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Impact of Artificial Intelligence-Based Learning Tools on Academic Achievement and Self-Efficacy among Secondary School Students

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Abstract

Artificial intelligence (AI) tools are increasingly used to provide adaptive practice, automated feedback, conversational tutoring, content explanation, and learning analytics. These functions may support secondary school students by making practice more responsive and by helping learners interpret errors, set goals, and persist with challenging tasks. Yet access to a tool does not automatically produce learning: effects depend on instructional design, teacher mediation, prior knowledge, digital access, age-appropriate safeguards, and the quality of feedback. This article synthesizes policy guidance and published research on AI-supported learning, with particular attention to academic achievement and self-efficacy among secondary school students. It uses a structured narrative-review approach rather than presenting a new student survey or experiment. Evidence from OECD PISA 2022 is used to contextualize digital learning time and distraction, while UNESCO guidance and systematic reviews inform the discussion of AI-enabled instruction and responsible implementation. The article argues that AI should be treated as a learning support within a teacher-led instructional system, not as a substitute for teachers or a guaranteed route to higher scores. A practical framework is proposed for evaluating achievement, task persistence, confidence, feedback quality, equity, and responsible use. The review concludes with recommendations for schools and a research agenda for rigorous, age-sensitive evaluation.

Keywords: artificial intelligence; secondary education; academic achievement; self-efficacy; adaptive learning; formative feedback; digital equity.

Article type and data-integrity statement

This is a literature-based analytical review. No original survey, intervention, or student-level dataset was collected for this article. Numerical figures reproduced in tables and charts are attributed to the relevant published sources. Where a score is calculated by applying a source-reported difference to a reported baseline, the calculation is explicitly identified. Conceptual diagrams represent a proposed framework and are not empirical findings.

Introduction

Artificial intelligence is changing how educational resources can be presented, practiced, and assessed. In secondary education, AI-supported tools may include adaptive question banks, intelligent tutoring systems, automated writing feedback, conversational assistants, speech and language supports, and

dashboards that help teachers identify learning gaps. Their potential contribution lies not simply in digitizing materials but in providing timely, individualized support while a student is learning. For example, a system may adjust the difficulty of practice questions, explain a mathematical step in alternative language, or suggest revision based on repeated errors.

Academic achievement is commonly represented through test scores, course grades, mastery of curriculum objectives, and performance on subject-specific tasks. Self-efficacy refers to a learner's belief that they can organize and carry out actions required for a particular task. It is not the same as actual ability, general self-esteem, or momentary enjoyment. Students with stronger task-specific self-efficacy may be more willing to attempt difficult work, seek strategies, and persist after setbacks; however, confidence must remain calibrated to actual competence. The educational promise of AI must be evaluated against real classroom conditions. UNESCO's 2023 guidance on generative AI emphasizes a human-centred approach, privacy protection, age-appropriate use, and institutional preparation. The UNESCO Global Education Monitoring Report (2023) also cautions that robust evidence about technology's added value is limited and that technology products evolve rapidly. These cautions are especially relevant for school-age learners, whose needs include safeguarding, developmental appropriateness, teacher support, and equitable access.

Problem statement

The central problem is not whether AI can generate answers, but under what conditions AI-supported learning improves durable understanding and students' belief in their own capability. Poorly designed use can encourage answer copying, shallow processing, misinformation acceptance, dependency, privacy risks, and unequal benefits.

Objectives

- To synthesize current evidence and policy guidance on AI-supported learning in education.
- To examine plausible pathways linking AI tools with academic achievement among secondary school students.
- To analyze how feedback, mastery experiences, and learner agency may relate to self-efficacy.
- To identify risks involving accuracy, overreliance, privacy, bias, distraction, and unequal access.
- To propose an evidence-informed framework for school implementation and future evaluation.

Review questions

- Which AI-enabled functions are most relevant to secondary school learning?
- What does existing research suggest about achievement and motivation-related outcomes?
- Which learner, teacher, and institutional factors may strengthen or weaken benefits?
- How should schools evaluate AI-supported learning without confusing usage with learning?

