 2: Draft the protocol

The protocol outlines the study process, ensuring transparency and reducing researcher bias (Xiao & Watson, 2017). It includes generating research questions, defining literature search strategies, identifying locations, selection criteria, assessing studies, and developing data extraction strategies.

Step 3: Apply practical screening

The screening step filters articles and selects studies focusing on AI use in school contexts. Criteria are determined based on the authors' experience and successful systematic reviews, as summarised in Table 1.

Step 4: Literature search

A literature search was conducted using education-specific reputable databases like Scopus, Web of Science, PubMed, PsycINFO, ScienceDirect, IEEE, and ERIC databases to identify articles on 'AI use in school.' The search resulted in 189 articles, which were analysed using the Rayyan web-based system (http://rayyan.qcri.org/). It is a free web and mobile app, that helps expedite the initial screening of abstracts and titles using a process of semi-automation while incorporating a high level of usability (Ouzzani et al., 2016). Duplicates were removed, and 69 unique articles were identified. The articles that contained the phrase "AI effects on school students" OR "Psychological effects of AI among students" in either the title, the abstract, main text or keywords were downloaded and reviewed by the researchers. The first author then filtered the articles and removed those that met the exclusion criteria. The authors decided to incorporate exclusively empirical studies solely focused on the psychological effects of AI use among school students, resulting in 24 articles eligible for final analysis (Table 2). The search discovered the articles published between 1st January 2019 and 31st December 2023, and there were 4 studies published by the end of 2023 as 'early cite' for 2024.

Table 1 Inclusion and exclusion criteria for article selection

Criterion	Inclusion	Exclusion
Article Topic	AI use in the school education contexts.	AI use in the out-of-school contexts.
Article Type	Empirical Studies.	Editorials, Reviews, Commentaries, Conference abstracts, and Opinion papers.
Article Publication	Published and peer-reviewed.	Unpublished or pre-printed.
Article Availability	Available online as full text.	Not available online.
Article Language	English	Non-English
Population	K-12 settings or within the age range of K-12 schools, aged 3-18 years.	Higher and adult education contexts are excluded.
Measure	Studies report the psychological impacts of AI use among school students, like attitude, achievement, engagement, cognitive functioning, mental health, emotion, etc.	Studies not reporting clearly on the psychological impacts of AI on school students.

Table 2 List of studies included in this systematic review

No	Study	Title	Country/ School level	Method/ Participants	Exposure and Outcome measures	Result
1	Lai et al. (2024)	The application of artificial intelligence technology in education influences Chinese adolescent's emotional perception	China/ Primary, Middle, High school	Quantitative quasi-experimental study/ 342 primary school students, 351 junior high school students and 639 senior high school students.	Exposure measure: AIEd affects. Outcome measure: Emotional perception.	AIEd has a negative effect on adolescents' emotional perception.
2	Lin et al. (2024)	Modelling the structural relationships among Chinese secondary school students' computational thinking efficacy in learning AI, AI literacy, and approaches to learning AI	China/ High school	Quantitative cross-sectional survey/ 509 secondary school students (319 males and 190 females) with age range of 14-17 years.	Exposure measure: AI literacy approaches. Outcome measure: Students' computational thinking efficacy in learning AI.	AI literacy approach positively impacts students' computational thinking efficacy in learning AI, mediated by their understanding of AI learning.
3	Weng et al. (2024)	Does scratch animation for sustainable development goals (SDGs) with AI-comics impact on student empathy, self-efficacy, scriptwriting, and animation skills?	Taiwan/ Primary school	Mix-method quasi-experimental study/ 133 fifth-grade students (67 males and 66 females).	Exposure measure: SDGs 'Scratch' animation course with comics, AI digital reflection platform. Outcome measure: Students' self-efficacy; Empathy; Scriptwriting and animation skills.	The Comic Refection AI digital learning platform significantly improved students' scriptwriting and animation skills in the 'Scratch' animation course, fostering creativity and engagement, as evidenced by classroom observations.
4	Kim & Kwon (2024)	Tangible computing tools in AI education: Approach to improve elementary students' knowledge, perception, and behavioural intention towards AI	USA/ Middle school	Mix-method quasi-experimental study/ 60 sixth grade students (35 male, 23 female, and two non-binary).	Exposure measure: AI curriculum (with tangible computing tools). Outcome measure: Students' AI knowledge, perception and behavioural intentions towards learning AI.	The curriculum's success was evident among all students, resulting in enhanced AI knowledge, perception, and behavioural intention through the use of tangible computing tools.
5	Lai et al. (2023)	Influence of artificial intelligence in education on adolescents' social adaptability: The mediatory role of social support	China/ Primary, Middle, High school	Quantitative survey/ 342 primary, 351 middle, and 639 senior high school students.	Exposure measure: AIEd Outcome measure: Social adaptability, Family support, School support.	AIEd negatively impacts adolescents' social adaptability, with a significant negative correlation with social adaptability and family support, but no significant correlation with school support.
6	Ericsson & Johansson (2023)	English speaking practice with conversational AI: Lower secondary students' educational experiences over time	Sweden/ Primary school	Quantitative longitudinal survey/ 22 seventh-grade students (13 males and 9 females) between 13- and 14-years age.	Exposure measure: AI-enabled conversational agent. Outcome measure: Students' cognitive, emotional, and social educational experience.	Students embraced conversational AI in language education, fostering a positive learning experience and inspiring teachers, stakeholders, and designers to develop such systems for this age group.

