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Artificial Intelligence Empowers Primary School Students' STEM Education: A Review of Independent Learning Interests in Hong Kong, 2024–2025

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Abstract:

Educational equity is an emphasis of the United Nations. Usually, due to the economic backwardness in remote areas, serious educational inequality problems still exist, especially in some developing countries, including China. Through accompanying learning and answering questions, it helps alleviate the problem of insufficient educational resources for students in remote areas and further enhances students' autonomous learning ability. However, even educational. Therefore, in this study, the systematic review method was adopted. Based on the summary of 12 core literature screened out, it was found that the primary stem research was conducted in Hong Kong. The results show that it can help enhance students' autonomous learning ability and provide timely personal feedback, thereby improving students' autonomous learning ability. However, in the future, it is necessary to set a reasonable scope for their use during their learning process. This study is the latest summary of research on the management of software use in the field of education in Hong Kong.

Keywords: Artificial Intelligence; Primary School Students; STEM Education.

1. Introduction

Since 2015, the United Nations has formulated 17 Sustainable Development Goals, among which 4 are most closely related to education, aiming to promote „inclusive and equitable quality education" [1]. However, research has found that schools in remote and poverty-stricken areas of many countries lack high-quality educational resources, making it impossible for local students to access educational equity [2]. Mathematics), are expected to address such challenges [3]. For instance, through intelligent robots and online learning platforms, educational conditions in marginal areas can be improved [4].

At present, the application of enhanced educational quality. Specifically, tools can adjust teaching content based on students' learning levels and interests, laying a solid foundation for their subject studies in primary and junior high schools. Meanwhile, it can

conduct real-time monitoring and analysis, which is conducive to helping students identify learning difficulties as early as possible, achieve personalized tutoring, and enhance students‘ autonomous learning ability [4].

Given the potential contribution of courses [5]. As one of the global education centers, Hong Kong has always attached great importance to the development of basic education and emphasized talent cultivation and scientific research output. Correspondingly, STEM has been positioned by the government as a core strategic deployment to maintain Hong Kong‘s status as an „international education center“ and a „smart city“. Especially since 2015, the Education Bureau of Hong Kong (EDB) has clearly defined education as a key educational reform direction for „enhancing Hong Kong‘s global competitiveness“ [6]. Although no relevant policies on the use of research are in place, there is an interdisciplinary integration to promote students‘ knowledge integration and innovative thinking in multiple fields. It is proposed that education should utilize technology and create and solve problems [7]. It is expected that in the future, technology and the integration of students‘ autonomous learning will be introduced. Therefore, it is of great significance to review the current application status of the curriculum in Hong Kong, the challenges it faces, and its future development direction.

For instance, Wang and Keung Cheng employed questionnaires and semi-structured interviews to understand the views and practical experiences of students‘ interests [8]. At the same time, by integrating the observation method, policy analysis education is conducted together. Research has found that schools and educators generally believe that age-appropriate technology is a feature of a future technological society.

Chng, Tan, in different primary school education scenarios. The potential and debating abilities. Research has found that most current studies emphasize that immersive technologies and AI can help students enhance their scientific self-efficacy [9].

However, most of the current literature consists primarily of case studies, with only a few being review papers. There is a lack of research specifically focused on how AI tools can be integrated into primary school STEM education. This is precisely the research gap that this paper aims to fill. Specifically, this study systematically reviews all Hong Kong primary STEM studies from 2024 to 2025 to assess the contribution and potential of AI technology in enhancing primary school students‘ self-directed learning. This study is expected to serve as a foundation for future research in the field of AI-enabled STEM learning in primary schools.

2. Methodology

This study used a systematic review approach to analyze the application of Large Language Models (LLMs) in enhancing self-directed learning in primary school students. The analysis focused on two specific perspectives: a) Which LLM-based AI tools, such as ChatGPT, are being used in primary education? b) How do these tools impact self-directed learning (motivation, strategies, and outcomes)?

Following the PRISMA process, a search was conducted on Google Scholar using four keywords: „STEM Education AND Large Language Model AND self-directed learning AND Hong Kong.“ Considering that Hong Kong began prioritizing the application of AI technology in STEM research in 2022, the literature search was conducted from 2022 to 2025.