Significance

This review is useful to teachers, school leaders, curriculum planners, and researchers who need to make decisions based on learning goals rather than technology novelty. It distinguishes the potential of AI from evidence of effectiveness and offers measurable outcomes for pilot studies. The focus on self-efficacy is important because achievement-only evaluation can miss changes in confidence, persistence, help-seeking, and independence. Conversely, positive student perceptions alone are not enough to demonstrate

improved learning.

Scope

The review focuses on secondary school students and educational AI applications relevant to instruction and feedback. It draws on international research and policy sources available through October 2026, while acknowledging that the evidence base changes quickly. Because many published studies include mixed age groups or higher education settings, findings are interpreted cautiously when they cannot be isolated to secondary-school populations.

Conceptual Foundations

AI-supported learning as a pedagogical system

AI-supported learning should be understood as an interaction among a tool, a learning task, a student, and a teacher. A tool can generate explanations or recommend practice, but the instructional value depends on whether the response aligns with curriculum objectives, whether the student understands it, and whether the teacher can detect misconceptions. Automated feedback is most useful when it is specific, actionable, timely, and connected to an opportunity to revise.

Self-efficacy and mastery experiences

Self-efficacy theory highlights the importance of mastery experiences, observing models, credible encouragement, and interpreting emotional or physiological states. An AI tutor may support mastery by breaking a difficult task into manageable steps and allowing low-stakes practice. It may undermine self-efficacy if it routinely supplies answers before students attempt a task, provides inconsistent explanations, or makes learners feel incapable without automated assistance. A sound design therefore gives hints before solutions, asks students to explain reasoning, and gradually reduces scaffolding.

Feedback and formative assessment

Formative assessment turns evidence of current understanding into next steps for learning. AI can increase the frequency of feedback, but speed is not equivalent to accuracy. Teachers need to verify feedback, particularly in open-ended tasks, factual explanations, and high-stakes assessment. Students should be taught to check claims against textbooks, classroom notes, and authoritative sources.

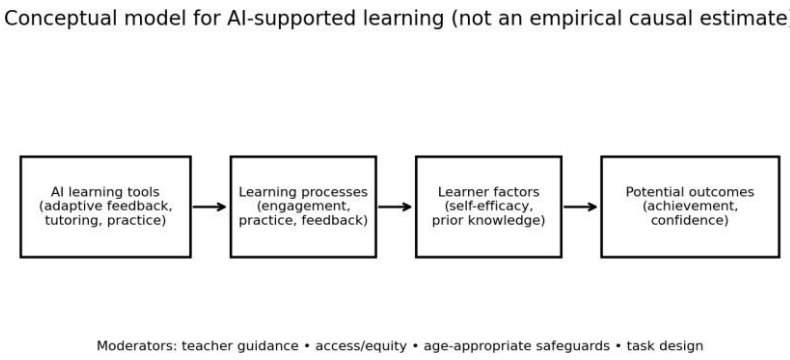


Figure 1. Proposed conceptual model; arrows represent hypothesized pathways, not measured causal effects.

Review Methodology

A structured narrative-review approach was used to synthesize peer-reviewed reviews, international policy guidance, and large-scale educational indicators. The approach is suitable for mapping a rapidly developing field where tools, definitions, and study designs vary. It is not presented as a registered systematic review, and no claim is made that every relevant publication has been captured.

Source selection and relevance

Priority was given to sources with transparent methods, identifiable publication details, and direct relevance to AI in education, digital learning, academic achievement, student motivation, or responsible technology use. Key sources include UNESCO's Guidance for Generative AI in Education and Research (2023, updated webpage accessed in 2026), the UNESCO Global Education Monitoring Report on technology in education (2023), OECD PISA 2022 reporting, and peer-reviewed systematic reviews on AI in education and AI-supported academic performance.