7	Sanusi et al. (2023)	Developing middle school students' understanding of machine learning in an African school	Nigeria/ Middle school	Mix-method quasi-experimental study/ 32 middle school students (20 boys and 12 girls).	Exposure measure: AIEd Outcome measure: Students' understanding, motivation, achievement, and engagement.	Students effectively learnt and comprehended machine learning, even without prior knowledge or interest in science-related careers.
8	Abdelghani et al. (2023)	GPT-3-driven pedagogical agents to train children's curious question-asking skills	France/ Primary school	Quantitative quasi-experimental study/ 75 students between 9- and 10-years age.	Exposure measure: AI-enabled pedagogical agent, GPT-3. Outcome measure: Students' curiosity.	The study validates GPT-3's effectiveness in implementing curiosity-stimulating learning technologies and efficiently proposes open cues, allowing children greater autonomy to express their curiosity.
9	Marrone et al. (2022)	Creativity and artificial intelligence- A student perspective	Australia/ High school	Qualitative using grounded theory approach/ 12 focus group discussions and 8 one-on-one interviews.	Exposure measure: AIEd. Outcome measure: Students' creativity in four domains- social, affective, technological, and learning factors.	Students with higher understanding of AI expressed positive attitudes towards integrating AI into classrooms, while those with low understanding were fearful. Most believed AI could never match human creativity.
10	Vertsberger et al. (2022)	Adolescents' well-being while using a mobile artificial intelligence–powered acceptance commitment therapy tool: Evidence from a longitudinal study	USA/ High school	Quantitative longitudinal survey/ 10,387 adolescents, aged 14-18 years.	Exposure measure: Kai.ai (AI-enabled conversational agent). Outcome measure: Students' psychological well-being.	Mobile-based conversational agents have the potential to effectively deliver engaging and effective Acceptance Commitment Therapy interventions, a tool aimed to increase adolescent well-being.
11	Rong et al. (2022)	Research on the influence of AI and VR technology for students' concentration and creativity	China/ High school	Quantitative quasi-experimental study/ 31 high school students (11 boys and 20 girls).	Exposure measure: Interactive technology of AI and VR (Virtual Reality). Outcome measure: Students' creativity and concentration.	Incorporating VR and AI technology into art education and promoting deep learning significantly enhanced student concentration and creativity.
12	Wu & Yang (2022)	The effectiveness of teacher support for students' learning of artificial intelligence popular science activities	Taiwan/ Primary school	Quantitative quasi-experimental study/ 22 primary school students in grades 5th and 6th.	Exposure measure: Teacher support in AI-enabled learning activities. Outcome measure: Students' achievement, computational thinking, and problem-solving ability.	The popular science activities enhanced cognitive enhancement of AI concepts, but require more time for skill improvement. Students' learning performance without teacher enhanced independent thinking and problem-solving abilities.
13	Chiu et al. (2022)	Creation and evaluation of a pre-tertiary Artificial Intelligence (AI) curriculum	China/ High school	Mix-method quasi-experimental study/ 335 students and 8 teachers	Exposure measure: Designed AI curriculum.	Students exhibited increased competence and developed a more positive attitude towards learning AI.

				from the secondary schools.	Outcome measure: Students' perceived competence, attitude, and motivation towards AI.	
14	Aung et al. (2022)	Designing a novel teaching platform for AI: A case study in a Thai school context	Thailand/ Primary school	Quantitative quasi-experimental study/ 106 students in 7th and 8th grades.	Exposure measure: AIThaiGen (a web-based learning platform for junior high school students). Outcome measure: Students' understating and attitude.	There was substantial enhancement in fundamental AI concepts, with a positive shift in students' attitudes.
15	Hsu et al. (2021)	Behavioral-pattern exploration and development of an instructional tool for young children to learn AI	Taiwan/ Primary school	Mix-method quasi-experimental study/ 8 primary students (7 boys and 1 girl) of 5th grade.	Exposure measure: AI instructional tool for young students and used learning analytics. Outcome measure: Sequential learning behaviours.	The course design and hands-on AI activity effectively taught students about machine learning, particularly the trial-and-error process, according to sequence behaviour analysis results.
16	Van Brummelen et al. (2021)	"Alexa, Can I Program You?": Student perceptions of conversational artificial intelligence before and after programming Alexa	USA/ Middle and High school	Quantitative quasi experimental study/ 47 middle and high School students.	Exposure measure: Alexa (AI-enabled conversational agent). Outcome measure: Students' perceptions of Alexa's friendliness, trustworthiness, safeness, and trustworthiness.	Students perceived Alexa as more intelligent, closer, friendliness, trustworthiness, safeness, and trustworthiness after workshops.
17	Chai et al. (2021)	Perceptions of and behavioral intentions towards learning artificial intelligence in primary school students	China/ Primary school	Quantitative cross-sectional survey/ involving 682 students (52.05% male) in the 3rd to 6th grades, with an average age 9.87 years.	Exposure measure: Students' perceived AI literacy, perceived use of AI for social good, readiness for the AI-powered world (attitude towards behaviours) and confidence in learning AI as their PBC (perceived behavioural control). Outcome measure: Students' behavioural intention (BI) to learn AI.	According to the SEM, all exposure factors could predict intention to learn AI, whether directly or indirectly.
18	Kewalramani et al. (2021)	Using Artificial Intelligence (AI)-interfaced robotic toys in early childhood settings: a case for children's inquiry literacy	USA/ Preschool	Qualitative design-based based study/ 21 children 4–5 years old.	Exposure measure: AI-interfaced robotic toys. Outcome measure: Children's inquiry literacy and engagement.	Children's play with AI robots fosters creative, emotional, and collaborative inquiry literacies, highlighting the potential of AI toys in shaping these literacies.

