

Analysis of the STEM Education Model in China and Australia from the Perspective of Course Content and Implementation Path

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ABSTRACT

STEM education is the core carrier for cultivating innovative talents. As important practitioners of STEM education in the Asia Pacific region, China and Australia have formed differentiated development models based on their local education ecology. This article takes a dual perspective of course content and implementation path, and systematically sorts out the policy orientation, curriculum composition, practical forms, and root causes of differences in STEM education between the two countries through literature research, comparative analysis, and other methods. Research has found that STEM education in China presents a curriculum feature of "subject based foundation+thematic integration" and an implementation logic of "policy driven+school-based implementation"; Australia takes "interdisciplinary integration" as the core of its curriculum, forming an implementation path of "school autonomy+social collaboration". The commonality between the two lies in adhering to practical orientation and innovation cultivation goals, while the differences stem from the underlying differences in education systems, cultural traditions, and social needs. Based on this, suggestions are proposed to optimize curriculum integration, improve collaborative mechanisms, strengthen teacher construction, and innovate evaluation systems, providing practical references for the high-quality development of STEM education in China.

KEYWORDS

STEM education; Comparison between China and Australia; Curriculum content; Implementation path; Optimization of educational models

1 Introduction

Against the backdrop of intensified global technological competition, the interweaving and evolution of a new round of technological revolution and industrial transformation further highlights the core value of STEM education in cultivating innovative thinking and practical abilities. At present, China is in a critical stage of building an innovative country, and the early cultivation of scientific and technological talents is directly related to the country's long-term development competitiveness. Consolidating the foundation of STEM literacy cultivation in the basic education stage has become a key lever to solve the shortage of innovative talent supply in China. At the same time, STEM education models are constantly iterating and innovating internationally. As representative practitioners in the Asia Pacific region, the differences and similarities in their development paths have important reference significance for China. Both China and Australia have incorporated STEM education into their national education development plans, forming distinctive practical models. The current academic research on STEM education in China and Australia mainly focuses on policy text interpretation or single link comparison, lacking systematic integration and analysis of curriculum content and implementation paths, making it difficult to fully reveal the core characteristics of the two models, and unable to provide accurate practical guidance for the deepening reform of STEM education in China. Based on this, this article takes "curriculum content" and "implementation path" as the core entry points, and systematically explores the differences and common rules of STEM education models in China and Australia by reviewing policy documents, curriculum standards, authoritative research reports, and public practice cases on the official websites of the education departments of the two countries. The research data and cases are all sourced from official publishing channels and core journal achievements in China and Australia, ensuring the authenticity and accessibility of the content. This article aims to provide valuable experience for the optimization and implementation improvement of STEM education curriculum in China through international comparison, and to help improve the system for cultivating innovative talents ^[1].

2 The Policy and Conceptual Basis of STEM Education in China and Australia

The policy layout of STEM education in China presents a distinct feature of "top-level design+layered promotion". To ensure the implementation of policies, the Ministry of Education has jointly launched supporting measures such as STEM education special training and demonstration school construction, promoting the precise transmission of policy requirements from top-level design to local schools, and forming a complete promotion chain of "national leadership

local coordination school implementation". In 2017, the Ministry of Education released the "Primary School Science Curriculum Standards for Compulsory Education", which for the first time included "technology and engineering" in the core areas of science curriculum and clarified the requirements for interdisciplinary integration; The revised "Technical Curriculum Standards for Ordinary High Schools" in 2020 further strengthen the cultivation of core competencies such as "engineering design" and "innovative practice", forming a policy framework of "laying the foundation for basic disciplines+enhancing comprehensive practice". At the conceptual level, STEM education in China is guided by core competencies, focusing on the comprehensive cultivation of scientific exploration, technological application, engineering design, and mathematical thinking, emphasizing the "application of knowledge", and serving the national science and technology innovation strategy and industrial upgrading needs.