Synthesis procedure

Evidence was organized under five themes: instructional affordances, achievement-related outcomes, self-efficacy and motivation, implementation conditions, and ethical or equity risks. Quantitative values are retained only when they can be traced to a source. Figures derived from reported differences are labelled as calculations. No pooled effect size is computed in this article, because combining heterogeneous studies without a formal meta-analytic protocol would be misleading.

Limitations of the review method

The review is limited by the speed of change in generative AI, variation in definitions of AI tools, differences in student ages and subject areas, and inconsistent outcome measures. Some studies measure attitudes or perceived usefulness rather than learning gains. Research conducted in higher education cannot be assumed to generalize to younger students. These limitations support cautious conclusions and a need for controlled, context-sensitive studies.

What AI Tools Can Offer Secondary Learners

Adaptive practice can adjust task difficulty in response to student performance. Intelligent tutoring systems may offer hints, stepwise feedback, and additional examples. Generative AI assistants can rephrase explanations, produce practice questions, support language access, and help learners brainstorm. Automated feedback can assist teachers with routine formative tasks, although final judgments about student understanding remain a professional responsibility.

AI function	Potential learning mechanism	Evidence-informed caution	Possible indicator
Adaptive practice	Practice at an appropriate level; rapid error correction	Algorithms may misdiagnose skill gaps	Mastery by curriculum objective
Conversational explanation	Alternative explanations and guided questioning	May produce plausible but incorrect answers	Accuracy of student explanation
Automated feedback	Faster revision cycles	Feedback may be generic or misaligned	Quality of revisions
Accessibility tools	Speech, translation, and reading support	Language and disability coverage varies	Access and participation measures
Learning analytics	Earlier identification of disengagement	Risk of surveillance and biased inference	Teacher-verified support actions

From tool use to meaningful learning

The instructional sequence matters. A productive cycle begins with an independent attempt, moves to a hint or diagnostic question, asks the learner to revise, and ends with a new task that tests transfer. This sequence makes the student an active problem-solver. In contrast, a workflow that requests a complete answer and copies it into an assignment offers little evidence of understanding.

Teacher mediation

Teachers determine learning objectives, select appropriate tools, set boundaries, model verification, and interpret student progress. They can use AI-generated examples as material for critique: students identify errors, compare explanations, and justify which answer is better. This turns the possibility of AI error into a learning opportunity while maintaining human oversight.

Evidence on Achievement and Digital Learning Conditions

Research syntheses report promising applications of AI and computational approaches, but the size and consistency of effects vary by task, implementation, and study design. Fernández-Cerero and colleagues' systematic review and meta-analysis (2023) reported generally positive impacts of AI and computational sciences on student performance and learning attitudes, particularly in STEM contexts, while also noting implementation and ethical challenges. Wang and colleagues' 2024 systematic literature review mapped diverse categories of AI in education and emphasized the field's breadth.

Large-scale digital-learning evidence offers a useful caution: technology use is not uniformly associated with better performance. OECD's analysis of PISA 2022 found that students who spent up to one hour per day on digital devices for learning at school scored 25 points higher in mathematics than students reporting no such use; after accounting for student and school socioeconomic profiles, the difference was 14 points. Students reporting 5–7 hours of digital learning at school scored 12 points lower than those reporting 3–5 hours, before adjustment; after adjustment the difference was 10 points lower. These associations are not causal estimates of AI effectiveness.

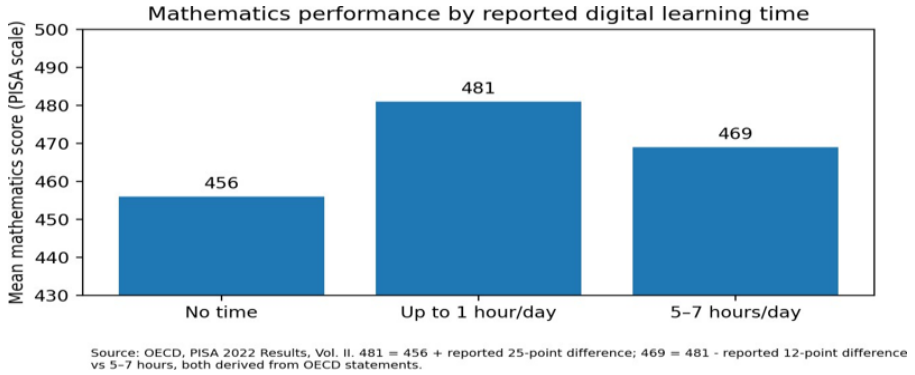


Figure 2. OECD-reported and transparently derived PISA 2022 score values; not AI-specific effects.

