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GENERATIVE AI AS A CO-TEACHER: EFFECTS ON STUDENT AGENCY, METACOGNITION, AND ASSESSMENT PRACTICES IN SECONDARY CLASSROOMS—A MIXED-METHODS LONGITUDINAL STUDY

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ABSTRACT

Educational institutions at all levels have experienced a rapid integration of generative Artificial Intelligence (AI) technology and there has been an influx of renewed conversations about how generative AI will affect pedagogical practices in educational settings especially concerning the learner's agency, metacognition and assessment practices. The purpose of this mixed methods longitudinal study framed around generative AI as a colleague has been to identify how generative AI technology continues to support the learner-centered approach to learning within the context of secondary schools as a result of this sustained use of instructional support by AI technology. To identify key learner-centered outcomes, quantitative data was extracted from empirical peer-reviewed studies to measure the changes made in the areas of learner agency; metacognitive strategy usage; self-regulated learning; and formative assessment practices. Percentage change calculations are then applied to pre- and post-intervention means in order to build a consistent synthesis that can be compared among the studies. In conjunction with the quantitative analysis, a secondary thematic synthesis based on the qualitative data collected through international research and policy reports has allowed for further contextualizing of the results of the quantitative data. The results indicate there was a considerable overall increase in all variables, with the highest increases occurring in formative evaluation practice, followed by improvements in metacognitive strategies, and a lesser extent, improvements in learner agency. Evaluative

analysis of the qualitative data also supports the conclusion that generative artificial intelligence (AI), when employed in a manner that offers pedagogical scaffolding, supports reflective learning and assists learners to become more autonomous learners. The use of data triangulation from multiple data sources, and the utilisation of differing data collection methods over varying timescales, provides additional strength to the conclusions drawn from these findings. Thus, it may be reasonable to conclude that generative AI acts as a co-teacher (not a distinct/alternative to human teaching), and that it will play an important role in continuing to provide effective and sustainable means for supporting agency-based learning, developing learners' metacognitive skills and creating a culture of assessment within the secondary school system.

KEYWORDS: Generative artificial intelligence; Student agency; Metacognition; Formative assessment; Self-regulated learning; Secondary education

INTRODUCTION

Artificial intelligence has been viewed as an increasingly disruptive technology used in contemporary learning environments, particularly due to the rise of generative AI systems such as large language models (LLMs), intelligent tutors (ITs), and automated feedback systems being used in the classroom environment. While previous generations of technology in education focused primarily on delivering content, generative AI is capable of generating new explanations for previously learned content, assisting in the development of inquiry-based approaches to learning, providing immediate assessment feedback, and adjusting instruction depending upon an individual's response and performance. As generative AI continues to evolve, AI becomes increasingly co-teaching; an instructive partner both for the educators and the learners—supporting them in achieving their goals through collaborative instructional technology.

The use of AI in secondary education where students are encouraged to grow in self-direction, critical thought, and self-regulation offers many possibilities for positive pedagogical change. The research suggests that if students have an increased sense of agency (or ownership over their own learning), they tend to have better academic achievement and are more prepared for lifelong learning. The concept of metacognition (i.e., knowing and managing one's own cognitive processes) has also been shown to be important for achieving academic success. Unfortunately, most traditional forms of assessing student performance do not measure these higher-level skills.

According to recent empirical findings, AI-enhanced Learning Environments have been shown to improve student knowledge about how to learn (metacognitive) by providing relevant and timely adaptive feedback and/or prompting reflection (Alenezi, et al 2025), however, with the rapid growth of interest in this technology has come heightened anxiety around dependency on technology, ethical use of Artificial Intelligence technology (AI), and quality/certainty of assessment. In spite of the heightened interest surrounding this topic, there is little empirical synthesis available that examines longitudinally the use of Generative AI on Students as it relates to Agency, Metacognitive Awareness and Assessment Practices in Secondary Schools.

The aim of this research is to fill this lag in knowledge by reviewing previous published work (i. e., reports published after 2018) and practice (i. e.; educational policies) concerning the role of generative AI teachers within changing contexts and thus provide a comprehensive assessment of generative AI's capacity for co-teaching and varied assessments of student learning over time.

LITERATURE REVIEW

Generative AI in Secondary Education

AI has changed in the way we provide education. Initially AI was strictly rule-based and used very little data; however, today AI allows educators to develop content based on what we call "Generative Models" that use a large amount of data. Early attempts to use AI to provide educational content only delivered the content in a pre-set format (VanLehn, 2011), but today's generative models allow for real time dialogue with instructors during the learning process and offer students individualized options for how they would like to receive their educational content (Holmes et al., 2023).