Australia adopts a policy model of "national strategy+local autonomy" ^[2]. Under this decentralized model, each state can optimize STEM education implementation strategies based on regional characteristics. For example, Queensland relies on mining resources to develop characteristic STEM courses, while New South Wales supports cooperation between schools and research institutions through special funding, making policy implementation more in line with local development needs. The "Australian STEM Education National Strategy" released in 2016 proposed three major goals: "improving STEM literacy for all, cultivating professional talents, and building a supportive ecosystem"; The updated Australian Curriculum Framework (AC) for 2022 does not establish independent STEM courses, but instead infuses STEM literacy into the four major fields of "science," "mathematics," "technology," and "design and technology," giving states and schools the authority to independently integrate curricula. In terms of philosophy, STEM education in Australia emphasizes "interdisciplinary integration" and "real-world problem-solving", emphasizing students' ability to enhance their skills in dealing with practical issues such as environmental challenges and technological innovation, and focusing on the combination of individual interests and social needs ^[3].

3 The Composition and Characteristics of STEM Curriculum Content in China and Australia

The content of STEM courses in China presents a binary structure of "subject based foundation+thematic integration". This structure follows the progressive logic of "solid foundation - gradient integration" in the academic stage, and the compulsory education stage focuses on infiltrating technical and engineering knowledge within the framework of basic disciplines to ensure a solid foundation in the discipline; In high school, specialized technical courses and school-based development provide a broader space for interdisciplinary integration, balancing unified requirements with school characteristics. In the compulsory education stage, science and mathematics are compulsory basic subjects, and technical and engineering knowledge is permeated through specialized modules of the "science" curriculum (such as the "technology and life" unit in primary school science); In high school, in addition to subject specific courses, compulsory courses on "General Technology" and "Information Technology" are set up, and schools are encouraged to develop school-based STEM courses. Taking Shanghai Kongjiang Ercun Primary School as an example, the "Campus Intelligent Waste Classification System" course developed by the school integrates science (classification standards), mathematics (recycling data statistics), technology (sensor programming), engineering (recycling device design) and other contents to form a theme based integrated curriculum. Its plan has been included in the Shanghai STEM Education Excellent Case Library and can be queried on the official website of the Shanghai Education Commission.

The STEM curriculum in Australia is centered around "interdisciplinary integration+competency advancement" ^[4], without distinguishing disciplinary boundaries, and the selection of curriculum content always closely follows local social issues and industry needs, forming a design logic of "issue leadership - competency advancement". The theme course of "Water Resources Protection" in primary school stage aims to achieve the integrated cultivation of knowledge and abilities through the complete chain of "exploring the principles of water cycle (science) - calculating household water consumption (mathematics) - designing water-saving devices (engineering) - making data recording tools (technology)" ^[5]. The "Solar Energy Applications" course developed by a high school in Victoria in collaboration with local renewable energy companies covers topics such as the working principles of photovoltaic panels, energy conversion calculations, and the design of small solar energy devices. It is closely integrated with industry realities and not only enriches course materials, but also strengthens the practical application value of knowledge. Course resources can be found through the school enterprise cooperation case collection published by the Victorian Department of Education.

4 The Practical form of the Implementation Path of STEM Education in China and Australia

The implementation of STEM education in China presents a top-down characteristic of "policy driven+school-based practice". To ensure the effectiveness of implementation, education departments in various regions have simultaneously established regional teaching-research communities, solving interdisciplinary teaching problems in school-based practice

through collective lesson preparation, high-quality lesson demonstration and other activities, forming a two-way force pattern of policy guidance and teaching and research support. In terms of teaching methods, project-based learning (PBL) and maker education are the main forms, emphasizing the connection between classroom and extracurricular practice^[6]. The "National Primary and Secondary School Maker Space Construction Program" promoted by the Ministry of Education has supported over 3000 schools to build hardware practice platforms by 2023. Some middle schools have launched "STEM Winter Camps" to strengthen practical abilities through projects such as bridge model construction and intelligent car production. Teacher training relies on the "National Teacher Training Program (NTTP) for STEM Backbone Teachers", adopting the "expert lecture+teaching observation+practical exercise" mode^[7]; The evaluation system adopts a combination of "process oriented+summative" approach, focusing on student project reports, work exhibitions, and other achievements. In some regions, STEM literacy is included in the comprehensive quality evaluation file.

