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Article

How does artificial intelligence promote teaching innovation in basic education? Teaching experience from Macau, China

Sio Hong Teng[†], **Fat Fai Ieong**[*†]

Faculty of Humanities and Social Sciences, Macao Polytechnic University, Macao 999078, China
*** Corresponding author:** Fat Fai Ieong, i9691393@yahoo.com.hk
[†] All authors contributed equally.

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Abstract: Artificial intelligence has transformed teachers' teaching models. This article explores the application of artificial intelligence in basic education in Macao middle schools. This study adopts case analysis in qualitative research, using a total of eight cases from the innovative technology education platform of the Macau education and Youth Development Bureau. These data illustrate how Macao's artificial intelligence technology promotes teaching innovation in basic education. These eight cases are closely related to the application of artificial intelligence in basic education in Macao. The survey results show that Macao's education policy has a positive effect on teaching innovation in artificial intelligence education. In teaching practice, the school also cooperates with the government's policy. The application of AI technology in teaching, students' learning styles, changes in teachers' roles, and new needs for teacher training are all influential.

Keywords: Macau; artificial intelligence; basic education; case analysis

1. Introduction

1.1. Artificial Intelligence in education: Global perspectives

In 2019, the United Nations educational, Scientific and Cultural Organization (UNESCO) released "Artificial Intelligence in education: Opportunities and Challenges for Sustainable Development", emphasizing that artificial intelligence can help humans improve learning outcomes (Pedro, 2019). In 2021, the Macau SAR Government of China promulgated the Macau SAR Medium and Long-term Plan for Non-Higher education (2021–2030). In the planning report, the Macau Government emphasized the need to strengthen the education of students in artificial intelligence literacy (Macau education and Youth Development Bureau, 2021). In 2023, the American Higher education Information Technology Association released the 2023 Horizon Report (Teaching Edition), which listed artificial intelligence as one of the six key technologies and practices that will have a significant impact on future education and teaching (Horizon Report, 2023). Therefore, we can find that the practice of artificial intelligence in the field of education is very important.

1.2. Characteristics of research on Artificial Intelligence in education

In recent years, the "double reduction" policy, core literacy, STEM education, artificial intelligence education, etc. have put forward new requirements for primary and secondary education and teaching. The most direct manifestation of this application in education is the transformation of teaching models. Based on the analysis of literature related to the application of artificial intelligence in education in

recent years, this study summarizes the characteristics of research on the application of artificial intelligence in education as follows: from the perspective of research subjects, most of the relevant research is concentrated in universities and enterprises; from the perspective of research objects, students (Dai et al., 2020) and teachers (Baidoo-Anu and Ansah, 2023; Mollick and Mollick, 2022), employees of enterprises (Yang, 2022); from the perspective of research methods, empirical research (Ramírez-Noriega et al., 2017), applied research (Duzhin and Gustafsson, 2018), and strategic research (Borges et al., 2021) mainly; from the perspective of research fields, it is mainly concentrated in technology (Bouali et al., 2019; Radianti et al., 2020), patterns (Belpaeme et al., 2018) and practice areas (Winkler-Schwartz et al., 2019); from the perspective of research topics, deep learning is formed (Sejnowski, 2020) , machine learning (Popenici and Kerr, 2017), smart education (Chen, et al., 2020), personalized learning (Bhutoria, 2022), learning analysis (Ouyang et al., 2023), educational big data (Luan et al., 2020), basic education (Ogunode and Ejike, 2023) and other research topics. When Ma and Zhang (2019) conducted research on the application of artificial intelligence in basic education, he found that: the research on basic education mainly focuses on using learning computing models for computing education, collecting educational data, conducting mining and evaluation, establishing educational motivation systems, and developing new basic education systems in the future, etc..

1.3. Policy requirements in Macao

In 2021, the Macau SAR Government of China promulgated the Macau SAR Medium- and Long-term Planning for Non-Tertiary education (2021–2030). In the planning report, the Macau Government emphasized the need to strengthen the education of students in artificial intelligence literacy (Macao education and Youth Development Bureau, 2021).

1.4. Case study motivation

Based on this, this study found that there are relatively few case studies on the application of artificial intelligence education in basic education. Therefore, this study aims to verify whether the current application of artificial intelligence in education in Macao is in line with the policy provisions of "Strengthening the education of Students' Artificial Intelligence Literacy" in the Macao Special Administrative Region's Medium- and Long-term Planning for Non-Tertiary education (2021–2030). Thus, this study will also analyze eight cases from the innovative technology education platform of the Macao education and Youth Development Bureau.