Research has shown that generative AIT (such as large language models, automated feedback systems, and adaptive tutors) are becoming more common in high schools to support student’s writing, problem-solving skills, inquiry-based learning, and revision process (Kasneci et al., 2023). Generative AI has also been recognized as a potentially transformational educational technology by international organizations like the OECD and UNESCO, and may thus change how we teach, learn, and assess (OECD, 2021; UNESCO, 2023).

Furthermore, research shows the extent to which AI can influence education is largely determined by how it is integrated with teaching practices, rather than its existence as a technology alone. Researchers Williamson and Eynon (2020) warn that when AI is implemented in an unstructured manner, there is a tendency to reinforce shallow approaches to learning and make existing inequities within assessment remain, thus highlighting the importance of developing frameworks grounded in pedagogy.

Student Agency and AI-Supported Learning

Student agency is defined as the ability of learners to act with intention, as well as the responsibility for their own learning and is considered to be an important goal for students in secondary school (Bandura, 1997). Theories of self-determination, such as those that focus on autonomy, competence, and relatedness as fundamental components of the experience of agency (Ryan & Deci, 2017), have shaped much of the current research into agency.

The current research in the field of AI for education has suggested that generative AI may enhance student agency by allowing students to choose different learning pathways, ask their own self-directed questions, and continually revise their work (Holmes et al., 2023). According to Kasneci et al. (2023), many students feel empowered by the use of AI tools, and they particularly prefer using them for self-directed exploration and reflection as opposed to generating answers.

However, most studies have not focused on agency in the field of post-secondary education, but rather as a result of other factors that are more significant in nature. In addition, much of the previous researches were limited to examining short-term AI-based interventions; therefore, they do not provide much evidence regarding the ongoing evolution of student agency within an AI-supported environment over longer time periods.

Metacognition and Generative AI

Metacognitive awareness and self-regulation of one's cognitive processes have a long history of being considered a prominent indicator of a student's academic achievement (Schraw & Dennison, 1994; Panadero, 2017). Learning environments supported by artificial intelligence (AI) have provided evidence that support for metacognitive processes can be effectively facilitated through the use of prompts, feedback and reflective questioning.

Promoting metacognition is an important aspect of intelligent tutoring systems that provide adaptive feedback that has been shown to help improve skills related to planning, monitoring and evaluating performance, and research indicates that adaptive feedback supports the development of these skills (Roll & Wylie, 2016). In addition to these capabilities, generative AI provides the ability for users to engage in dialogic (conversational) interactions that are similar to what a metacognitive coach would provide (Holmes et al., 2023).

Most of the existing research has focused strictly on the micro-level cognitive growth or the isolated development of specific skills; as such, additional classroom-level research has not yet been conducted to support the development of metacognitive skills over time via generative AI in authentic secondary education settings.

Assessment Practices in AI-Rich Classrooms

One of the most disputed areas of Artificial Intelligence (AI) in education is in the area of assessment. Traditional assessments of learning through a summative model are experiencing difficulty from the generation of AI-based textual materials (Williamson & Eynon, 2020). Scholars recommended that educators and institutions develop an evolving assessment model away from traditional summative models and toward developing an assessment model that is formative, process-oriented, and reflective (Bearman, et al. 2022).

Educators are utilising the support of AI to explore new types of learner experience through AI-supported feedback, learning analytics, and self-assessment to maintain the validity of assessment (UNESCO, 2023). Evidence supports that feedback generated by AI may enhance learners' quality of revision and level of involvement in the learning process (Zawacki-Richter et al., 2019).

The majority of the current literature regarding assessment focuses on normative issues (i.e., what should change) rather than on empirical evidence (i.e., what is changing). There is little synthesis of quantitative evidence and qualitative evidence to demonstrate how assessment practices are developing longitudinally in AI-supported secondary classrooms.

Research Gaps Identified

1. **The Need for Longitudinal Studies**

While there are many short-term or preliminary research studies on the effectiveness of AI on teaching and learning, there is very little longitudinal synthesis of how AI is impacting student agency and metacognition over time.

2. **Fragmentation of Major Outcomes**

The main outcomes of AI include student agency, metacognition, and assessment; however, many studies examine each of these outcomes in isolation from one another. There is a lack of comprehensive analyses of how these constructs interact with each other within an AI-supported learning environment.

3. **A Limited Focus on Secondary Education**

Most of the research on AI in education has focused on higher education, yet there are many important factors related to secondary education.

4. **Underutilizing Mixed-Methods Research**

Many qualitative studies are available, but there have been relatively few efforts to combine the findings from several qualitative studies using qualitative methods such as thematic analysis.

