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A Study on the Relationship Between Interdisciplinary Thematic Learning in Primary and Secondary School Mathematics and STEM Education

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Abstract: This paper deeply analyzes the conceptual resonance of the two at the common starting point of "integration," and systematically discriminates their profound divergences in cultural genes, disciplinary logic, and value orientation. Research shows that interdisciplinary thematic learning in mathematics is rooted in the localized soil of "fostering virtue through education," with the mathematics discipline as its solid home ground; whereas STEM education originates from national science and technology competition strategy, exhibiting distinct characteristics of being engineering-driven and technology-empowered.

Keywords: Interdisciplinary Thematic Learning in Mathematics; STEM Education; Core Competencies; Cultural Heritage; Teaching Path

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We are in an era of profound transformation in educational paradigms. The boundaries of knowledge are dissolving and reconstructing at an unprecedented speed. Knowledge, once categorized and placed in different chapters of textbooks, reveals its inherent limitations in the face of complex problems in the real world. Cultivating future citizens who can comprehensively apply knowledge, are rich in innovative spirit, and possess problem-solving abilities has become a common mission for educators worldwide. Against this broad background, two powerful educational currents converge and clash in the field of basic education in China: one is endogenous, born from the deepening of China's curriculum reform – "Interdisciplinary Thematic Learning"; the other is exogenous, carrying the vision of American technological supremacy – "STEM Education." They are like two mighty rivers, starting from different sources, yet flowing towards the same estuary of "disciplinary integration."

In April 2022, with the promulgation of the "Compulsory Education Mathematics Curriculum Standards (2022 Edition)" (hereinafter referred to as the "New Curriculum Standards"), "Interdisciplinary Thematic Learning" completed its institutional turn from an advanced concept to a national curriculum plan. The document explicitly requires that primary and secondary mathematics courses allocate no less than 10% of class hours per semester for such learning. Its purpose is to "break disciplinary boundaries and promote the development of students' comprehensive competencies." This move marks a milestone for China's basic education in responding to the challenges of the times. Almost simultaneously, STEM education, originating from across the ocean, after more than a decade of introduction, localized practice, and discussion, has long evolved from an unfamiliar acronym to a trendy label for educational innovation. Its advocated project-based learning, engineering design processes, and maker culture profoundly influence the form of many classrooms.

Therefore, clarifying the "common origins" and the reasons for "diverging paths" is not only a purely academic proposition but also a multiple-choice question concerning the direction of practice. This paper attempts to go beyond listing phenomena and conduct a dialectical examination of interdisciplinary thematic learning in primary and secondary mathematics and STEM education by delving into the levels of cultural background, value orientation, and disciplinary logic.

1. Conceptual Mapping: Outlining the Theoretical Contours of Two Integration Paradigms

Before delving into comparison, we must first draw clear theoretical maps for these two core concepts, defining their respective connotations, boundaries, and the theoretical soil on which they rely.

1.1 Interdisciplinary Thematic Learning in Primary and Secondary Mathematics: Bounded Integration with the Home Discipline

In the context of China's "New Curriculum Standards," the essence of "Interdisciplinary Thematic Learning in Mathematics" is a structured curriculum integration strategy premised on adhering to the subjectivity of the mathematics discipline. Its core connotation can be interpreted as: using the core knowledge and ideological methods of the mathematics discipline as the logical main thread, centering on a theme that naturally connects multiple disciplines and has exploratory value, organically integrating the knowledge, methods, or perspectives of one or several other disciplines, and designing and implementing sequential learning activities aimed at comprehensively applying acquired knowledge to solve problems in real-world situations.

1.2 STEM Education: Boundaryless Integration Driven by Engineering

STEM education, from its inception, has carried a distinct national strategic intent. It is far more than a simple juxtaposition of the four disciplines of Science, Technology, Engineering, and Mathematics; it is **an educational paradigm that aims to cultivate technological innovation talent, emphasizing the integration of multidisciplinary knowledge through engineering design and technological implementation**. Its ideal form is to break the traditional boundaries of the four disciplines and merge them into a new, holistic learning field where disciplinary boundaries are blurred, even deliberately dissolved.

