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ORIGINAL

The application of AI-generated content in Macao's study tour context based on grounded theory

La aplicación de contenido generado por IA en el contexto del viaje de estudio de Macao basado en la teoría fundamentada

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ABSTRACT

Introduction: as a World Heritage City and a demonstration zone of "One Country, Two Systems," Macao is an important study tour center in the Guangdong-Hong Kong-Macao Greater Bay Area. Artificial Intelligence Generated Content (AIGC) has shown great potential in meeting Macao's diverse cultural education needs, but empirical research on its application models remains scarce.
Objective: to explore the practical application scenarios of AIGC in Macao's study tours and to construct a student-centered theoretical framework for AIGC application.
Method: this study was conducted from July 2023 to January 2025, employing a qualitative research method based on grounded theory. Data collection involved semi-structured interviews with 24 university students who had used AIGC in their study tours. Two researchers independently coded the data, with a coding consistency coefficient of 0,87.
Results: ten initial categories and five main categories were extracted from the data, forming a dynamic closed-loop mechanism for cultivating students' AIGC application abilities. This mechanism covers five stages: tool exposure, cognitive transformation, interactive advancement, practical output, and long-term maintenance.
Conclusion: the established framework enriches the theoretical research on AIGC educational applications and provides practical guidance for Macao's study tour industry, further enhancing Macao's status as a distinctive educational platform in the Greater Bay Area.

Keywords: Study Tour Instructor; AI-generated content; Grounded Theory; Digital Study Tour Practice.

RESUMEN

Introducción: como Ciudad Patrimonio de la Humanidad y zona de demostración del modelo "Un País, Dos Sistemas", Macao es un importante centro de viajes de estudio en la Gran Área de la Bahía de Guangdong-Hong Kong-Macao. El Contenido Generado por Inteligencia Artificial (AIGC) ha demostrado un gran potencial para satisfacer las diversas necesidades de educación cultural de Macao, pero la investigación empírica sobre sus modelos de aplicación sigue siendo escasa.
Objetivo: explorar los escenarios de aplicación práctica del AIGC en los viajes de estudio de Macao y construir un marco teórico centrado en el estudiante para su aplicación.
Método: este estudio se llevó a cabo entre julio de 2023 y enero de 2025, empleando un método de investigación cualitativo basado en la teoría fundamentada. La recopilación de datos incluyó entrevistas semiestructuradas con 24 estudiantes universitarios que habían utilizado el AIGC en sus viajes de estudio. Dos investigadores codificaron los datos de forma independiente, con un coeficiente de consistencia de

codificación de 0,87.
Resultados: se extrajeron diez categorías iniciales y cinco categorías principales de los datos, formando un mecanismo dinámico de ciclo cerrado para cultivar las habilidades de aplicación del AIGC en los estudiantes. Este mecanismo abarca cinco etapas: exposición a las herramientas, transformación cognitiva, desarrollo interactivo, resultados prácticos y mantenimiento a largo plazo.
Conclusión: el marco establecido enriquece la investigación teórica sobre las aplicaciones educativas del AIGC y proporciona orientación práctica para el sector de viajes de estudio de Macao, consolidando aún más la posición de Macao como plataforma educativa distintiva en el Área de la Gran Bahía.

Palabras clave: Instructor de Viajes De Estudio; Contenido Generado por IA; Teoría Fundamentada; Práctica de Viajes de Estudio Digitales.

INTRODUCTION

In recent years, Macao has become a distinctive study tour center in the Guangdong-Hong Kong-Macao Greater Bay Area (GBA) by virtue of its institutional advantages as a "World Heritage City"[1,2,3] and a demonstration zone of "One Country, Two Systems". This growth is due to the support of relevant policies. In order to cooperate with the central government's strategic planning, the Macao government has launched a number of measures, such as building Macao into an "education city"[4] and encouraging technological innovation in educational activities. Although specific local market data is still to be improved, the size of China's study tour market reached RMB146,9 billion in 2023 and is expected to exceed RMB300 billion by 2028.[5]