19	Ali et al. (2021)	A social robot's influence on children's figural creativity during gameplay	USA/ Primary school	Quantitative case study following a quasi-experimental method/ 78 students (34 female, 44 male) of the 5–10 years old age.	Exposure measure: Jibo (AI-enabled social robot). Outcome measure: Students' figural creativity.	Children showed higher figural creativity when interacting with the AI robot that modelled creative behaviour through its drawings, suggesting that creativity demonstration led to increased expression.
20	Lin et al. (2020)	Zhorai: Designing a conversational agent for children to explore machine learning concepts	USA/ Primary school	Quantitative quasi experimental study/ 14 students (6 boys, 8 girls) age range 8-11 years.	Exposure measure: Zhorai (AI-enabled conversational platform and curriculum designed to help young children understand ML). Outcome measure: Students' understanding and learning engagement.	The AI platform's conversational feature enhanced learning engagement and provided novel visualisations that made machine knowledge more understandable.
21	Chai et al. (2020)	An extended theory of planned behavior for the modelling of Chinese secondary school students' intention to learn artificial intelligence	China/ High school	Quantitative quasi-experimental study/ 545 high school students (56.33% male) in the age of 13 to 18 years.	Exposure measures: AI literacy, subjective norms, AI anxiety, perceived usefulness, AI for social good, attitude towards using AI, confidence in learning AI, AI optimism, behavioural intention. Outcome measure: Students' intention to learn AI.	The SEM revealed eight factors that significantly influenced students' intention to learn AI, which should be taken into account when designing an AI curriculum.
22	Xiao et al. (2020)	Deep interaction: Wearable robot-assisted emotion communication for enhancing perception and expression ability of children with autism spectrum disorders	China/ Middle and High school	Quantitative quasi-experimental study/ 33 students (20 boys, 13 girls) age range 12-18 years.	Exposure measure: AI-enabled Wearable robot. Outcome measure: Perception and expression ability of ASD (Autism Spectrum Disorder) students.	The use of wearable robots for emotion communication, specifically for children with autism spectrum disorders, to improve their perception and expression abilities.
23	Estevez et al. (2019)	Gentle introduction to artificial intelligence for high-school students using Scratch	Spain/ High school	Quantitative design-based research/ 37 students (40% girls, 60% boys) of 16-17 years old.	Exposure measure: AI intervention with 'Scratch' (AI tool). Outcome measure: Minds and perception regarding AI.	Students easily grasped code and mathematical concepts using with Scratch, demonstrating an effective approach to learning AI fundamentals, offering alternative ways to learn machine learning.
24	Williams et al. (2019)	PopBots: Designing an artificial intelligence curriculum for early childhood education	USA/ Preschool	Quantitative quasi-experimental study/ 80 kindergarten children of 4–6 years age.	Exposure measure: PopBots (AI-enabled social robot). Outcome measure: Students' cognition and learning.	The social robot positively guided young children to enhance their reasoning and metacognitive skills.

Step 5: Quality appraisal

The review process involved carefully evaluating extracted articles, excluding 7 that did not meet Fink's (2010) standards for providing enough details on methodology, results, conclusions, strengths and limitations, resulting in 24 studies. The above process is illustrated in the flowchart in Figure 1.

Step 6: Data extraction

We extracted data using Creswell's (2015) coding strategies, which included open, axial, and selective coding. This helped us comprehend the material more thoroughly, create thorough categories, and hone our primary ideas.

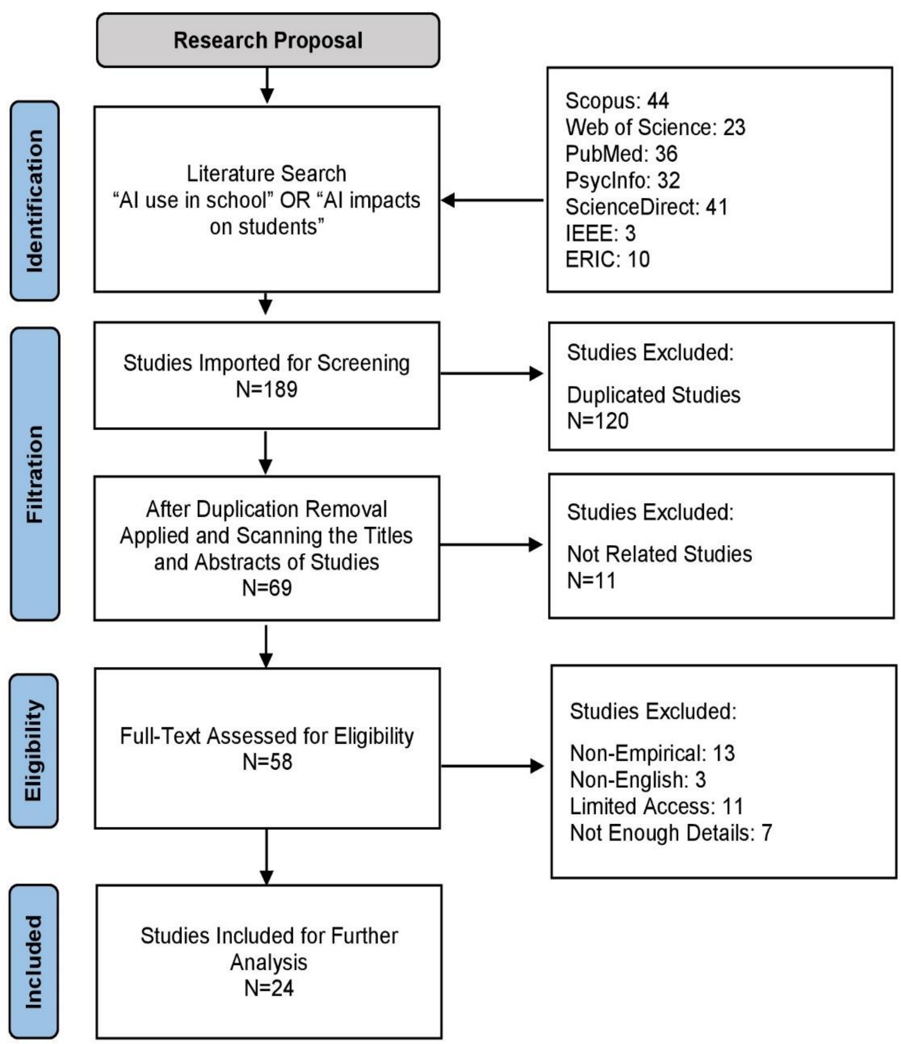

Fig. 1 The flowchart for study selection process

Our aim was to conduct a SWOT (Strengths, Weaknesses, Opportunities, and Threats) analysis to evaluate the positive and negative psychological impacts of AI use on school students and the codes were selected accordingly at the open coding stage. Strengths and weaknesses were more focused on internal prospects and problems, while opportunities and threats concentrated on the external factors and future directions (Cox, 2023). The 'strengths' included codes relating to enhanced learning experiences and increased engagement, while 'weaknesses' highlighted issues such as dependency on technology and reduced social interactions. 'Opportunities' focused on the potential for personalised learning and the development of new skills, whereas 'threats' included concerns about data privacy and the potential for increased anxiety and stress.