2. Literature review

2.1. National policies on Artificial Intelligence in education

In 2017, the Chinese government launched the policy of "New Generation Artificial Intelligence Development Plan", which pointed out the development direction of "artificial intelligence + education" (Xinhua News Agency, 2017). In 2019, the Chinese government launched "China education Modernization 2035", a policy that states that modern information technology should be fully utilized in the teaching

of primary and secondary school courses. The main artificial intelligence-related technologies used in the field of education include: computational thinking (Dl Olmo-Muñoz et al., 2020), machine learning (Popenici and Kerr, 2017), computer vision (Abdrakhmanov et al., 2024), etc.

2.2. Macau's emphasis on AI literacy education

In 2021, the Macau government also emphasized the need to strengthen the education of students' artificial intelligence literacy (Macau education and Youth Development Bureau, 2021).

2.3. The impact of AI technology on teaching methods

In 2022, the Chinese government launched a notice on compulsory education curriculum plans and curriculum standards. It is pointed out in the new curriculum plan to explore the changes in learning environment and methods under the background of new technology (Ministry of education, 2022). The impact of AI technology on students' learning methods is mainly reflected in: from traditional offline courses to the combination of online courses and offline courses; from traditional standardized courses to student-oriented personalized courses; in traditional teaching Integrate artificial intelligence technology (Yang and Ye, 2022). The smart education model has gradually matured, and teachers from different disciplines often use it in teaching. Liu (2024) found in her research that artificial intelligence can improve the teaching effect of college mathematics. Zhao and Liu (2022) found in a teaching case study on the cross-integration of high school mathematics and artificial intelligence that artificial intelligence can help students master mathematics knowledge. When Li and Liu (2024) studied the application of ChatGPT in junior high school mathematics teaching, he found that: artificial intelligence can help teachers clarify teaching goals, improve teaching design, assist in teaching evaluation, etc. The role of teachers has changed from one-way knowledge transfer to in-depth guidance and human-machine collaborative education (Zhang ang Yu, 2023). AI technology has put forward new demands for teacher training, such as: improving teachers' teaching abilities; improving the inclusiveness of teachers' teaching abilities; and strengthening two-way communication between teachers and students (Zhang et al., 2023). AI technology also improves the possibility of human-machine collaborative education (Huang et al., 2023) and intelligentizes teachers' teaching evaluation (Zhou et al., 2024). However, artificial intelligence technology still has many problems in smart education, such as: student privacy and security; the algorithm is not transparent enough; there may be coordination problems when teachers, students, and machines collaborate in education; artificial intelligence may be inconsistent with STEM education teaching situation, etc. (Chen, 2024).

3. Methodology

This study focuses on eight cases from the education and Youth Development Bureau of the Macau. This study conducts a case analysis of the 2021 Macau artificial intelligence education and teaching case display event. The reason for selecting these cases: It is a pilot plan of the Macau government to launch artificial intelligence

education courses in some schools in Macau through the education Development Fund, and then select one of the outstanding teaching cases (Macau Convention and Exhibition Economic News, 2021). This case is of great significance to the artificial intelligence teaching design in Macau.

These eight cases are from the artificial intelligence education and teaching case display activities of the Innovation and Technology education Platform of the Macau education and Youth Development Bureau (Macao education and Youth Development Bureau, 2021).

The chosen data analysis method was thematic analysis (see **Table 1**), which allowed the findings to be grouped into commonalities or "most common" forms, as noted by Guest et al. (2012). Although content analysis is a common data collection method in qualitative research, thematic analysis is useful for analyzing and understanding the data (Deale and Lee, 2021; Guest et al., 2021). This study is also used to understand teachers' perceptions and attitudes towards artificial intelligence teaching and artificial intelligence teaching models.

Table 1. Thematic analysis framework of eight cases.

Analyze topics	**Subtopic**		
Application of AI technology in teaching	Teaching objectives	Teaching methods	Teaching content
The impact of AI technology on students' learning styles	Learning objectives	Learning methods	Learning results
New changes in the role of future teachers due to AI technology	Teaching objectives	Teaching methods	Teaching effects

4. Results and discussion

The application of artificial intelligence has penetrated all aspects of modern society and people's daily lives and has been integrated with the fields of mathematics and education. The cases selected for this study found that Macao's education policy has a role in promoting teaching innovation in artificial intelligence education. In teaching practice, teachers' educational methods are not only conducive to stimulating students' interest in learning mathematics, etc., but also conducive to stimulating students' interest in learning artificial intelligence. When conducting interdisciplinary teaching in the classroom, we must first consider the closeness of the integration of the subject with artificial intelligence knowledge as well as the students' knowledge level and cognitive ability. Thus, attention should also be paid to the rationality and interest of the cases so that students can not only learn knowledge but also realize the application value of artificial intelligence.