This background reflects the market's urgent need for high-quality study tour resources. Macao is committed to meeting this need through intelligent transformation. In this context, Artificial Intelligence Generated Content (AIGC) has become one of the important technologies in the field of study tours in Macao. It can effectively address the unique challenges posed by Macao's multicultural background and diverse educational needs. Unlike general digital tools, AIGC's capabilities in multilingual content creation,[6,7] scenario simulation,[8] and personalized customization [9] perfectly align with the characteristics of Macao study tours. For example, it can simulate Sino-Portuguese trade interactions through large-scale language models (LLM), create augmented reality (AR)-enhanced Macao "One Country, Two Systems" practice scenarios, and customize cross-border study tour routes connecting Macao with cities in the Greater Bay Area such as Zhuhai and Hong Kong. These applications not only simplify the development process of study tour resources, which has long been hampered by the limited number of local educational content development teams in Macao, but also enhance the interactivity and immersion of the learning experience, helping students to more intuitively understand Macao's unique culture and national positioning.

Although AIGC has great potential, its application in the field of Macao study tours is still in the exploratory stage, lacking empirical research to clarify its application models and optimization paths. Current practices face many challenges. AIGC-generated content is sometimes inaccurate in terms of Macao's unique historical details, such as the evolution of Macao's administrative system, or fails to objectively balance the Sino-Portuguese cultural narrative. Study tour agencies often struggle to integrate AIGC (AI-generated Content) outputs with on-site teaching, such as linking AI-simulated scenarios with guided tours of the Ruins of St. Paul's. Currently, there is no clear framework for evaluating the educational effectiveness of AIGC-assisted learning activities.

To fill this gap, this study employs a grounded theory-based qualitative research approach, focusing on the practical application of AIGC in the Macao study tour sector. Data will be collected through in-depth semi-structured interviews and participatory observation with students who have participated in study tour programs. This study aims to: identify existing application scenarios and implementation models of AIGC in study tour programs, such as content creation, scenario design, and personalized guidance.

This research aims to provide empirical support for the effective utilization of AIGC in the Macao study tour industry. It further enhances Macao's status as a distinctive educational platform in the Greater Bay Area and promotes the preservation of Sino-Portuguese cultural heritage.

METHOD

This study aims to explore the application scenarios and student experience mechanisms of AI-generated content (AIGC) in the Macau study abroad program, with the core objective of constructing a student-centered theoretical framework for AIGC applications. Given that the core subjects of this study are university students who have participated in the study abroad program, possessing diverse cognitive backgrounds and

personalized AIGC usage experiences, this study employs a qualitative research method based on grounded theory. This method is particularly suitable for revealing complex context-dependent, and can deeply capture students' genuine perceptions of AIGC tools (such as multilingual content generators and scenario simulation models), their problem-solving paths in AIGC-assisted study abroad programs, and their needs for technological optimization. These are aspects that quantitative methods such as questionnaires cannot fully cover.

To ensure the rigor and reproducibility of the research methodology, clear definitions of core concepts are necessary. The research subjects of this study are university students aged 18 to 35 who have participated in the Macau AIGC (Artificial Intelligence Generative Learning) program in the past year, including students from local Macau universities and mainland universities. The inclusion criterion is "experience in directly using AIGC tools during the learning period." Both Doubao and ChatGPT fall under the category of AIGC. If students use these tools during their studies to complete learning tasks (e.g., generating notes, organizing materials, assisting in writing learning reports), they fully meet the requirement of "experience directly using AIGC tools." However, if they are only used for casual conversation unrelated to learning (e.g., casual chat or entertainment), they are not included in the study.

This study was conducted from July 2023 to January 2025. Grounded theory emphasizes conceptual diversity rather than statistical representativeness. Therefore, this study used theoretical sampling rather than stratified sampling. The core objective of this study was to capture the diverse experiences of students using AIGC during their study abroad trips, ultimately reaching theoretical saturation. The sampling process revolved around the research question: "How do college students view and use AIGC for study abroad trips?" The final sample included 24 students. Data processing followed the three-stage coding process of grounded constructivist theory, with two researchers independently coding to ensure reliability. The coding consistency coefficient reached 0,87, exceeding the acceptable threshold of 0,80.

Declaration statement

Approval statement

This study is a qualitative research on the digital literacy of Chinese study tour instructors based on grounded theory, with semi-structured interviews as the core research method. The research focuses on respondents' cognition and practical experience of digital literacy, and does not involve the collection of sensitive personal information or research activities that may pose physical or mental risks to respondents.