The findings were then synthesised into a comprehensive four-quadrant SWOT matrix, providing a balanced view of the psychological impacts of AI on school students. To ensure the robustness and accuracy of the SWOT analysis, we shared the preliminary SWOT matrix with a panel of experts, including educational psychologists and AI researchers, for feedback. Following the first 24 articles' coding, all of the assigned codes were examined and categorised based on similarity, which helped to cut down on duplicate codes during the axial coding step. The remaining articles were analysed using the preliminary set of codes. Any additional codes that surfaced as a result were added to the list. To provide more evidence in favour of the codes, specific quotes were reserved. Lastly, during the selective coding stage, related codes were categorised. To improve the classification's coherence, a few illustrative quotes that aptly reflected each group were identified. The data were reviewed several times to keep coding consistent.

Another round of expert opinion was collected in a final review to ensure the analysis accurately reflected the collected data and provided actionable insights.

Step 7: Synthesise studies

At this stage, we summarised, discussed, and assessed the most significant findings from the selected papers. The synthesis stage can be considered as a shift from an author-centric to a concept-centric emphasis, allowing us (researchers) to map all the information supplied to attain the most efficient appraisal of the material (Kundu, 2022).

Results

There are two distinct subsections in this result section. A preliminary descriptive analysis of the evaluated studies is covered in the first half, while the research issues and important findings of the studies under examination are addressed in the second half.

Part 1: Descriptive analysis

This subsection presents a descriptive analysis of the evaluated studies, considering factors like study context or country, participants, method, exposure and outcome measures, and their key results.

A. Number of reviewed studies and publication years

The total number of studies finally included in this scoping review were 24. All studies were empirical and published in different reputed journals focusing on the psychological impacts of AI use among school students. The studies are arranged chronologically in Figure 2 starting from 2019 to 2023. The year-wise statistics and trend analysis reveal a steady rise in publications in this field, indicating the topic's growing significance.

B. Educational levels and fields

The four levels of school education—preschool through high school—are covered in 24 articles. Children between the ages of 3-6 are usually the subjects of preschool research. Students in grades 1-5 between the ages of 6 and 11 clustered in primary school studies. Participants in middle school studies are students in grades 6-8, with the age range of 12-14. Students in high school are divided into age groups of 15-18 for grades 9-12. There are 9 studies at the primary school level, 7 at the high school level, 2 at the middle school level, and 2 at the preschool level. Mixed groups of preschools, primary, middle, and high school students participate in 4 studies. The chosen studies guarantee that all school education levels have had research done on the subject matter discussed here.

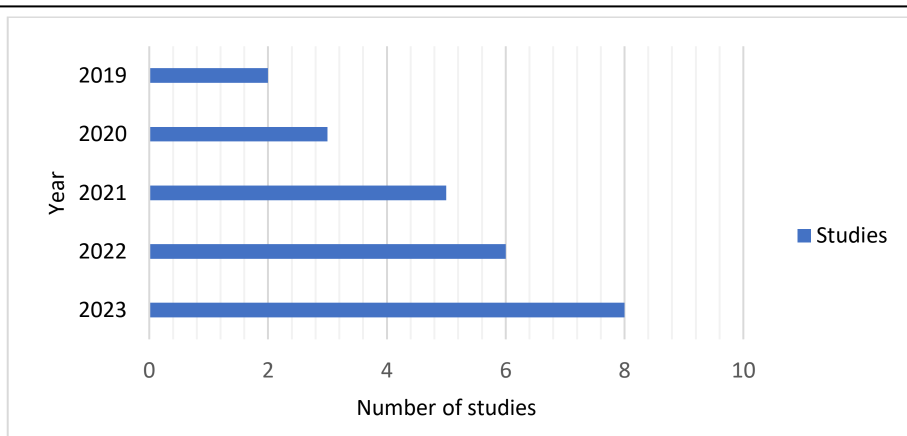

Fig. 2 Year-wise distribution of the reviewed studies

C. Country distribution

The reviewed studies have been conducted across different geographic regions, providing a diverse representation of country and contexts (Figure 3). Most of the studies focused on a single country, China (8). The countries following are USA (7), Taiwan (3), Thailand (1), Sweden (1), Nigeria (1), Australia (1), France (1), and Spain (1). Research from Thailand, Sweden, Nigeria, Australia, France, and Spain, though fewer in number, contributed unique perspectives on cultural and contextual factors influencing AI's psychological impacts on students. This country-wise distribution highlights the global interest in AI's educational implications and underscores the need for culturally sensitive approaches to studying AI's psychological effects on students. The findings suggest that future research should consider regional differences and aim to develop globally applicable strategies for integrating AI in educational systems to support students' psychological well-being.

D. Study population and sample size

School children are the primary sample in all 24 studies, and their psychological experiences with the use of AI are documented. Students with different degrees of experience with AI are selected from a wide spectrum of participants, spanning from early childhood to high school levels. The sample size varies from 8 (Hsu et al., 2021) to 10387 in a longitudinal study (Vertsberger et al., 2022). The variation in sample sizes reflects the range of methodological approaches used in the literature, which, in turn, impacts the strength and applicability of the research conclusions (Creswell, 2015).

E. Research methodology approaches and source(s) of data

There are 17 quantitative studies, 2 qualitative studies, and 5 mixed-method studies. In terms of the source(s) of data, the reviewed studies obtained their data from various sources,