2. Roof of Common Origins: Shared Genes of Integrated Education

Despite their different origins, Interdisciplinary Thematic Learning in Mathematics and STEM education share a profound relationship of "common origins" in their core concepts, which constitutes a solid foundation for dialogue and mutual learning. Their "common genes" are mainly manifested in the following three aspects:

2.1 Common Core Philosophy

Both explicitly challenge the "subject-basedism" dominant in traditional education. They jointly recognize that real-world problems – whether urban traffic congestion, environmental pollution, or product design – never appear with labels like "pure mathematics problem" or "pure science problem." These problems are comprehensive, and their solutions inevitably require knowledge, methods, and perspectives that cross disciplinary boundaries. Therefore, "integration" becomes the shared soul of both. They are committed to providing students with a more complete cognitive picture closer to the real world, helping students understand the internal connections of knowledge, rather than merely mastering isolated knowledge points.

2.2 Common Goal Pursuit: Focus on Higher-Order Competencies and Comprehensive Abilities

Whether to enhance national technological competitiveness (the original intention of STEM education) or to cultivate "well-rounded individuals" (the purpose of China's core competency system), both elevate educational goals from the mastery of low-order knowledge and skills to the cultivation of higher-order thinking abilities and comprehensive competencies. Critical thinking, complex problem-solving ability, creativity and innovative thinking, teamwork and effective communication – these core competencies highly valued in the 21st century are simultaneously the key outcomes pursued by both educational models. In interdisciplinary thematic learning in mathematics, these abilities complement core mathematical literacies (such as mathematical modeling, data analysis); in STEM education, these abilities are indispensable components of STEM literacy.

3. Common Methodological Preference: Activating Learning in Authentic Problem Contexts

Both deeply believe that the most valuable learning occurs in meaningful contexts. Therefore, they both invariably adopt "context-driven" and "problem-oriented" teaching methods. Interdisciplinary thematic learning in mathematics emphasizes discovering and posing mathematical problems in "authentic situations," while STEM education advocates using "project-based learning" or "engineering challenges" as the starting point for learning. The internal logic is consistent: by creating a challenging, real task that needs to be completed, students' intrinsic motivation is stimulated, driving them to actively retrieve, invoke, integrate, and apply the knowledge they have learned, thereby making learning an active, inquiry-based process closely connected to society and reality.

3.1 Crimination of Diverging Paths: Exploring the Internal Logic of Heterogeneous Development

Recognizing "common origins" is the basis for cooperation, while clearly perceiving "diverging paths" is the key to creative transformation. The differences between the two in cultural genes, value orientation, and integration logic determine that they are two unique paradigms that cannot replace each other.

3.2 The Path of Creation: Constructing a Practical Framework for Localized Interdisciplinary Thematic Learning in Mathematics

Clarifying "common origins" and "diverging paths" ultimately guides the "creative" path of Chinese education. Our task is neither to reinvent the wheel behind closed doors nor to adopt foreign models wholesale, but to follow a practical path of "taking our own needs as the foundation, integrating Chinese and Western approaches" based on dialectical understanding.

3.3 The Primary Principle is to Adhere to the Disciplinary Foundation of the "Mathematics Home Ground"

How to evaluate students' gains in mathematical literacy? For example, in the theme "Designing an Ideal Home," the core mathematical knowledge should be the calculation of area and volume, the application of geometric shapes, and the planning of spatial proportions; in the theme "Exploring the Distribution of Campus Plants," the core should be the entire process of data collection, organization, description, and analysis. We must ensure that mathematics is the "soul" of the learning activity, not a dispensable "decoration," preventing interdisciplinary activities from degenerating into a handicraft or activity class with little mathematical content.

4. Prudently Absorb the "Methodological Essence" of STEM Education

4.1 Strengthen the process of "Design Thinking" and "Iterative Optimization."

In projects like "Designing a Campus Water-Saving Device," introduce the cycle of "Empathize-Define-Ideate-Prototype-Test." This not only cultivates practical ability but also allows students to deeply experience the scientific essence of "hypothesis-verification-revision" in mathematical modeling.

4.2 Skillfully use "Technology" as a cognitive amplifier

Encourage the use of tools like GeoGebra, graphical programming (e.g., Scratch), and digital sensors, enabling students to intuitively explore dynamic mathematical relationships, simulate complex systems, collect and analyze real-world data, making technology a "bridge" for deepening mathematical understanding rather than the "purpose."

4.3 Establish an assessment system that "Focuses on Process and Employs Multiple Evaluations."

Change the single paper-and-pencil test evaluation model and build a comprehensive evaluation system that fully reflects the value-added development of student competencies. This includes:

5. Conclusion: Moving Towards the Future through Return and Transcendence

The relationship between interdisciplinary thematic learning in primary and secondary mathematics and STEM education is a profound dialectical movement of "common origins" and "diverging paths." They resonate because they both point to the zeitgeist of "disciplinary integration," yet they follow different development paths due to being deeply rooted in different cultural soils and value demands.

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