Since the research institution does not have a dedicated Institutional Review Board (IRB) for humanities and social sciences research, and this study complies with the relevant requirements of Measures for the Ethical Review of National Social Science Fund Projects (Trial) and Ethical Review Norms for Humanities and Social Sciences Research (Trial), the requirement for formal ethical approval was waived after internal ethical review by the research team.

RESULTS

This study follows grounded theory methodology and analytical steps, progressively coding in-depth interview data through open-ended coding, axial coding, and selective coding. After obtaining the conceptual model, a theory saturation test was conducted (no new concepts emerged), ultimately constructing and elucidating the behavioral mechanisms by which students use AIGC in study tour contexts.

Open Coding

Open coding is a core step in grounded theory's approach to extracting concepts from raw data. This study interviewed 24 students who participated in the study abroad program. Based on approximately 180 000 words of interview text, researchers labeled, extracted semantics, and categorized each statement, transforming fragmented AIGC user experiences into systematic analytical units. The coding process followed a three-step approach: First, based on the core theme of "AIGC usage practice in the study abroad program and the formation of students' AIGC application cognition and ability," the raw statements were labeled (marked as "a"); second, initial concepts reflecting the core connotations were extracted based on semantic associations (marked as "aa"); finally, the common features of the initial concepts were integrated to refine the initial categories (marked as "A"). During the coding process, researchers eliminated duplicate categories and merged similar concepts to ensure the independence and representativeness of the categories.

Through coding, researchers extracted 22 initial concepts from the interview data and further refined them into 10 initial categories. Examples of the core coding are shown in table 1 below.

Table 1. Open coding example (part)

Initial Categories (A)	Initial Concepts (aa)	Original Statements (a)
A1 AIGC Tool Exposure in Study Tours	aa1 AIGC Tool Application	"Using ChatGPT to organize study tour materials and create mind maps is much more efficient than copying notes myself" (Undergraduate, 21 years old)
A2 AIGC Application Perception and Adaptation	aa2 Tool Operation Experience	"The AI-simulated trade scene provides a more intuitive immersive experience than watching documentaries" (Undergraduate, 22 years old)
	aa3 Scenario Adaptation Cognition	"Some AI-generated study tour content is too general, and I have to supplement the materials myself" (Undergraduate, 23 years old)
A3 Recognition of AIGC's Value in Study Tours	aa4 Recognition of Learning Efficiency Improvement	"When writing the report, artificial intelligence helped me organize relevant data and policy documents, saving me a lot of time." (Undergraduate student, 22 years old)
	aa5 Affirmation of Deepened Cultural Cognition	"Artificial intelligence turned the legends of the iconic historical sites at my destination into stories, which helped me understand the origins of local place names. This presentation was much more vivid than textbooks." (Undergraduate student, 21 years old)
A4 Reconstruction of AIGC Application Ability Cognition	aa6 Deepened Cognition of Ability Connotation	"I used to think using AI was just typing questions, but now I know I also need to be able to screen authoritative data sources" (Undergraduate, 20 years old)
	aa7 Update of Study Tour Role Positioning	"As the leader of the study tour group, I not only organize activities but also teach team members how to use AI for cross-cultural comparative analysis, becoming a 'coordinator of AIGC-assisted learning'" (Undergraduate, 23 years old)
A5 Ability Improvement Through Interaction	aa8 Promotion of AIGC Interaction Between Teachers and Students	"The teacher pointed out the deviations in the text I generated with AI and taught me how to revise it" (Undergraduate, 21 years old)
	aa9 Peer Experience Exchange and Learning	"During discussions with group classmates, they shared methods for generating study tour theme models with AI. I learned from them and made visual presentations for my part of the task" (Undergraduate from partner university, 22 years old)
A6 Online AIGC Practice Behaviors	aa10 AIGC Resource Integration and Sharing	"I shared the key points with my group members and was able to mark the parts I had questions about for group discussion." (Undergraduate student at the partner university, 20 years old)
	aa11 Online AIGC Collaborative Interaction	"After the study tour, we used AI-powered collaborative tools to jointly revise the report. Everyone marked the source of their AIGC-generated content and discussed points of contention with each other in real time, which was very efficient." (Undergraduate student, 21 years old)
A7 Offline AIGC Practice Behaviors	aa12 AIGC-Assisted Field Inquiry	"During my study tour, I used artificial intelligence to identify architectural patterns. It immediately matched the corresponding historical period and cultural origins, which was much faster than flipping through a manual." (Undergraduate student, 22 years old)
	aa13 On-Site AIGC Content Verification	"When I saw AI claim that 'a certain place was once a legislative body', I checked the local basic law provisions on my phone on the spot, found that it had confused functions, and immediately marked and corrected it in my notes" (Undergraduate, 23 years old)
A8 Daily Accumulation of AIGC Ability	aa14 Independent Learning of AIGC Skills	"I follow AI education official accounts for study tours and learned from their tutorials how to make AI generate targeted study tour questions. Now I can design group inquiry tasks by myself" (Undergraduate, 21 years old)
	aa15 Attention to AIGC Trends in Study Tours	"I heard an AI study tour cloud platform will be launched, so I specifically checked relevant reports and hope to use tools more tailored to local scenarios in the next study tour" (Undergraduate, 20 years old)
A9 Moderating Factors for Ability Improvement	aa16 Tool-Scenario Adaptation Limitations	"During the field trip, the signal was very poor, and the AI-powered navigation wouldn't load. I originally wanted to use it to learn about the community's history, but ultimately I had to rely on paper materials. The tool's dependence on signal strength severely impacted the learning experience." (Undergraduate student, 22 years old)