4.1. Application of AI technology in teaching

In eight cases, teachers clearly understood that their teaching goal was to increase students' interest in artificial intelligence, and therefore clearly explained the relationship between artificial intelligence and the subject during the teaching process. Teachers also combine AI with STEAM and daily life cases for teaching, so that students can actively think about how to use AI and other skills to solve life problems and improve the quality of life.

4.2. The impact of AI technology on students' learning styles

In eight cases, students could feel the integration of artificial intelligence technology into teaching. This allows students to explore the principles of artificial intelligence during the learning process, thereby cultivating their thinking habits by integrating the subject with basic knowledge in smart speech, computer vision, natural language processing, etc., helping to improve students' ability to better understand these relationships, improve their problem-solving abilities, and thereby improve their learning effectiveness. Teachers have also transformed traditional standardized courses into student-oriented personalized courses.

4.3. New changes in the role of future teachers due to AI technology

In eight cases, it can be found that the one-way knowledge transfer has shifted to guidance. However, human-machine collaborative teaching still needs to be strengthened.

4.4. AI technology's new demand for teacher training

In eight cases, it can be found that AI technology has improved teachers' teaching abilities, improved the inclusiveness of teachers' teaching abilities, and strengthened two-way communication between teachers and students.

4.5. Problems of AI technology in education

In eight cases, it can be found that the class size is large and the teacher may not be able to pay good attention to all students. This issue can be attributed to several factors. For instance, limited teaching resources may make it difficult for teachers to manage large classes effectively. Additionally, variations in teacher quality can impact their ability to handle large class sizes. Students' diverse backgrounds and learning abilities can also pose challenges in a large class setting.

To address this problem, specific solutions can be implemented. For example, schools could consider dividing large classes into smaller groups for more personalized instruction. Teachers could also utilize AI tools to monitor students' progress and provide individualized feedback. Moreover, professional development programs for teachers could focus on strategies for managing large classes and incorporating AI in teaching.

4.6. Case comparative analysis

By analyzing these eight cases, similarities and differences can be found. In terms of student learning effects, different teaching methods show varying degrees of impact. Some methods may be more effective in enhancing students' understanding and retention of knowledge. In terms of interest arousal, certain methods may be more successful in capturing students' attention and stimulating their curiosity. For the cultivation of problem-solving abilities, different teaching strategies will bring different results. For example, some cases involving practical applications of artificial intelligence in daily life appear to have a more significant impact on students' problem-solving abilities. Through this comparative analysis, the depth and systematicness of the research are enhanced.

Overall, this article has significant advantages in terms of education policy integration, case richness, multi-angle impact analysis, and forward-looking perspectives. It provides valuable experience and theoretical support for the innovative application of artificial intelligence in basic education, and provides an important reference for subsequent research and practice.

5. Conclusion

This study provides Macao's experience with how artificial intelligence promotes teaching innovation in basic education. These experiences can supplement research on the combination of basic education and artificial intelligence teaching. These experiences also prove that the Macau government strengthens the education of students' artificial intelligence literacy (Macau education and Youth Development Bureau, 2021). Firstly, it focuses on Macao's specific educational context, providing insights that may not be available from studies. Secondly, the in-depth analysis of eight cases offers detailed understanding of the practical application of artificial intelligence in education. This research contributes to future studies by highlighting the importance of considering local factors such as education policy, teaching resources, teacher quality, and student background. It also suggests areas for further research, such as exploring more effective ways to manage large class sizes and enhancing human-machine collaboration. However, if the class size is large, there may be a problem that the teacher cannot pay good attention to all students, which deserves attention. In this study, the application of AI technology in teaching is consistent with the research by Li and Liu (2024), Liu (2024), Zhao and Liu (2022), and others. The impact of AI technology on students' learning styles is consistent with the research of Yang and Ye (2022). The new transformation of AI technology in the role of future teachers is consistent with the research of Zhang ang Yu (2023). The new demands of AI technology for teacher training are consistent with the research of Zhang et al. (2023).

The results of this study show that Macao's education policy has a positive effect on teaching innovation in artificial intelligence education. In teaching practice, the school also cooperates with the government's policies. This research suggests that research on the three-dimensional collaborative learning mechanisms of teachers, students, and machines can be strengthened, as well as increasing the possibilities of human-machine collaborative education and making teachers' teaching evaluations intelligent.

Future direction

In order to strengthen the work of artificial intelligence in the field of education, subsequent researchers can strengthen the study of the interaction dynamics between teachers, students and AI. This research should be a longitudinal study, conducted by observation and analysis methods.

In terms of teacher training, researchers can design targeted training programs based on different teaching environments and learner needs. For example, seminars and workshops can be organized to provide teachers with practical experience in using relevant technology tools. In addition, the education sector can also establish online platforms to support continuous learning.

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