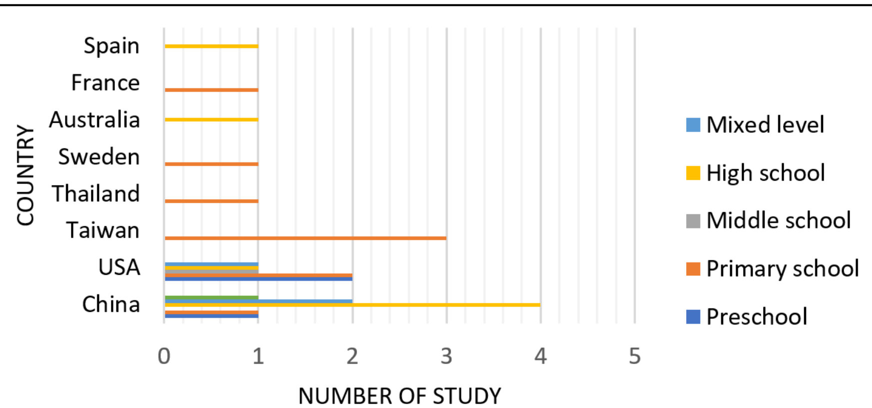

Fig. 3 Country and school level wise distribution of the reviewed studies

such as interviews, self-report questionnaires, and pre-and post-tests combining both quantitative and qualitative patterns. Most of the studies adopted a quasi-experimental research methodology approach (17) followed by 2 longitudinal survey, 2 cross-sectional surveys, 1 design-based research (DBR), 1 grounded theory, and 1 case study. Figure 4 illustrates the research methodologies and the source(s) of data used in the reviewed studies. The key findings highlight a predominance of quantitative over qualitative studies, a reliance on self-reported data, and varied approaches to measuring psychological outcomes.

F. Topics covered in AI use in school

We further categorised the studies based on the identified psychological domains of school students that may be impacted by using AI (cognitive functioning, emotional balance, and behavioural change) grounded in the literature reviewed earlier (Figure 5). The highest number of 12 studies are in the category of cognitive functioning, followed by emotional regulation (5 studies), behavioural change (4 studies), and mixed-effect reporting (3 studies).

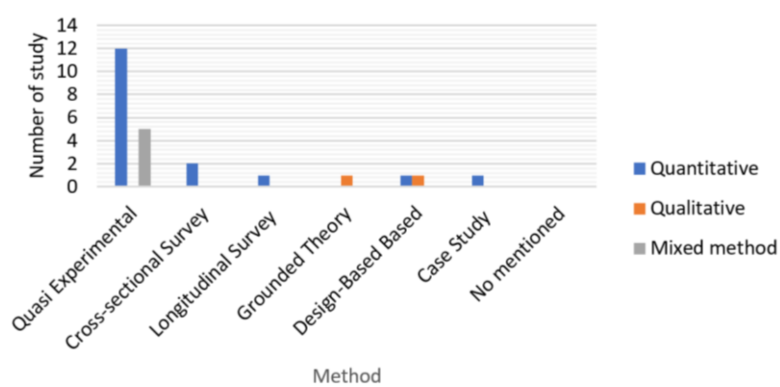

Fig. 4 Methods followed in the selected studies

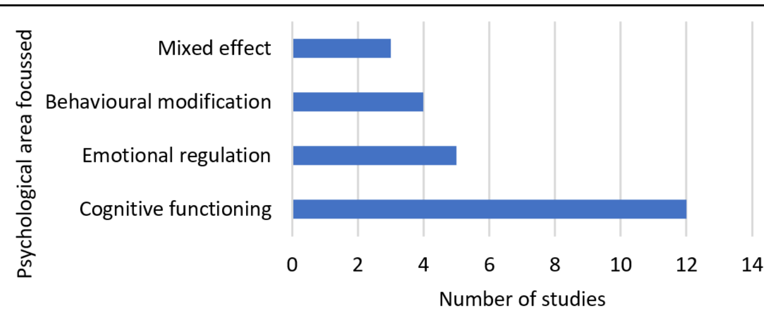

Fig. 5 Number of studies according to psychological area focused

Part 2: Main findings of the reviewed studies

This part will present the answers to the research question, and the main findings of the reviewed studies in Tables 3 to 5. It sheds light on a fascinating tapestry of cognitive, emotional, and behavioural changes brought about by students' interactions with AI systems along with the possible promises and limitations.

Table 3 Impacts of AI use on students' cognition

Study	Effects	
	Promises	Limitations
Lin et al. (2024)	Students' AI literacy promoted their computational thinking efficacy in learning AI. Approaches to learning AI functioned as a partial mediation in the above relationship.	Not recognised.
Weng et al. (2024)	Significant improvement in students' self-efficacy levels was noticed in the Scratch animation course. The Comic Reflection AI digital learning platform enhanced students' scriptwriting and animation skills by boosting their creativity, engagement, and enthusiasm.	Not recognised.
Kim & Kwon (2024)	Using AI computing tools enhanced cognitive learning among young students. AI positively influenced their learning intention.	The tool did not significantly improve their AI readiness or behavioural intention.
Ericsson & Johansson (2023)	AI-enabled conversation increased students' language confidence. Females showed higher improvement than males in the overall educational experience.	Different results were found in the AI-enabled speaking practice among boys and girls.
Abdelghani et al. (2023)	AI-enabled natural language prompting (LLMs) GPT-3 effectively supported children in generating curious questions and provided more autonomy to express their curiosity.	Not recognised.
Marrone et al. (2022)	The students with a higher self-reported understanding of AI reported more positive thoughts about integrating AI into their classrooms. AI helped them develop their creativity.	The students with a low understanding of AI tended to be fearful of AI. Most of the students reported that AI could never match human creativity.
Rong et al. (2022)	Use of VR and AI technology in art education encouraged students to carry out deep learning. AI improved students' concentration and creativity.	Not recognised.
Wu & Yang (2022)	Students' AI activities with teacher support enhanced learning outcomes, but students became accustomed to relying on their teachers. In contrast, activities without teacher support appeared more effective in fostering students' independent computational thinking and problem-solving abilities.	Students' learning performance was different with and without the teacher's support. Teacher support reduced students' critical thinking.
Aung et al. (2022)	AIThaiGen, a web-based learning platform for Thai junior high school students significantly improves students' understanding and customised learning of AI.	The outcome was context-specific.
Chiu et al. (2022)	The designed curriculum increased students' competence, motivation and attitude to learn AI.	Some students felt cognitive overloading due to overreliance.
Chai et al. (2021)	Students' intention to learn AI was influenced by their self-efficacy, readiness, and perceived use of AI for social good. AI literacy influenced students' self-efficacy, readiness, and perceptions of the use of AI for social good directly.	Not recognised.
Kewalramani et al. (2021)	AI toys improved children's creativity, emotion, and collaborative inquiry, as well as related literacy skills, accompanied by intermediary artefacts in a game-based environment.	Learning environment influenced cognition.
Ali et al. (2021)	Students who interact with robots showed a high degree of creativity and development of their social ability.	Low interaction brought low cognition.