	aa17 Cognitive Differences Due to Professional Background	"As a history student, I have very high standards for the historical content of AI-generated study tour destinations, and I verify it word by word. However, tourism management students focus more on the practicality of AI tour guides and are less concerned about minor errors." (Undergraduate, 23 years old)
A10 Motivation for Sustained Application	aa18 Driven by Academic and Ability Needs	"This research report required cross-cultural analysis, and using artificial intelligence for multicultural literary comparison was both fast and accurate, which helped me get a higher score. I will definitely use it in similar projects in the future." (Undergraduate student, 21 years old)
	aa19 Positive Incentives from Experience Feedback	"My teacher said my AI-generated study tour presentation was more creative than a traditional PowerPoint presentation, and my classmates also asked me for advice. This recognition makes me even more eager to learn more advanced AIGC (AI-generated content) applications." (Undergraduate student, 22 years old)

Axis coding

The core objective of axial coding is to integrate the initial categories of open coding, clarify the logical relationships between categories, and thus answer the research question of how students' practical experience in study tour scenarios drives the formation and improvement of their AIGC application capabilities. This study, based on semantic recognition, identified the relationships between 10 initial categories, ultimately simplifying them into 5 main categories. It also clarified the functional positioning of each main category in the development of students' AIGC application capabilities, providing a core framework for the subsequent construction of theoretical models.

Table 2. Main categories formed by axial coding

Main Categories	Initial Categories from Open Coding	Explanation of Core Functions
AIGC Practice Trigger Input in Study Tours	A1 AIGC Tool Exposure in Study Tours	The starting point for students' AIGC application capabilities refers to the AIGC tools they encounter in study tour scenarios (such as ChatGPT), which provide a practical foundation for capability development.
Cognitive-Value Transformation of AIGC Application	A2 AIGC Application Perception and Adaptation, A3 Recognition of AIGC's Value in Study Tours, A4 Reconstruction of AIGC Application Ability Cognition	The core intermediary link in capability formation has achieved an intrinsic transformation from the perception of tool operation and value cognition to the reconstruction of capability cognition and role positioning.
AIGC Ability Advancement in Interactive Scenarios	A5 Ability Improvement Through Interaction	Through interactive scenarios such as teacher-student guidance and peer communication, we can accelerate the transformation of personal cognition and skills into practical applications and improve the efficiency of ability enhancement.
Practical Output of AIGC Application Ability	A6 Online AIGC Practice Behaviors, A7 Offline AIGC Practice Behaviors, A8 Daily Accumulation of AIGC Ability	External manifestations of capability development include building online collaboration, offline exploration, and daily accumulation.
Regulation and Long-term Maintenance of Ability Improvement	A9 Moderating Factors for Ability Improvement, A10 Motivation for Sustained Application	The guarantee mechanism for the long-term development of ability. A9 regulates the process of ability improvement through tool adaptation limitations and professional cognitive differences; A10 maintains the sustainability of ability accumulation based on academic needs and positive feedback.