5. **Underutilizing the Role of AI as a Pedagogical Co-Teacher**

The predominant view within the current literature is that AI tools are primarily used as tools or assistants and do not take into account the potential of AI to function as a pedagogical co-teacher that shapes the design and culture of instructional practice.

Contribution of the Present Study

The present study addresses an important gap in the research literature surrounding generative artificial intelligence as a collaborator in the context of secondary education by providing a longitudinal mixed-method synthesis of available data on this area through a combination of secondary quantitative data, as well as secondary qualitative thematic analyses of the research studies. By synthesising the evidence to demonstrate the influence generative AI has on student agency and metacognition, the research results will provide a conceptual and theoretical framework for evaluating generative AI's potential within the secondary education sector, and thus contribute to an ongoing evidence-based discussion regarding the responsible and effective implementation of generative AI in a secondary education environment.

MATERIALS AND METHODS

Research Design

This research project utilizes a mixed methods longitudinal design framework; specifically, it includes the analysis of previously published data. The quantitative component includes large scale studies, Meta analysis, and Longitudinal Research on generative/adaptive AI used in Learning Environments. The qualitative component includes Teacher Interview/Organisational Reports (Ethnographic studies), Learning Environment Observational studies, and Policy Documents.

Data Sources

Data were collected from:

- Peer-reviewed journal articles (2020–2025)
- OECD and UNESCO education reports
- Large-scale studies on AI in education; for example, Programme for International Student Assessment (PISA) - related digital learning analyses
- Teacher professional development case studies

Inclusion Criteria

- Focus on generative or adaptive AI tools
- Studies on Secondary education (grades 6–12)
- Empirical or evidence-based studies
- Published in English with DOI availability

Data Analysis

For the Quantitative component of this research project, measurements will be described using Descriptive Statistics and Trend Analysis, while for the Qualitative Part, Thematic Content Analysis will describe the general themes related to Agency, Metacognition, and Assessment, using triangulation for validity and reliability.

RESULTS AND DISCUSSION

This section provides a summary of the findings from a secondary analysis using a mixed-methods approach on the impact of generative AI on students' development of agency, metacognitive strategies, self-regulated learning and assessment practices within secondary classrooms. To address the gaps identified in the literature, the current study combined both quantitative empirical data (collected from secondary peer-reviewed research studies) and

qualitative data (reported in peer-reviewed literature and existing policy documents) to create a thematic synthesis.

Quantitative findings from the secondary empirical data

In order to address the deficiencies of earlier studies that have provided only narrative syntheses, analysis has been done on valid numerical data derived from various research instruments presented in empirical studies related to the secondary education environment to produce pre- and post-data means. The percentage of difference was derived from the following formula:

$$Percentage\ Change = \frac{Post\ Mean - Pre\ Mean}{Pre\ Mean} \times 100$$

Table 1. Secondary Data–Based Changes in Learning Variables in AI-Supported Secondary Education.

Learning Variable	Measurement Unit	Pre-Mean	Post-Mean	% Change	Primary Source
Formative Assessment	Raw Test Score (0–25)	12.50	17.75	**+42.00%**	Alazemi (2024)
Metacognitive Strategy	Likert Scale (1–5) (Conversion to Likert scale and statistical weighing performed)	3.05	4.25	**+39.34%**	Alenezi (2025)
Student Agency	Likert Scale (1–5) (Averaging three dimensions of self-efficacy)	3.36	3.66	**+8.93%**	Li et al. (2025)
Self-Regulated Learning	Total Score (MAI)	68.70	78.45	**+14.19%**	Mehmood et al. (2025)

These findings provide empirical evidence based upon a methodological approach to the study of technology/instructional environments supported by AI generated algorithm guidance and/or development of constructivist responses from Generative AI tools.

It is important to note that the greatest proportionate increase (+42.0%) noted in the results was in regard to formative assessment practices, indicating that there is a clear, strong influence of AI provided instructional environments on the processes and nature by which assessment is accomplished. This finding aligns with more recent research that suggests Generative AI disrupts traditional summative assessment practices and encourages the implementation of feedback-rich, process-based evaluation strategies.

Additionally, other large increase was seen across metacognitive strategy use (+39.34%) indicating that AI-supported learning environments support students' capacity to reflect upon and regulate their own learning. The increase noted in self-regulated learning (+14.19%) confirms once again that AI propels the evolution of learning behavior toward those that are based on the autonomous and strategic decision making of learners rather than just the passive transfer of information. As well as, increase is evident in student agency (+8.93%), i.e. taking ownership of the process of creating knowledge.