The implementation path in Australia is centered around "school autonomy+social collaboration", presenting diverse characteristics. In this mode, the deep integration of social resources becomes a key support for practical implementation. Enterprises and universities not only provide resource supply, but also participate in curriculum design and teaching guidance, enhancing the professionalism and pertinence of practice. Emphasis is placed on inquiry based learning and collaborative learning in teaching, encouraging students to independently design research projects. In the "Campus Botanical Garden" project of a primary school in New South Wales, students independently complete the entire process of plant selection, planting planning, and growth monitoring, while teachers only provide guiding support. In terms of social collaboration, the "STEM Partner Program" promotes deep cooperation between schools, enterprises, and universities: aerospace companies provide simulated spacecraft experimental resources for middle schools, and universities open laboratories for primary and secondary school students to carry out simple scientific research projects. The teacher training relies on the online courses and cross-school teaching-research mechanism of the Australian Institute for Teaching and School Leadership (AITSL), and the evaluation is mainly process oriented, reflecting students' exploration process and innovative thinking through project portfolios, group presentations, and other forms.

5 Attribution of Commonalities and Differences in STEM Education Models between China and Australia

From a practical perspective, there is a significant consensus in the STEM education model between China and Australia: firstly, STEM education is regarded as a national strategic priority, focusing on the cultivation of innovative and practical abilities; The second is to break through the limitations of traditional subject based teaching and emphasize interdisciplinary knowledge integration^[8]; The third is to take real problems as the teaching orientation, emphasizing the combination of theory and practice. These consensuses were not formed by chance, but based on the common understanding of the value of STEM education and the laws of talent cultivation between the two countries, providing a core guideline for the standardization of STEM education in each country, and also laying the foundation for mutual learning of educational experience between the two countries. These commonalities reflect the essential characteristics of integration, practicality, and innovation in STEM education, and are a common trend in the development of STEM education worldwide.

The core attribution of the differences between the two includes three levels: firstly, differences in the education system. China's centralized education system ensures the nationwide unified promotion of STEM policies, facilitating the allocation of high-quality resources to weaker areas and ensuring educational balance; The decentralization system in Australia grants states and schools greater autonomy, allowing them to adjust their practical strategies based on local industry characteristics and regional needs, forming diverse forms of practice and enhancing educational adaptability. Secondly, there are differences in cultural traditions. Chinese culture values a solid grasp of basic knowledge, STEM courses focus on laying the foundation of the subject, and teaching is mainly guided by teacher led exploration^[9]; Australian culture emphasizes individual independent exploration, and curriculum design focuses more on the problem-solving process, encouraging students to initiate exploration and verify conclusions independently. Thirdly, there are differences in social demands. China's STEM education serves technological innovation and industrial upgrading, with a focus on cultivating large-scale scientific and technological talents to support national development strategies; Australia focuses on improving STEM literacy for all citizens, while addressing the shortage of professionals in the STEM field in a targeted manner, balancing inclusive and professional needs. It is worth noting that these three attribution dimensions do not exist in isolation, but are intertwined and influence each other, jointly shaping the differentiated form of STEM education in China and Australia, and determining that the two countries need to adapt and transform based on their local ecology when learning from each other's experiences.

6 Practical Implications for the Development of STEM Education in China

6.1 Promote the Deep Integration of Interdisciplinary Courses and Address the Dilemma of Formal Integration

Drawing on the experience of thematic integration in Australia, reducing barriers to subject based curriculum, adding curriculum modules guided by real issues such as environmental governance and new energy development in compulsory education, optimizing curriculum content based on school-based regional characteristics and students' cognitive levels, and naturally integrating multidisciplinary knowledge into the exploration process^[10]. Encourage schools to collaborate with industry experts in designing courses, draw on the experience of school-based curriculum development such as Shanghai Kongjiang Ercun Primary School, establish a mechanism for evaluating the effectiveness of curriculum integration, ensure the depth and practicality of integration, and avoid "labeling-style integration".