Among all search results, this study‘s inclusion and exclusion criteria were: Primary school-level LLM tools, used for self-directed learning, and with educational data. Exclusion criteria included articles that focused solely on algorithm improvement without student/teacher application, as well as review articles.

A total of 206 articles were found, of which 12 met the criteria of both addressing the primary school stage of STEM education in Hong Kong and addressing the core application of LLM tools in the AI field.

The author coded and analyzed all selected core literature. Based on the research question, „The impact and role of AI on primary school students‘ autonomous learning,” the literature was categorized into three types:

1) Technology Type: ChatGPT, other LLM tools (Claude, Bard), and AI-assisted platforms;

2) Learning Dimension: Motivation for autonomous learning, strategies (planning/monitoring/reflection), and learning outcomes;

3) Implementation Value: Improving existing methods (faster feedback/more personalized learning) and transforming learning models (students becoming active learners, AI serving as cognitive partners).

For each core literature, we categorized the literature according to these code types in an Excel spreadsheet and extracted and recorded key code-related content. These compiled results served as materials to answer the research questions.

3. Literature Review and Thematic Analysis

3.1 Application Types of AI Tools Based on LLM in Primary Education

First, regarding the current LLM tools used in Hong Kong

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STEM primary education research, they include ChatGPT, Claude, and Bard. These tools primarily help students create a question-and-answer interactive space during the learning process, quickly acquiring the desired learning information and thus improving their independent learning and self-correction abilities.

Among these 12 core studies, almost every one explored the application of ChatGPT in primary education. Dai et al. found that LLM tools such as ChatGPT, Claude, and Bard can provide students with personalized learning support and language proficiency improvement through natural language processing and generation, especially in English as a foreign language (EFL) teaching [10].

Dimitriadou and Lanitis argue that ChatGPT can be widely used to generate teaching materials, assist in answering questions, and provide interactive learning support [11]. At the same time, the AI-assisted platform combines multimodal functions to support multimedia teaching such as graphics, text, and animation, enhancing students' understanding and participation. Lee et al perform multimodal (including image and video) analysis to support classroom observation and teacher analysis [12]. ChatGPT's applications in teaching mainly include automatic content generation, assisted programming, data analysis, and academic writing support. Similar conclusions were found in Wei et al. and Dylan Edward Moore et al [13,14]. The study found that ChatGPT's generative artificial intelligence (GAI) technology provides students with open and structured question-and-answer interactions through natural language processing APIs, supporting personalized learning experiences. The AR environment integrates multimodal representation (text, voice, 3D models, gestures, and facial expressions) and LLM-based dialogue functions to form a multifunctional teaching agent (GPA) with high-quality, realistic human images, covering multiple roles such as teacher assistant, guide, and dialogue partner [15].

Rahman et al. further emphasized that AI-assisted education platforms can serve as teaching assistance tools, supporting personalized learning plans, classroom assessment, feedback generation, and language translation, providing real-time assistance to students and teachers [16].

Li et al. not only studied but also explored multiple tools, including large language models (such as AI Chatbot, corresponding to something similar to ChatGPT), AI Art generation tools (AI Art Lab), and AI Music creation tools (AI Music Studio). It is pointed out that all these belong to natural language processing and multimodal interaction. In future studies, students should be encouraged to use AI for question clarification and homework tutoring. At the same time, the visual and musical content generated by AI should promote interdisciplinary learning and expand the application to build an AI-assisted platform [17].

Zhu et al. Research indicates that AI-assisted platforms, such as Qwen2.5, are used for educational resource recommendation, EduChat is a customized model for education, and MathGPT is used for solving complex mathematical problems. These technologies are gradually being adopted in STEM primary education in Hong Kong to meet diverse teaching needs.

3.2 The Impact of AI Tools on Autonomous Learning Motivation

These LLM tools, based on the current research progress, indicate that in research in Hong Kong, these tools as a whole are encouraged by the teaching system for students to use. In promoting the direction of students' autonomous learning, they mainly have two motivational influences, including a) stimulating learning interest and b) personalized feedback [14].