6.1 Interpretation

The evidence supports a measured conclusion: purposeful, limited, curriculum-aligned digital use may support learning, while excessive or poorly structured use may reflect distraction, weak pedagogy, or other differences between students and schools. AI-specific evaluation must therefore compare clearly defined instructional conditions and control for prior attainment, access, teacher practice, and time on task.

Self-Efficacy: A Potential Pathway and an Outcome

Self-efficacy can influence the goals students choose, the effort they invest, and how they respond to setbacks. AI tools may strengthen efficacy when they help learners experience progress, provide understandable hints, and make improvement visible. For example, a student who repeatedly fails a problem may benefit from a sequence of increasingly explicit prompts and then successfully solve a new, similar problem independently. That independent success is more meaningful than simply receiving a correct answer from a chatbot. A risk arises when students attribute success to the tool rather than their own developing skill. Over-scaffolding can also prevent students from learning to tolerate productive struggle.

Teachers should therefore ask students to show their reasoning, solve parallel problems without AI, and reflect on which strategies they can now use independently.

Design choice	Likely implication for self-efficacy	Recommended safeguard
Hints before full answers	Supports agency and attainable progress	Require an attempt before revealing solution
Progress dashboard	Makes improvement visible	Use transparent, non-stigmatizing metrics
Personalized explanations	Can reduce confusion	Teach verification and source checking
Instant completion of tasks	May create dependency or false confidence	Include unaided transfer tasks
Public ranking by AI score	May damage confidence for some learners	Prefer private formative feedback

Measuring self-efficacy responsibly

A school-based study should use a validated, age-appropriate, task-specific self-efficacy scale, report reliability, and avoid treating a single general confidence question as a complete measure. Measurement should occur before and after the intervention, with an appropriate comparison group where feasible. Qualitative interviews can help explain why students' confidence changed, but they should complement rather than replace achievement measures.

Risks, Ethics, and Equity

Accuracy and hallucination

Generative systems can produce fluent but inaccurate explanations, fabricated references, or incomplete solutions. Students may be particularly vulnerable when they lack the subject knowledge needed to detect errors. Teachers should model verification and establish a simple protocol: check the claim, compare it with trusted course materials, and explain the reasoning in the student's own words.

Privacy and safeguarding

Students should not enter personal information, school records, identifiable assignments, or sensitive family details into unapproved tools. Schools need age-appropriate policies, clear consent and data-handling rules, and a process for reporting unsafe outputs. UNESCO's guidance calls for human-centred regulation and attention to privacy and age limits.

Equity and access

AI may widen inequalities when some students have high-quality devices, stable internet, paid subscriptions, or private study space while others do not. Accessibility features may help some learners but can be unavailable or poorly localized for others. Schools should provide equivalent learning opportunities, offline alternatives where possible, and monitoring of outcomes by relevant groups without exposing student identities.