Estevez et al. (2019)	AI foundation knowledge, real-world applications, and ethical implications effectively promoted students' social awareness and critical thinking about AI's impact.	AI foundation knowledge was effective in attaining the next level of cognitive achievement.
Williams et al. (2019)	The designed AI curriculum helped young children understand the concept of AI.	The impersonal teaching methods had a big impact on students' learning.

Table 4 Impacts of AI use on students' emotion

Study	Effects	
	Promises	Limitations
Lai et al. (2024)	Not recognised.	AI use has negative impacts on students' emotional perception, as it neglects the importance of care and respect for them. The implementation of AI technology has resulted in a decrease in genuine interpersonal interactions between students and teachers.
Lai et al. (2023)	Not recognised.	AI use is negatively correlated with students' social adaptability and family support but there is no significant correlation with school support. AI use could not only affect social adaptability directly but also affect it through family support.
Ericsson & Johansson (2023)	Students' sustained practice with conversational AI slightly enhanced their social and emotional engagement. Students' ratings regarding the speaking activity increased over time, indicating associative feelings of safety and enjoyment.	AI-enabled speaking practice has a higher impact on female participants about the overall educational experience.
Sanusi et al. (2023)	ML use enhanced students' learning engagement, motivation, achievement and overall educational experience.	Not recognised.
Van Brummelen et al. (2021)	Students perceived Alexa as more intelligent and closer after workshops, with strong correlations between its understanding and friendliness, trustworthiness, and safety.	Understanding of AI has a bearing on greater enjoyment.
Xiao et al. (2020)	Wearable machines enhanced the expression ability of adolescents with ASD.	Not recognised.
Vertsberger et al. (2022)	Students' mental well-being increased over time using mobile-based AI conversational agents that delivered engaging and effective Acceptance Commitment Therapy interventions.	Initially there has been isolation and anxiety among students with the AI agent.

Table 5 Impacts of AI use on students' behaviour

Study	Effects	
	Promises	Limitations
Ericsson & Johansson (2023)	The speaking sessions with conversational AI content were moderately relevant to their interests.	Female participants have a better overall educational experience. Misinformation, Dependency, Technology addiction.
Sanusi et al. (2023)	ML activities enhanced students' learning engagement- cognitively, emotionally, socially, and behaviourally.	Contextualised ML (Machine learning) activities could be more effective considering the country's tribes, languages, and cultural differences.
Hsu et al. (2021)	The designed AI course enhanced student-student and teacher-student interactions.	Not recognised.
Chai et al. (2020)	Students' attitudes towards AI depend on their perception of its usefulness and potential for social good.	AI exposure had a negative correlation with students' social skills.

Lin et al. (2020)	The conversational AI platform increased engagement during learning and visualisations helped their understanding.	There has been a decrease in the duration of attention spans.
Chai et al. (2021)	To foster a strong behavioural intention towards learning AI, developers of AI curricula should pay attention to students' attitudes and perceived behavioural change.	Not recognised.

Discussion

AI impacts on students' cognition

AI improved individualised learning by adjusting to students' unique learning preferences and speeds, as confirmed in the SWOT analysis (Table 6), which improved cognitive growth (Aung et al., 2022; Ericsson & Johansson, 2023; Lin et al., 2024; Weng et al., 2024). It provided immediate feedback and supported differentiated instruction, fostering better understanding and retention of complex concepts (Aung et al., 2022; Marrone et al., 2022). AI also enables access to vast educational resources, promoting critical thinking and problem-solving skills (Rong et al., 2022; Williams et al., 2019). Designed AI courses inspired collaborative inquiry (Kewalramani et al., 2021), autonomy in interaction (Abdelghani et al., 2023), and social ability (Ali et al., 2021). AI-powered educational games, simulations, and interactive learning platforms make learning more engaging and enjoyable for students (Rong et al., 2022). Increased engagement with AI leads to higher levels of motivation and ultimately improved students' academic achievement in science, technology, engineering and mathematics (STEM) education (Sanusi et al., 2023). A few studies found that AI-powered tutoring systems provided additional support to students outside of regular classroom hours (Aung et al., 2022; Chai et al., 2021; Chiu et al., 2022). Notably, here teachers' support and teaching methods are instrumental in bringing these positive changes among school students (Williams et al., 2019; Wu & Yang, 2022).

Table 6 Common insights about AI impacts on students' cognition through a SWOT analysis

Interior	Strengths • Self-paced learning. • Differentiated instruction. • Promoting critical thinking and problem-solving skills. • Collaborative inquiry. • Inspired learning autonomy.	Weaknesses • Impaired critical thinking. • Cognitive overload. • Lacked human touch. • Issue of over-reliance.
Exterior	Opportunities • Engaging and enjoyable learning. • Higher motivation and achievement. • AI-powered tutoring systems for additional support. • Help in STEM education.	Threats • Data privacy concerns. • Digital divide exacerbates inequalities. • Reduced human oversight. • Overshadowed teacher's role.

Weaknesses and threats are also surfaced during the SWOT analysis. Over-reliance on AI tools hinders the development of independent learning and critical thinking skills, as students might become too dependent on technology for answers (Chiu et al., 2022). There is also the potential for cognitive overload if AI tools are not appropriately integrated into the curriculum (Chiu et al., 2022). Additionally, AI's impersonal nature might fail to engage students who benefit from human interaction and encouragement (Williams et al., 2019). Students' intention to learn AI was influenced by their self-efficacy, readiness, and perceived use of AI for social good (Chai et al., 2021). Gender affected the AI-enabled speaking practice with girls exhibiting higher improvement in conversation with AI (Ericsson & Johansson, 2023). Data privacy concerns and the ethical use of student cognitive data pose significant risks (Kewalramani et al., 2021). The digital divide exacerbated inequalities in some studies, with students lacking access to AI technologies being left behind in cognitive development (Weng et al., 2024). There is also the risk of reduced human oversight, where AI's role in cognitive assessment and feedback might overshadow the teacher's role, leading to a less holistic educational experience (Marrone et al., 2022). Sanusi et al. (2023) talked about a contextualised use of AI which they found missing in current practices.