Dylan Edward Moore et al., 2024 Research finds that AI tools stimulate students' interest in STEM subjects and intrinsic learning motivation by introducing fun and interactivity. Especially through interactive learning experiences, enhance the sense of participation and motivation [10]. Dai et al.'s study further explains the reasons why LLMs can enhance students' autonomous learning ability. Mainly because the „humanized" interaction between AI chatbots and LLMS enhances students' interest and confidence in learning and stimulates their autonomous learning motivation [13]. Wei et al.'s study further confirms this view on this basis, pointing out that LLM tools like ChatGPT enhance students' interest and learning engagement by introducing highly interactive and vivid digital human teaching agents (such as DongDong), and stimulate continuous learning motivation.

The studies of Lee et al. and Zhu et al. both emphasize that LLM tools can enhance students' learning interest and intrinsic motivation through immediate and precise feedback. And through personalized responses and guidance, AI helps students participate in the learning process more actively [12,17]. Li et al.'s study explores the application of LLM tools in students' autonomous learning from the perspective of teachers [16]. It points out that many teachers recognize AI tools as „24/7" tutoring resources to stimulate students' interest in self-exploration and learning. Especially, low-income students lacking family support can also obtain assistance through AI to enhance their learning motivation. Rahman et al. also reached a similar conclusion [15]. The research found that ChatGPT enhances students' learning enthusiasm and autonomy by answering students' questions in a timely manner, simplifying complex knowledge points, and providing personalized suggestions.

3.3 . AI tools support for autonomous learning

strategies

Based on the content of Sections 3.1 and 3.2, we have currently understood the benefits of the primary education stage in Hong Kong, and have also received support at the teacher level. However, regarding how to correctly use tools to promote the improvement of autonomous learning ability, correct strategies are still needed for guidance. This includes discussions on aspects such as learning plans and monitoring, reflection and correction, and cooperative learning.

Dai et al.‘s research indicates that students can promote their planning, monitoring, and reflection abilities in learning through stages such as Empathize, Define, Ideate, Prototype, and Test based on the EDIPT model [10].

Dimitriadou and Lanitis argue that Gen-AI supports students in effectively self-regulating and applying strategies during learning, by helping them plan their learning and monitor their progress [11]. Lee et al. and Dylan Edward Moore et al. further the importance of metacognitive strategies such as planning, monitoring, and reflection [12,14]. They emphasized that AI systems like VidAAS support student and teacher reflection, promoting „reflection-in-action“ and „reflection-on-action.“ Specifically, AI-assisted tools help students plan learning tasks, detect programming errors, and optimize solutions, supporting self-monitoring and reflection during the learning process. In this study, from the perspective of the 5E learning model, the implementation plans, monitoring, and reflection strategies of AI teaching agents for students‘ learning at each stage were explored, such as helping students adjust and deepen their understanding through immediate feedback [13].

Li et al. pointed out from the perspective of teachers that the AI prompt evaluation guidance function can help students raise questions more accurately, promote the improvement of logical reasoning and metacognitive abilities, and thereby support the planning, monitoring, and reflection links in students‘ learning [16]. The studies of Dylan Edward Moore et al. and Zhu et al. also indicate a similar view that AI-assisted learning includes the planning, monitoring, and reflection stages of learning [17]. For instance, an intelligent question-answering system can not only answer questions but also prompt students to reflect through multiple rounds of dialogue, stimulating thinking by adopting the Socratic questioning method.

3.4 Impact of AI Tools on Learning Outcomes

The impact of LLM tools on learning outcomes in Hong Kong STEM primary schools is primarily reflected in three aspects: academic performance, critical thinking, and long-term outcomes.

First, regarding academic performance, Dylan Edward Moore et al. found that the immediate feedback and personalized guidance provided by AI tools improved students‘ learning outcomes and the speed of knowledge internalization [14]. Wei et al. demonstrated through experiments that combining AR with GAI agents significantly improved students‘ scientific knowledge and academic performance, while also reducing cognitive load, indicating enhanced learning outcomes [13].