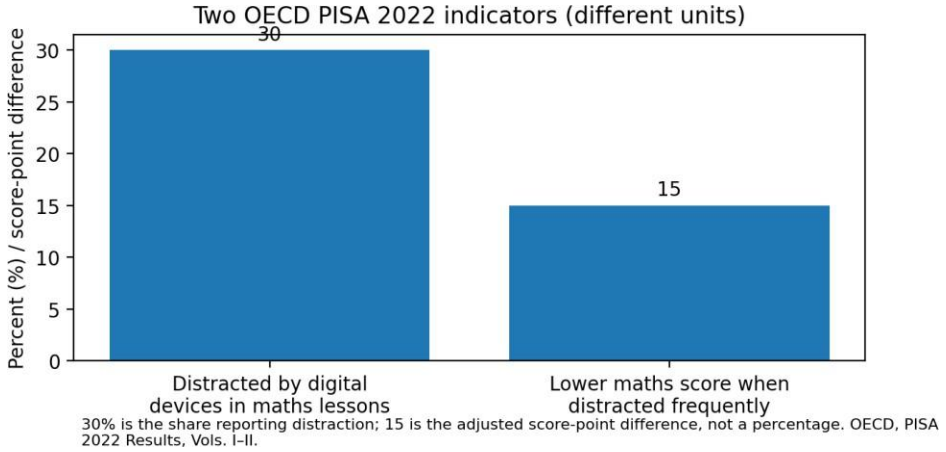


Figure 3. OECD PISA 2022 indicators on device distraction; the two bars use different units and must not be compared as equivalent quantities.

Evidence Summary

Source	Type and scope	Contribution	Caution for this paper
UNESCO (2023), GEM Report	Global policy/evidence synthesis	Technology requires evidence, equity, and context-sensitive decisions	Not a direct test of one AI product
Miao & Holmes / UNESCO (2023)	Guidance on generative AI	Human-centred use, privacy, age-appropriate safeguards	Policy guidance rather than effect estimate
Fernández-Cerero et al. (2023)	Systematic review and meta-analysis	Reports positive trends in AI/computational learning outcomes	Studies differ in tools, ages, and outcomes
Wang et al. (2024)	Systematic literature review	Maps categories and themes in AI in education	Broad field; not a single intervention estimate
OECD PISA 2022	Large-scale international assessment	Shows dose/purpose and distraction matter in digital learning	Associations are not AI-specific causal effects

Overall synthesis

The strongest defensible position is conditional rather than absolute. AI can expand the availability of explanations and feedback, but its impact depends on the instructional sequence, teacher expertise, student agency, data protection, and the fairness of access. Achievement should be measured through valid assessments and transfer tasks; self-efficacy should be measured as task-specific belief and interpreted alongside performance. A technology's novelty, usage frequency, or student satisfaction cannot independently establish effectiveness.

9.2 Implications for secondary schools

- Begin with a curriculum problem, then select a tool that addresses it.
- Require students to attempt, question, revise, and verify AI-assisted work.
- Use teacher-reviewed prompts and age-appropriate access settings.
- Keep sensitive student information out of unapproved systems.
- Evaluate learning gains, confidence, equity, and unintended consequences.

Proposed Evaluation Framework

Schools can evaluate AI-supported learning through a small, well-designed pilot rather than broad unmonitored adoption. A pilot should identify one subject and a clearly specified unit, define the AI-supported activities, train teachers, establish a comparison condition, and collect baseline and follow-up evidence. If random assignment is feasible and ethical, it strengthens causal interpretation; otherwise, matching or statistical adjustment should be described transparently.

Domain	Example measure	Timing	Interpretation
Achievement	Curriculum-aligned pre/post test plus transfer item	Baseline and endline	Learning change, not just task completion
Self-efficacy	Validated task-specific scale	Baseline, midpoint, endline	Confidence relative to task demands
Engagement	On-task observation and task completion records	During lessons	Use alongside learning evidence
Feedback quality	Teacher rubric for accuracy/actionability	Sampled sessions	Whether feedback helps revision
Equity	Access, participation, and outcomes by relevant groups	Throughout	Detect uneven benefits
Safety and integrity	Privacy incidents, citation checks, misuse logs	Throughout	Identify risks and response needs

Example research design

A feasible design could compare two comparable classes studying the same curriculum unit: one receives teacher-led instruction with structured AI-assisted formative practice, while the other receives the usual formative practice. Both groups should receive equivalent instructional time and curriculum content. The intervention should specify allowed tool functions and teacher support. The analysis plan should be established before examining outcomes and should report effect sizes and uncertainty, not only statistical significance.

Research ethics

Research involving minors requires institutional approval where applicable, parental consent and student assent as required, secure data handling, and a clear explanation that participation does not affect grades. Students should retain access to ordinary teaching and support. Any AI-generated assessment must be reviewed by qualified educators.