AI-enabled teaching no doubt enhances cognitive engagement and motivation, but requires balanced integration with traditional methods, data privacy, and equitable access to maximise its cognitive benefits.

AI impacts on students' emotion

A range of emotional reactions to AI use was reported by the reviewed studies as presented in the SWOT analysis in Table 7. Student participants expressed satisfaction and trust in their interactions with smart devices and virtual assistants (Ericsson & Johansson, 2023; Van Brummelen et al., 2021). These affective ties were especially strong when AI systems exhibited human-like traits and sympathetic reactions (Sanusi et al., 2023). AI-powered educational tools provide personalised support and feedback to students, enhancing their emotional well-being by fostering understanding and support for their unique learning styles (Sanusi et al., 2023; Van Brummelen et al., 2021). AI-driven educational games, adaptive learning platforms, and interactive tutorials have made learning more engaging and enjoyable for students (Sanusi et al., 2023). Higher levels of engagement led to increased motivation and a sense of accomplishment boosting students' self-esteem and emotional resilience (Ericsson & Johansson, 2023). AI chatbots and virtual counsellors offer students confidential, non-judgmental access to mental health resources, aiding in coping with stress, anxiety, and other school-related emotional challenges (Vertsberger et al., 2022). AI tools made education more accessible to students with disabilities or special needs like ASDs by an early identification and by providing assistive technologies such as

Table 7 Common insights about AI impacts on emotion through a SWOT analysis

Interior	Strengths • Personalised support and feedback to students. • Improved learning engagement. • Early identification of emotional and behavioural issues. • Tailored support and interventions.	Weaknesses • Worries about privacy, isolation, anxiety, and the fear of losing control. • Uncertainty in response. • Hampered social adaptability. • Gender dependent response. • Over-reliance on technology.
Exterior	Opportunities • Emotional resilience by providing real-time feedback and support. • Accessible to students with disabilities or special needs like ASDs. • Family support enhanced positive emotions.	Threats • Ethical concerns like data privacy. • Induced anxiety and social isolation. • Hampered interpersonal interactions.

speech-to-text, text-to-speech, and adaptive learning platforms (Xiao et al., 2020). This can help level the playing field and improve inclusive academic achievement for all students.

However, some studies reported participants who did express dread and uncertainty, particularly when AI made decisions that were better than their own (Lai et al., 2024). These negative emotional reactions were found to be significantly influenced by worries about privacy, isolation, anxiety, and the fear of losing control (Lai et al., 2024; Vertsberger et al., 2022). AI technology's implementation has negatively impacted students' emotional perception by neglecting care and respect and has led to a decrease in genuine interpersonal interactions between teachers and students (Lai et al., 2024). AI use negatively affected students' social adaptability (Lai et al., 2023). Enhanced practice with conversational AI added to students' feelings of confidence, safety, and enjoyment (Ericsson & Johansson, 2023) which got strengthened with the family support (Lai et al., 2023). Understanding the AI system is important which has been a significant predictor for students' feeling of enhanced friendliness, trustworthiness, safeness and adoption (Van Brummelen et al., 2021). Here, gender had an effect with girls showing a better edge (Ericsson & Johansson, 2023).

AI in education can improve emotional well-being, but careful consideration of limitations and risks is crucial, requiring equitable access and balancing technological integration with human interaction.

AI impacts on students' behaviours

Students' behaviour changed as a result of AI being used by them as evident in the SWOT analysis in Table 8. Some of them communicated confidently adjusting to have conversations with chatbots and virtual assistants powered by AI (Ericsson & Johansson, 2023; Lin et al., 2020). Some changed their daily routines and habits and started using AI tools to manage their time and stay organised (Chai et al., 2021). Speaking habits and

Table 8 Common insights about AI impacts on behaviour through a SWOT analysis

Interior	Strengths • Enhanced communication skills. • Enhanced monitoring and tracking of student behaviour. • Teachers understand behavioural patterns and adapt their teaching methods accordingly.	Weaknesses • Technology addiction. • Affected mental and physical well-being. • Difficulty forming meaningful interpersonal relationships offline. • Risk of misinterpreting data, resulting in unfair disciplinary actions.
Exterior	Opportunities • Personalised behaviour improvement plans. • Visuals contributed to engagement. • Collaboration with educators and psychologists.	Threats • Hampered concentration. • Dependency on technology and technology addiction. • Impaired social skills. • Reduced human oversight and empathy in managing student behaviour.

interests were enhanced by conversational AI technologies, with girls exhibiting a greater gain in this regard (Ericsson & Johansson, 2023). Sanusi et al. (2023) found the use of AI increased students' science learning engagement in all three domains- cognitive, affective, and behavioural. The life-like visuals in the AI platforms contributed significantly to their learning engagement and understanding (Lin et al., 2020). AI platforms increased interactions among students (Hsu et al., 2021).

In addition to the aforementioned beneficial developments, some research has shown behavioural issues related to excessive use, such as misinformation, dependency, and technology addiction, which have a detrimental effect on students' mental and physical health (Chai et al., 2020; Ericsson & Johansson, 2023). Lin et al. (2020) pointed out that AI shortened students' attention span which might affect them with difficulty in concentrating on tasks that require sustained effort. When AI is abused, kids' social abilities are compromised (Chai et al., 2020). This has a bearing on past studies that spending excessive time interacting with AI or technology in general instead of engaging in face-to-face communication with peers and teachers can lead to impaired social skills and difficulty in forming meaningful interpersonal relationships (Lai et al., 2023; Limone & Toto, 2022; Seo et al., 2021).

In conclusion, while AI use in education presents promising opportunities for improving the behavioural domain of school children, it is essential to carefully address its limitations and potential risks. In order to maximise benefits and reduce risks in this field, Chai et al. (2020) proposed striking a balance between technological integration and human contact as well as guaranteeing equitable access.