Selective coding

Selective coding is a crucial analytical stage in grounded theory. This study conducted multi-round semantic and logical comparisons on the five main categories of the main axis coding (AIGC practice-triggered input, AIGC application cognition-value transformation, AIGC capability advancement in interactive scenarios, AIGC application capability practice output, capability enhancement adjustment and long-term maintenance) and

their ten subordinate initial categories. Retrospective verification was also performed using interview data to confirm that all main categories revolve around the core proposition of "how students' AIGC application capabilities are dynamically formed and advanced through research-based practice." Based on the functional positioning of each major category in the competency development process, this study defines the core category as the dynamic formation and progression mechanism of students' AIGC application competency driven by research-based AIGC practice. Research-based AIGC practice triggers input as the fundamental prerequisite for competency development; AIGC application cognition – value transformation – is the core intermediary for competency internalization; AIGC competency advancement in interactive scenarios acts as an efficiency amplifier for competency enhancement; AIGC application competency practice output is the external representation of competency formation; and competency enhancement regulation and long-term maintenance serve as the guarantee mechanism for sustainable competency development.

Table 3 presents the paradigmatic relationship structure and connotation of each main category under the core category. Its key insights can be summarized into five logical chains: First, exposure to AIGC tools in research and learning scenarios directly triggers students' application perception, further promoting their psychological transformation from tool cognition to value identification and then to the reconstruction of competency connotation; Second, the internalized AIGC application cognition and value judgment will drive students to transform abstract competency cognition into three-dimensional practical behaviors: online collaboration, offline exploration, and daily accumulation; Third, teacher-student AIGC interaction and peer experience exchange can simultaneously strengthen cognition. The depth of value transformation and the efficiency of practical output play a dual regulatory and reinforcing role; fourth, regulatory factors such as limitations in tool scenario adaptation and differences in professional background cognition, as well as long-term motivations such as academic needs and positive experience feedback, will run through the entire process of ability development, respectively ensuring the adaptability of ability transformation and the sustainability of ability accumulation; fifth, there is a short-path logic of "tool contact → direct practical output", that is, highly practical AIGC tools can skip complex cognitive transformation and directly trigger students' practical application behavior.

Table 3. Core categories and paradigmatic relationships formed by selective coding

Paradigmatic Relationship Structure	Explanation of Relationship Connotation
AIGC Practice Trigger Input in Study Tours → Cognitive-Value Transformation of AIGC Application	The examination of AIGC tools used in travel scenarios, such as ChatGPT and AI cultural heritage recognition systems, provides foundational material for the transformation of cognitive values. Experiences using these tools trigger operational perception and contextual adaptive judgments, thereby driving the reconstruction of value and competency cognition, ultimately completing the transformation from tool exposure to psychological internalization.
Cognitive-Value Transformation of AIGC Application → Practical Output of AIGC Application Ability	Internalized cognition and value judgments constitute the core motivation for externalizing abilities. Students transform abstract cognitive understanding of abilities into concrete cognitive understanding of study tour applications, and further externalize it into three-dimensional practical behaviors (online, offline, and daily life), thus realizing the connection between psychological changes and behavioral implementation.
AIGC Ability Advancement in Interactive Scenarios → Cognitive-Value Transformation of AIGC Application / Practical Output of AIGC Application Ability	Teacher-student guidance and peer experience exchange can supplement individual cognitive perspectives, amplify the resonance effect of skill perception and value recognition, while lowering the threshold of behavioral transformation and promoting the rapid conversion of cognition into practice.
Regulation and Long-term Maintenance of Ability Improvement → Cognitive-Value Transformation of AIGC Application / Practical Output of AIGC Application Ability	Tool adaptation limitations and professional background differences optimize the adaptability of ability transformation, while academic needs and positive feedback ensure the long-term nature of ability accumulation. Together, they maintain the overall stability of the ability development process.
AIGC Practice Trigger Input in Study Tours → Practical Output of AIGC Application Ability (Direct Path)	Highly practical AIGC tools can bypass complex cognitive shifts and directly trigger practical actions. For example, efficient AIGC study tour collaboration platforms can quickly resolve report coordination issues, and students can apply them directly to their study tour experiences after using them.