Secondly, in terms of critical thinking, the research by Zhu et al. pointed out that AI technology promotes efficient learning, supports understanding and knowledge acquisition through rapid feedback and personalized guidance, and helps improve learning outcomes [17]. Li et al. further pointed out that through the immediate feedback of AI and diverse learning materials, students can carry out projects more effectively, such as design, creation, and other activities, promoting the development of deep learning and innovation capabilities [16].

Finally, in terms of long-term effectiveness, although the experimental and survey studies by Dai et al. Lee et al. and Rahman et al. all demonstrate that AI-powered feedback and language practice can provide students with rapid and targeted feedback, improving learning outcomes, language skills, and the development of higher-order thinking, students should avoid over-reliance on technology in the long term, strengthen assessments of affective and cognitive aspects, and improve the accuracy of LLM tools themselves and address issues such as information illusions [10,12,15].

Overall, current research on STEM education in Hong Kong‘s primary schools highlights the diverse applications of ChatGPT in education, such as generating course materials, providing feedback, and generating assessment tasks. While other LLM tools (such as Claude and Bard) are also discussed, the overall discussion explores the technological advancements and multimodal capabilities of LLM tools and recognizes the potential for AI-assisted platforms. Most studies confirm that LLM tools like ChatGPT can promote self-driven learning, support personalized instruction and self-paced learning, and effectively enhance learning motivation, particularly in resource-limited settings. In particular, it can combine multiple educational models to support students‘ timely reflection and feedback during the autonomous learning process, which helps them to self-monitor their learning outcomes and adjust their learning strategies.

However, based on the current application results, ChatGPT improves learning efficiency through real-time feedback and personalized suggestions, supporting multiple fields such as language learning and mathematics learning. Experiments have shown that it can enhance academic performance and self-confidence. However, it should be noted that as a cognitive partner, ChatGPT can

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enhance the accuracy of its own knowledge while encouraging students to become active participants in learning and supporting collaborative learning and emotion recognition, which is a challenge that needs to be improved in the future. It is necessary to enable AI technology to play a multi-dimensional role in educational implementation under the guidance of correct learning methods, helping students form a dynamic and benign ecological environment for autonomous learning.

4. Conclusion

Overall, this study used a systematic review approach to collect and analyze research from the past three years on the progress and challenges of AI applications in STEM education in primary schools in Hong Kong. Four key findings emerged: First, to date, research on the application of LLM-based AI tools in primary education has primarily focused on machine learning platforms/software, particularly ChatGPT, as well as other tools like Claude and Bard. These tools typically use natural language processing and generation to provide personalized learning support for students, including language learning and mathematics. Second, all ten core studies found that LLM AI tools like ChatGPT can enhance student learning interest by providing timely answers to student questions and simplifying complex knowledge points. Furthermore, they can provide personalized suggestions based on students' learning abilities and daily questions, further enhancing student autonomy in learning.

Thirdly, in the research on primary school students in Hong Kong so far, although it has been confirmed that tools can promote the improvement of autonomous learning ability, it is necessary to do so under the premise of providing correct strategic guidance, especially in the formulation of learning plans, monitoring, reflection, and correction, and cooperative learning. education students in Hong Kong primary schools, particularly in terms of students' academic performance, critical thinking, and long-term outcomes. Specifically, in terms of academic performance, through personalized guidance, students' cognitive load is effectively reduced, and their learning outcomes and the speed of knowledge internalization are enhanced. In terms of critical thinking, it is found that students can make use of the diverse learning materials provided by AI's real-time feedback, which is helpful for them to conduct some critical thinking management training and promote the development of deep learning and innovation capabilities. In terms of long-term effectiveness, in the future, students are encouraged to use it for autonomous learning. However, it is necessary to regularly update the accuracy and information illusion issues of the tools themselves, and call on students to avoid excessive reliance on technology.

This study provides valuable insights into expanding the use of AI tools for STEM learning in primary schools in Hong Kong. a timely summary of Hong Kong's current developments. This research is expected to serve as a basis for review and provide a reference for Hong Kong's education authorities to formulate policies or plans to further encourage the use of AI tools.

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