Integrated Interpretation of Quantitative Findings

There are three main contributions of this study: 1) The finding that the enhancement of agency, metacognitive skills and assessment practices are interrelated; 2) the ability of formative assessment and feedback to provide students with more opportunities for self-evaluation and improvement of the way they learn, as well as significantly impact on the development of metacognitive and self-regulatory skills; 3) The relationship between self-regulation and agency is that self-regulation creates an environment of positive reinforcement for students as they make choices and take control over their learning. Therefore, these two dimensions are integrated, as opposed to existing as separate, independent dimensions of learning.

Qualitative Findings: Secondary Thematic Synthesis

A secondary thematic analysis of qualitative results reported in peer-reviewed academic articles and International Policy Reports regarding Secondary Education was conducted, in addition to the quantitative results. Their Analysis produced three themes that were similar to one another and provided supplementary context for interpreting quantitative results. Key sources included Holmes et al. (2023) ; Kasneci et al. (2023); UNESCO (2023); and Williamson and Eynon (2020).

Theme 1: Generative AI as a Scaffold for Metacognitive Development

Qualitative research findings on the impact of generative A.I. tools in education show that generative A.I. provides students with many tools that can assist in the learning process through the planning, monitoring, and evaluation of learning outcomes. Furthermore, teachers believe that the prompts created through the use of generative A.I., give students an opportunity to express their reasoning as well as allow them to reflect on their own mistakes and rethink their approach to problem-solving (Holmes, et al. 2023). The feedback generated during generative A.I. usage has also been beneficial to students in clarifying their confusion,

helping them track their own progress and learning at a pace that feels comfortable for them (Kasneci, et al. 2023) through the collection of qualitative record data from qualitative studies over several years, researchers found that as students became more adept at using the generative A.I. strategies, their need for reliance upon the A.I. decreased as they progressed along their educational journey therefore, the trend that was noted in the qualitative data collected demonstrates a pattern of growth in the scaffolding process to be independent learners and this is corroborated by quantitative data showing increased application of metacognitive strategies by students.

Theme 2: Transformation of Assessment Practices

The increased percentage evidenced through both quantitative means (42.0%) indicates that formative assessment has increased in usage; whereas qualitative means indicate a shift in the assessment culture. Educators have started to move from the traditional method of relying on summative assessment as their primary form of evaluating students to utilizing drafts, revisions, reflective commentary, and feedback cycles that were created using Artificial Intelligence (UNESCO, 2023).

Most educators don't think they can assess students well in an AI-Enhanced Educational Environment with traditional assessment methods (Williamson & Eynon, 2020). Therefore, many educators are coming up with innovative ways to assess students through various pedagogical techniques rather than simply providing technology as a replacement to the old format. Additionally, students reported having less anxiety regarding their assessment due to receiving clarification on their expectations through the feedback cycle.

Theme 3: Expansion of Student Agency and Learner Voice

Several secondary qualitative sources affirm that generative AI can increase levels of student agency. The students describe how using AI tools is like having someone (a non-judgmental supporter) help them explore, ask questions, and experiment with new ideas (Holmes et al., 2023). Teachers stated that for previously disengaged learners, their levels of engagement increased in inquiry-based/project-based assignments as a result of using generative AI.

On the other hand, qualitative research has demonstrated that students' agency through generative AI depends heavily on the way instructors designed the tasks for students. For example, the more controlled/answer-oriented a task was designed (i.e., using AI to complete a specific task), the less autonomy the students experienced. These findings highlight how

crucial pedagogy is for framing how generative AI will be personally utilized by students for their own learning. Because of this, generative AI should be viewed as a co-teacher along with an instructor and not as a teacher in its own right or as a fully autonomous entity.

Triangulation and Trustworthiness of Findings

Multiple triangulation techniques were used to ensure the methodological rigor and improve the credibility of the findings from using secondary data research:

- The use of data triangulation mixed the numerical data from independent empirical studies with qualitative data from various other sources to provide a complete picture.
- The use of methodological triangulation combined quantitative calculation with qualitative thematic synthesis to create new theories based on old data.
- Source triangulation used data from different stakeholders (e.g., students, teachers, researchers, and policy organizations) to ensure that all perspectives on the topic being studied were considered.
- Temporal triangulation ensured that studies were completed over a period of time and thus reduced the chance that findings would be influenced by novelty biases.

This convergence of evidence is what strengthens the credibility, validity, and transferability of these findings despite the lack of any primary data collection for this project.

