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Research on Project-Based Learning Practice in Primary School Mathematics Focused on Core Literacy Cultivation

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Abstract: Project-based learning integrates mathematical knowledge and methods into real-life contexts and practical problems from the perspective of core literacy. By designing key stages such as project initiation, exploration, and optimization, students are encouraged to think like mathematical experts, actively integrate various resources, and personally experience the entire process of problem identification, formulation, analysis, and resolution. An outstanding project-based learning design should prioritize understanding of disciplinary knowledge, emphasizing the selection of materials derived from real-life situations, constructing scenarios leading to the core of the discipline, and using problem-driven approaches to stimulate student motivation. Furthermore, it should emphasize problem-solving during project implementation and aim for competence-building in project evaluation. This way, students gradually accumulate life and activity experiences, grasp mathematical thoughts and methods, develop various mathematical awareness, and ultimately cultivate core literacy in mathematics.

Keywords: Primary School Mathematics, Core Literacy, Project-Based Learning.

1. Introduction

The 2022 version of the Primary School Mathematics Curriculum Standards issued by the Ministry of Education explicitly requires mathematics to return to the real world, to practical applications, and to adopt a top-level design based on the "three competencies" as curriculum objectives. It describes the core literacy indicators such as numerical sense, quantitative sense, symbolic awareness, operational ability, geometric intuition, spatial concept, reasoning awareness, data awareness, model awareness, application awareness, and innovation awareness that students at different stages of primary school should develop and cultivate in real-world problem contexts.

Based on this, the author relies on the practice teaching and construction bases of basic education in the local area provided by universities and the professional internship platform for primary school education majors. By combining the actual physical and mental development levels of students in local rural schools with the characteristics and positioning of primary school mathematics curriculum, the author interprets concepts such as big ideas, big unit teaching, and project-based teaching. This research explores the strategies of project-based teaching in primary school mathematics based on big concepts, aiming to implement the educational philosophy of the New Curriculum Standards.

2. Current Shortcomings in Primary School Mathematics Teaching

In practical primary school mathematics teaching, influenced by various factors, some classes do not achieve the expected teaching quality and efficiency. Teachers fail to fully implement the educational requirements and curriculum concepts of the New Curriculum Standards. Specifically, from a practical perspective, the current primary school mathematics teaching has the following three main shortcomings:

(1) Weak Research on Project Learning in Elementary Education: Currently, the majority of project-based learning research is focused on higher education and vocational education, with limited exploration in elementary education. Many primary schools lack comprehensive planning when conducting project-based learning. The learning content lacks systematic design, resulting in fragmented, superficial, and project-centered implementation issues.

(2) Lack of Systematic Clarification of Core Literacy Connotations and Key Indicators: In terms of literature distribution, most research on core literacy is concentrated in higher education and vocational education, with limited involvement in primary education. There is currently a lack of in-depth research on the connotations, key indicators, and specific performance levels of core literacy within the framework of core literacy in primary school. This limitation hinders the integration of core literacy into the revision of primary school curriculum standards, textbook development, teacher teaching, and evaluation practices.

(3) Weak Research on Core Literacy Development in Rural School Students: Research literature mainly focuses on talent cultivation based on core literacy, but it mainly discusses higher education, with limited coverage of rural education. Over the years, rural education has been influenced by the "urban-rural dual structure" and "examination-oriented education." The autonomy of school curriculum construction is very limited, and backward education methods are common. This includes rote memorization, mechanical training, and other practices. Therefore, there is insufficient theoretical research and practical exploration on how to enhance the core literacy of rural students based on the characteristics of rural education.

3. Project Design Based on Understanding of Disciplinary Knowledge

A project serves as the external driving force propelling the entire mathematical discipline practice, and its essence is the comprehensive literacy demonstrated based on a profound understanding of disciplinary knowledge. An excellent project should cover a broad context, big ideas, and child-centered concerns. Therefore, teachers can consider how to design projects from the following three aspects:

(1) Select materials derived from real-life situations: Guided by the core literacy target system for mathematics in rural primary schools, and combining academic quality standards and subject characteristics, design project themes tailored to the rural real world. In project theme design, the emphasis should be on fully tapping into situational elements available in rural settings, establishing a localized knowledge content system for local mathematics curriculum, and creating a rich learning space that combines in-school and out-of-school experiences. This shift will transform teaching content from isolated projects to thematic projects. In other words, project design should focus on the broader context of student learning, emphasize the connection between in-school and out-of-school, on-campus and off-campus, and ensure the formation of a three-dimensional learning space, allowing teaching content to become knowledge or problems related to mathematics that students encounter in actual life. Only in this way can students transition from "detachable" to "embodied" in mathematical learning, linking mathematics with life through real and wholehearted experiences, deepening their understanding of mathematical knowledge.