Based on the above paradigm relationship, this study outlines the logic of the formation and improvement of students' AIGC application ability: In the AIGC-empowered research and learning scenario, students first engage in AIGC practice through tools, then combine their professional background and research and learning needs to complete cognitive and value internalization, and strengthen the efficiency of ability transformation

through interaction with teachers, students and peers, which then externalizes into three-dimensional practical behavior. Finally, under the dual effects of moderating factors and long-term motivation, a dynamic closed loop of "tool contact → cognitive transformation → interactive advancement → practical output → long-term maintenance" is formed, realizing the continuous formation and advancement of AIGC application ability.

Saturation test

To verify the completeness and applicability of the theoretical framework constructed in this study, we retained five interview records from 24 students participating in the AIGC empowerment research for supplementary coding.

The supplementary coding results showed that no new initial categories, main categories, or paradigm relationships emerged; no new AIGC tool types were added, and no AIGC application practices outside the online-offline-daily three-dimensional framework were found; the logical relationships between the main categories were completely consistent with the theoretical framework.

Therefore, the theoretical model of the dynamic formation and improvement mechanism of students' AIGC application ability driven by research-based AIGC practice proposed in this study has reached theoretical saturation and can effectively explain the logic of the formation and improvement of students' AIGC application ability in research-based learning contexts.

DISCUSSION

Based on grounded theory, this study, through in-depth interviews with 24 university students participating in AIGC-enabled study tours, reveals the dynamic formation and advancement mechanism of students' AIGC application abilities in study tour scenarios. This section will combine existing research findings with the unique scenario attributes of study tours to deepen the understanding of the value of integrating AIGC with study tours in Macao.

AIGCEmpowering the Development Logic of Study Tours in Macao

This study focuses on the dynamic development of students' AI-guided tour (AIGC) application skills. Firstly, the shift from tool exposure to cognitive reconstruction echoes the cross-cultural needs of the Macao study tour program. In open-ended coding, the scope of cognitive reconstruction of AIGC application skills evolved from tool exposure (A1) to improving the efficiency of AIGC tool use, indicating that students' understanding of AIGC has upgraded from an efficiency tool to an auxiliary system for cross-cultural study tour. This shift is directly related to the core needs of the Macao study tour program, such as the comparison of Chinese and Portuguese cultures and cross-border cooperation in the Guangdong-Hong Kong-Macao Greater Bay Area. For example, history students can use AIGC to verify the accuracy of the evolution of Macao's administrative system (aa13), and tourism management students can use AI-guided tours to optimize the efficiency of field trips (aa17), demonstrating the adaptability of AIGC to the diverse needs of the Macao study tour program. This cognitive reconstruction breaks through the traditional study tour understanding of "tool use = skill mastery," forming a composite cognitive ability of "tool operation—data source selection—cultural context adaptation" (aa6). This aligns with the core concept of "technology application—content recognition—scenario adaptation" in the "three-dimensional model of generative AI user capabilities" proposed by Li et al. However, this study further emphasizes the uniqueness of "cross-cultural content verification capability" by considering the specific circumstances of Macao.

Secondly, the online-offline-daily practice model adapts to the virtual-reality integration characteristic of the Macao study tour. The main category of "AIGC application capability practice output" (including A6, A7, and A8) extracted from the main axis coding reveals the three-dimensional practice model of students' AIGC application: online, students integrate Macao historical policy documents through ChatGPT (aa4) and complete cross-school study tour reports using collaborative tools (aa11); offline, students use AI to identify architectural patterns of attractions such as the Ruins of St. Paul's (aa12) and verify the accuracy of AI-generated cultural narratives (aa13); in addition, students also independently learn AIGC (Macao Study Exchange Program) application skills daily through public accounts (aa14). This closed-loop model perfectly aligns with the typical process of learning and exchange in Macao: "online pre-study—offline field trip—post-class result deepening," effectively addressing the pain points of traditional learning and exchange, such as "fragmented online resources, superficial offline experiences, and insufficient post-class extension."