AI impacts on students of specific school level

Table 9 demonstrates that for preschoolers AI enhances metacognitive skills (Williams et al., 2019) and supports early cognitive and language development (Kewalramani et al.,

Table 9 Common insights about AI impacts on students of different school levels through a SWOT analysis

Interior	Strengths • Preschool: AI provided engaging, interactive learning experiences, supporting early cognitive and language development. • Primary School: AI facilitated personalised learning, helping to address diverse learning needs and improving foundational skills. • Middle School: AI tools enhanced student engagement and motivation, supporting the transition to more complex subjects. • High School: AI offered advanced analytics for personalised learning pathways, college preparation, and career guidance.	Weaknesses • Preschool: Over-reliance on AI impede the development of social and motor skills, essential at this stage. • Primary School: AI tools failed to fully address the emotional and social needs of young students. • Middle School: The impersonal nature of AI led to reduced teacher-student interaction during a critical developmental period. • High School: Excessive screen time and potential data privacy concerns hampered students' overall well-being and trust.
Exterior	Opportunities • Preschool: AI enhanced early intervention for developmental delays, provided tailored support. • Primary School: AI enabled adaptive learning, ensured that each student progresses at their own pace. • Middle School: AI offered innovative approaches to STEM education, fostering interest and proficiency in these areas. • High School: AI supported personalised college and career readiness programs, helping students make informed decisions about their futures.	Threats • Preschool: Data privacy issues and the potential for inadequate human interaction could negatively impacted young children. • Primary School: Unequal access to AI technologies widened educational disparities among students. • Middle School: Dependency on AI reduced critical thinking and problem-solving skills. • High School: AI's impact on mental health and the digital divide exacerbated existing inequalities in educational outcomes.

2021), but raises privacy and security concerns due to data collection (Kewalramani et al., 2021). As such, "consideration of developmental appropriateness to avoid overwhelming or confusing young children" (Williams et al., 2019, p.9) is necessary.

For primary school students AI facilitated personalised self-paced learning, fosters creativity, curiosity, and engagement (Abdelghani et al., 2023; Ali et al., 2021; Lin et al., 2020; Weng et al., 2024), but threats evolved include technology dependence (Weng et al., 2024), reduced critical thinking (Lin et al., 2020), reduced social interaction (Abdelghani et al., 2023) and negative emotional perception (Lai et al., 2024) leading to technology addiction and decreased attention spans (Aung et al., 2022; Ericsson & Johansson, 2023; Hsu et al., 2021).

For middle schoolers AI tools enhanced student engagement and motivation having opportunities for innovative approaches to STEM education (Kim & Kwon, 2024) but threats evolved like reduced teacher-student interaction due to impersonal nature of AI and hampered critical thinking (Sanusi et al., 2023).

AI offered advanced analytics for personalised learning intention (Chai et al., 2020), technology trust (Van Brummelen et al., 2021), college preparation and career guidance for the high school students (Vertsberger et al., 2022) but a few serious threats evolved like cognitive overloading, isolation, anxiety, data privacy, algorithmic bias, and ethical issues among high schoolers (Chai et al., 2020; Chiu et al., 2022; Estevez et al., 2019; Marrone et al., 2022).

However, a few additional negative impacts evolved that cannot be categorised for a particular grade of students include difficulty in forming meaningful interpersonal relationships offline (Lai et al., 2024), hampered concentration (Lai et al., 2023), and fear and anxiety produced by poor cognition (Xiao et al., 2020).

Even though integrating AI into education has many advantages for all educational levels, it's important to handle the unique risks and problems that come with each level. It seems that equal access and striking a balance between AI use and human engagement are necessary to optimise the benefits of AI in education.

Research implication

The results of this study have extensive implications for AI developers, policymakers, and mental health practitioners. Fostering a future where AI-human interactions are advantageous and emotionally helpful requires an understanding of the psychological effects of AI on individuals.

Determining how AI affects students' cognition and addressing it can help in the creation of AI systems that enhance rather than replace human cognition. Policymakers and AI developers may create more efficient systems for school students that put user comfort and trust first by understanding the emotional reactions that AI elicits. Fear and uncertainty may be reduced by addressing privacy issues and guaranteeing transparency in AI decision-making procedures.

AI systems ought to be built with empathy and the ability to adjust to the emotional requirements of their users to foster healthy AI-human relationships. People and intelligent machines can have a more harmonious relationship if open communication is promoted and reasonable expectations are created regarding AI's capabilities.

Policymakers can create ethical standards for AI development that put students' welfare first based on this study's findings. These policies might promote the creation of AI systems that respect students' privacy, support human decision-making rather than replace it, and put policies in place to mitigate the possible psychological challenges including misinformation, loneliness, dependency, and technology addiction.

Conclusion

In conclusion, the use of AI by school students brings numerous benefits, but it also presents significant psychological challenges. From heightened anxiety, isolation, and dependency issues to concerns about identity formation, hampered social adaptability, ethical dilemmas and cognitive overloading. The psychological impacts are multifaceted, complex, and across different education levels. As technology continues to shape the educational landscape, teachers, parents, and policymakers need to recognise and address these challenges proactively. By fostering a supportive environment that promotes emotional resilience, critical thinking skills, and a healthy balance between technology use and human interaction, we can help students navigate the psychological effects of AI use and thrive in an increasingly digital world. Additionally, promoting digital literacy and ethical education can empower students to engage with AI responsibly and ethically, ensuring that they are prepared to harness the benefits of technology while mitigating its potential drawbacks on their psychological well-being.

Abbreviations
AI: Artificial Intelligence; AIEd: AI in Education; ASD: Autism Spectrum Disorder; BI: Behavioural Intention; CRC: Convention on the Rights of the Children; DBR: Design-Based Research; ML: Machine Learning; PBC: Perceived Behavioural Control; PRISMA: Preferred Reporting Items for Systematic Reviews and Meta-Analyses; SWOT: Strengths, Weaknesses, Opportunities, and Threats.

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Authors' contributions
The first author led the research, designing, conducting methods, analysing, developing a framework, and writing the manuscript, with the second author contributing to planning, results discussion, and manuscript proofreading.

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