6.2 Building a Diverse Social Collaboration Mechanism and Integrating High-quality Resources from Multiple Parties

Drawing on the Australian STEM Partner Program, special support policies and tax incentives will be introduced to encourage enterprises to donate hardware equipment, provide practical venues, promote the opening of laboratory resources in universities, and assign dedicated personnel to guide primary and secondary school practices. Establish a regional STEM education resource sharing platform, clarify the rights and responsibilities of each subject, integrate high-quality courses, teacher training, practical bases and other resources, alleviate the problem of insufficient resources in some schools, and form a collaborative system of "government guidance, school leadership, enterprise participation, and university support".

6.3 Strengthen the Interdisciplinary Ability of Teachers and Improve the Diversified Training System

Build a targeted training model of "online learning+cross-school teaching-research+industry practice": learn interdisciplinary teaching theories through an online course system similar to the Australian Institute for Teaching and School Leadership (AITSL)^[11], rely on regional teaching-research communities to carry out themed lesson preparation and lesson case discussions to share teaching experience, organize teachers to participate in real project research and development in technology enterprises or universities, and enhance technical application and interdisciplinary design capabilities. Establish an incentive mechanism for STEM teachers, encourage participation in school-based curriculum development and teaching innovation, and solve the dilemma of "single subject teachers being unable to handle interdisciplinary teaching".

6.4 Innovate the Evaluation System, Highlighting Process-oriented and Diversified Orientation

Reduce the proportion of quantitative evaluation, adopt qualitative evaluation methods such as project reports, work exhibitions, and group defenses, refine evaluation indicators, and focus on students' thinking advancement, innovative breakthroughs, and collaborative effectiveness in the exploration process. Introduce multiple evaluation subjects such as parents and industry experts, refer to the evaluation experience in Australia, establish a linkage mechanism between evaluation results and teaching improvement, comprehensively reflect the development of students' STEM literacy, avoid evaluation oriented alienation, and truly serve the cultivation of abilities.

7 Conclusion

Overall, this article systematically compares the core characteristics and underlying logic of STEM education models in China and Australia from the dual perspectives of curriculum content and implementation path. The advantage of STEM education in China lies in its strong policy implementation and solid foundation, with the core features of "subject based foundation+theme integration" and "policy driven+school-based implementation"; Australia, on the other hand, has formed a flexible and efficient practical model with the advantages of interdisciplinary integration and social collaboration. The differences between the two stem from the underlying differences in education systems, cultural traditions, and social needs, while the commonality lies in adhering to the practical orientation and innovative cultivation goals of STEM education.

For China, the high-quality development of STEM education requires maintaining its own advantages, focusing on the practical needs of basic education reform and the construction of an innovative country, and drawing targeted lessons from the Australian experience: solving formal integration problems through deep integration of curriculum, integrating

multiple resources through the construction of collaborative mechanisms, enhancing teachers' interdisciplinary abilities through diversified training, and guiding the direction of education through innovative evaluation systems. This localized adaptation approach can not only avoid the drawbacks of blindly copying, but also fully activate the effectiveness of local educational resources, helping to form a Chinese style STEM education model with "solid foundation, deep integration, efficient practice, and distinctive characteristics".

The limitation of this study is that it did not conduct empirical analysis on the practical effects of STEM education in China and Australia. In the future, the impact of different modes on students' STEM literacy can be further explored through questionnaire surveys, classroom observations, and other methods. With the development of technology and the deepening of education reform, the STEM education model will continue to innovate, and it is necessary to continue conducting international comparative research to provide more targeted references for the development of STEM education in China.

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