Third, the dual role of interaction and adjustment mechanisms ensures the adaptability and sustainability of capacity development. Correlation analysis of the two main categories: "AIGC Capacity Enhancement in Interactive Scenarios" (A5) and "Adjustment and Long-Term Maintenance of Capacity Enhancement" (A9, A10). It shows that teacher-student interaction and peer communication not only improve students' knowledge levels but also help them better adapt to Macao's learning and exchange environment. For example, in the future, Macao teachers can point out students' deviations in AI-guided texts regarding the practice of "One Country,

Two Systems" (aa8), and peers can share methods for designing AI-guided routes for cross-border study tours between Macao and Zhuhai (aa9). This demonstrates the role of interaction in the "scenario adaptability" of AI-guided applications. Meanwhile, adjustment factors such as tool signal limitations (aa16) and differences in professional backgrounds (aa17) provide practical references for implementing AI-guided tourism in Macao study tours. For example, weak signals in some historical districts of Macao indicate that travel agencies need to develop offline AI navigation modules; the cognitive differences between history and tourism management students require AI navigation tools to possess both academic rigor and a practical and convenient output mode. This "interactive enhancement + adjustment and adaptation" mechanism makes up for the shortcomings of existing research that only focuses on the "technical level" of artificial intelligence navigation applications, highlighting the importance of the "scenario level" and the "interpersonal level".

Theoretical contribution: Constructing a scenario-based AIGC application capability development model

This study enriches the application paradigm of grounded theory in the field of technology education. Following Charmaz's constructivist grounded theory approach, this study employs a complete process of "open coding—axis coding—selective coding," not only extracting categories and relationships but also ensuring the rigor of the model through theoretical saturation testing. In particular, during the selective coding stage, this study identifies a short path logic of "tool exposure → direct practical output" (e.g., highly practical AI collaboration tools can be directly applied to research report writing), which compensates for the shortcomings of the single "cognition-behavior" path in existing technology acceptance models (TAMs) and reveals the unique acceptance mechanism of AIGC and other technologies in educational environments.

Limitations and Recomandations

While this study constructed a relatively complete theoretical model using grounded theory, the sample primarily consisted of undergraduate students, and future research could include a broader population. Secondly, the study's methodology relied mainly on qualitative interviews, lacking quantitative data to validate the theoretical model, thus failing to clarify the weight of each factor's influence on competency development. Therefore, future research could employ quantitative methods, designing questionnaires based on the categories extracted in this study and utilizing large-sample surveys to verify causal relationships between variables, thereby constructing a quantitative competency development model. Thirdly, longitudinal studies could be conducted to track changes in students' AIGC application abilities during multiple study tours to Macau, analyzing the stage-specific characteristics and long-term influencing factors of competency development. Furthermore, future research could further explore the unique value of AIGC in "national identity education" during study tours to Macau. For example, using artificial intelligence to simulate Macau's development and changes before and after its return to China could enhance students' national identity awareness and provide educational support for building Macau into a "One Country, Two Systems" demonstration zone.

CONCLUSIONS

AIGC provides new technological support for the high-quality development of study tour programs in Macao. The formation of its application capabilities is not a simple process of technology learning, but a dynamic process involving tool practice, cognitive transformation, enhanced interaction, and practical output. The theoretical model constructed in this study reveals the internal logic of this process, enriches the theoretical research on the educational application of AIGC, and provides clear practical guidance for study tour institutions, educators, and technology developers in Macao. In the future, with the continuous iteration of AIGC technology and the ongoing expansion of study tour scenarios in Macao, the integration of the two will be further deepened, helping Macao build a study tour center in the Greater Bay Area that integrates cultural characteristics and technological advantages, and providing a more efficient way to inherit Sino-Portuguese culture and carry out national identity education.

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FINANCING

No applied.

CONFLICT OF INTEREST

The authors declare no conflicts of interest.

DATA AVAILABILITY STATEMENT

The dataset used and analyzed during the current study is available from the corresponding author on reasonable request.

AUTHORSHIP CONTRIBUTION

Conceptualization: Sio Hong TENG, FatFai Ieong.
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