Discussion

The reviewed literature points to AI as a potentially useful instructional resource, but not a self-sufficient pedagogy. Its most plausible value is in increasing opportunities for guided practice and feedback while allowing teachers to devote attention to diagnosis, discussion, and complex learning needs. This value is realized only when AI outputs are aligned with curricular aims and students are prompted to think, explain, and verify. Self-efficacy should be treated both as a potential pathway and as an outcome. When students experience manageable challenge and see evidence of their own progress, confidence may become better calibrated and persistence may improve. Yet automated assistance can obscure whether the student can perform independently. Hence evaluation must include tasks completed without AI and questions requiring explanation or transfer. The OECD findings on digital learning time reinforce the importance of purpose and dose. Students' performance patterns are not a direct estimate of AI effects, but they caution against assuming that more screen time is better. AI should be embedded in a balanced learning environment that includes discussion, reading, practice on paper where appropriate, collaborative problem-solving, and direct teacher feedback.

Practical implications

- Adopt AI to solve specific learning problems, not as a general symbol of modernization.
- Build AI literacy: students should learn how systems fail and how to verify outputs.
- Use AI to provide hints, practice, and feedback, while preserving student authorship.
- Make teacher professional development part of implementation costs.
- Audit the impact on students with limited connectivity or assistive needs.

Recommendations and Future Research Recommendations for policymakers

Policy should define approved uses, minimum privacy protections, age-appropriate access, disclosure expectations, and procedures for handling errors or harmful outputs. Procurement decisions should require evidence of educational value, accessibility, data minimization, and interoperability. Policies should also provide clear guidance on assessment integrity, distinguishing permitted support from substitution for a student's own work.

Recommendations for school leaders and teachers

School leaders should begin with limited pilots, document training needs, and review results before scaling. Teachers should design tasks where students show reasoning and reflect on AI suggestions. Students should be encouraged to challenge a system's answer rather than accept it uncritically. Families should receive clear information about tool use and privacy.

Future research agenda

- Longitudinal studies on whether AI-supported gains persist after the tool is removed.
- Subject-specific studies with secondary-school samples and clearly defined AI interventions.
- Research on self-efficacy calibration, help-seeking, and independent transfer.
- Comparisons of hint-based support, answer-generating support, and teacher feedback.
- Equity-focused research across language, disability, socioeconomic, and rural/urban contexts.
- Independent replication and transparent reporting of null or negative results.

Conclusion

AI-based learning tools may support academic achievement and self-efficacy when they provide accurate, timely, curriculum-aligned scaffolding that strengthens student agency. Their benefits are not automatic and should not be inferred from access, usage, or enthusiasm alone. Responsible implementation requires teacher mediation, independent assessment, privacy safeguards, equitable access, and continuing evaluation. The central principle is to place learning objectives and student development before the technology.

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Appendix A. Suggested School AI-Use Protocol

Step	Action	Evidence to retain
1. Define	State the learning objective and what AI may/may not do	Lesson plan and approved-use note
2. Prepare	Check age suitability, privacy settings, accessibility, and teacher readiness	Tool review checklist
3. Teach	Model prompting, verification, and disclosure of AI assistance	Student practice examples
4. Scaffold	Require an attempt; offer hints before complete answers	Selected learning logs
5. Verify	Check factual claims and compare with trusted course resources	Verification rubric
6. Assess	Include independent transfer questions and oral explanation	Pre/post assessment results
7. Review	Examine outcomes, equity, errors, and student feedback	Pilot evaluation report

Appendix B. Suggested reporting checklist

- Describe the AI tool, version/date, access conditions, and permitted functions.
- Report student age/grade, subject, sample, comparison condition, and duration.
- Describe validated measures and reliability where applicable.
- Report missing data, effect sizes, uncertainty, and limitations.
- Separate empirical results from conceptual interpretation.
- Document ethics approval, consent, privacy, and academic-integrity procedures.

Author Notes

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