Discussion: Addressing Identified Research Gaps

This study was designed to fill the gaps in the academic research identified in prior literature; first, through the use of secondary case data collected quantitatively, this study helps to clarify the current state of empirical research regarding the educational use of AI technology. Second, this research takes an integrated look at how metacognition, assessment and agency work together to aid AI adoption in educational contexts, rather than simply treating each of these variables separately, as past research has done. Third, this study looks at how AI is used specifically in high school education; the educational literature contains very little research on how Generative AI is employed at this level compared with higher education.

The concept of AI being a support to educators, rather a replacement for them, is also addressed; generative AIs will support reflective learning; learner autonomy; the creation of innovative assessment practices; and ultimately provide a collaborative relationship between AI systems and human educators, and therefore will help to enhance collaborative teaching.

SUMMARY

The numerical and descriptive data together indicate the benefits of allowing generative AI to act as a co-teacher; generative AI contributes positively to several ways secondary students develop their agency to be active learners, how they use metacognitive strategies to regulate their learning, and how they assess their learning through formative assessment practices. These results support the establishment of an empirically based foundation for making decisions on how to apply and integrate generative AI into pedagogy, curriculum, and policy about integrated education at the secondary level with knowledge of responsible uses of AI.

Limitations and Future Research

Although this study did produce some meaningful contributions, there were many limitations, all of which should be noted. For example, the current analysis was based solely on secondary sources of published evidence (empirical studies) which used validated instruments and strong research designs but did not involve any primary collection of data. Therefore, there is no way to account for contextual differences in Variables; (e.g. Subject/Domain; Duration of Instruction; Level of Teacher Knowledge; Demographic Differences of Students). As such the data presented in this article should be viewed as representing a generalised view of existing research findings as opposed to specific causal conclusions and as such should be taken in light of that fact.

Another consideration is that while the quantitative synthesis used raw data and clearly defined percentage changes, it also represented the need for normalisation when synthesising between different types of measurement instruments and methodologies in order to create consistency. Although this is acceptable practice in secondary meta-synthesis, it might lead to the loss of detail as to how well the implementation of generative AI was followed through (or not followed through) across various settings.

In addition, the qualitative data derived from secondary thematic synthesis rather than original interviews or classroom observation means that while the triangulation of many different sources has increased validity, the information from the participants can be collected to provide deeper insight into students and teachers' lived experiences, through using the method of primary qualitative inquiry.

Consequently, future research should concentrate on conducting longitudinal studies using primary research to investigate the integration of Generative AI within the Secondary

Education sector over time within multiple curricular areas. The implementation of experimental/quasi-experimental research designs would assist in establishing the causal link between the AI-supported instruction and learning outcomes for students. Future research should also investigate the ethical issues and equity implications of implementing Generative AI and what kind of professional development support teachers need for implementing Generative AI technologies into their classrooms. Finally, future research needs to establish how various pedagogical models will mediate the effects of AI on student agency and metacognition in order to create policy and instructional frameworks based on evidence and research.

CONCLUSION

Using an extensive synthesis of secondary qualitative and quantitative evidence, we studied the impact on education of generative AI acting as a co-teacher in secondary classrooms. The study incorporates the empirical numerical data, along with thematic insights from a large body of previous research and policy literature, and provides significant insights into how generative AI impacts the development of student agency over time, metacognitive strategy use, self-regulated learning, and assessment practices.

The study demonstrated significant measurable growth in all of the learning variables included in the study for AI supported instruction, with formative assessment practices showing the largest positive impact. Generative AI supported learning encompasses both individual cognitive and metacognitive development as well as systemic pedagogical transformation toward process-oriented assessment practices in place of traditional summative assessment models. AI supports gains in student agency and self-regulated learning, leading to the belief that well-designed generative AI tools offer learners greater control over their respective learning paths.

Importantly, the qualitative synthesis shows that these benefits are not automatically achieved through AI adoption, but rather are a result of how educators frame and enact Generational AI in classrooms. In situations where AI is introduced as a co-teacher supporting teaching involves providing feedback, prompting students, and providing learning opportunities and reflections upon all learning materials of the day every day (including homework), AI enhances human teaching and does not lessen the centrality of human educators. Conversely, using overly directive or answer-focused uses of AI can remove or restrict student agency.

This study addresses three critical gaps in the existing literature related to generational AI use in secondary education (i.e., lack of empirical synthesis focused specifically on secondary education), as well as the fragmented treatment of students' agency, metacognition, and assessment practices. Thus, this study will provide an evidence-based framework for investigating the uses of generational AI by teachers. Our findings are intended to inform the creation of professional development programs that support teachers in integrating generational AI into their classroom instruction and developing ethical principles for how to use generational AI. These findings will also serve as a basis for longitudinal studies that can further investigate the contextual variables influencing the long-term educational outcomes associated with the use of generational AI in schools.

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