(2) Create scenarios leading to the core of the discipline: In the paradigm of project organization, guided by the cultivation of core literacy in mathematics in rural primary schools, based on local knowledge and children's experiences, follow the design of disciplinary big units centered around major problems, forming significant conceptual understandings. Establish diverse organizational paradigms; the shift towards "big concept curriculum and teaching" signifies that basic education in China is moving towards a direction of "big concept curriculum and teaching." This means that the mathematics curriculum will no longer be limited to the transmission of factual knowledge and key points, but will advance towards a deeper understanding of major disciplinary concepts. Therefore, when designing project scenarios, it is essential to closely focus on the core of the discipline, which is the major conceptual understanding of the discipline. Only when students can deeply understand the major conceptual understanding of the discipline, forming conceptual understanding, higher-order thinking, and creative ability, can they become "three-capacity" talents adapted to the needs of the information and intelligent age.

(3) Stimulate motivation through problem-driven approaches: In terms of project learning methods, the focus is on integrating real-life situations, setting problem boundaries, iterating scheme conception, refining activity design, generating group proposals or works, exchanging group results, and evaluating group activities. Problem-driven motivation is crucial in project-based learning. Major conceptual understandings and core concepts are typically highly abstract. Only by transforming them into specific problems can students engage in exploration and deep understanding. Different types of problems have different effects on understanding major conceptual understandings and core concepts, as well as on stimulating student learning motivation. From the perspective of understanding major conceptual understandings and core concepts, problems can be categorized into three types: essential problems, factual problems, and philosophical problems. Among them, philosophical problems and essential problems are most suitable as core driving problems for project-based learning, as they involve exploration of "why" and directly address the deep origins of major conceptual understandings and core concepts. Factual problems are relatively straightforward, mainly involving basic knowledge and information in the discipline. They can serve as specific detailed questions supporting philosophical and essential problems.

4. Project Implementation Targeting Problem Solving

The essence of project-based learning lies in guiding students to solve problems like experts, making students the subjects of learning, while teachers play the role of facilitators. The teacher's task is to provide students with rich resources, learning strategies, and learning support, helping them solve complex problems like mathematical experts, ultimately cultivating responsible, moral, and capable problem solvers.

(1) Project Implementation Process: In project-based learning, the entire process can be divided into three parts: project initiation, project exploration, and project optimization. These correspond to "project initiation—problem clarification," "project exploration—problem solving," and "project optimization—problem reflection," respectively, making project learning a complete process from problem identification to problem resolution. The specific steps are as follows:

- Step One: Project Initiation—Problem Clarification: The teacher or student presents a specific problem, sparking students' interest and curiosity in solving the problem. At the same time, the teacher helps students further interpret and describe the problem, guiding them to understand and contemplate the problem.
- Step Two: Project Exploration—Problem Solving: The teacher assists students in exploring the methods and paths for solving the problem through independent learning, group cooperation, and other methods, forming a solution plan. Then, they guide students in practical operation and exploration, ultimately solving the problem and creating a work.
- Step Three: Project Optimization—Problem Reflection: Through project presentations, the teacher and students collectively reflect on the process and results of problem solving, summarizing experiences and optimizing the work.

Additionally, in mathematical project-based learning, students achieve continuous exploration and deep understanding of core knowledge by "learning through doing," "learning through comprehending," and "learning through creating." Therefore, it is essential to consider the three questions of "what to do," "what is the most crucial thing to do," and "what else needs to be done to do the most crucial thing."

(2) Project Implementation Strategies: When designing activity structures, it is necessary to differentiate between three types of activities:

- Well-structured activities: These activities have clear definitions and a single form but are relatively scattered and closed, not conducive to the development of students' higher-order thinking. Therefore, they are not suitable as the core tasks of project-based learning.

- Poorly-structured activities: These activities are usually closely related to the real world, exhibiting comprehensiveness, divergence, and expansiveness, and may not even have an absolutely correct answer. However, depending on whether the project task and activity are derived from the real world, some may be suitable as core tasks and activities, while others may not.

- Real activities deconstructed and reorganized by teachers: These activities are based on poorly-structured activities, where the teacher removes some cumbersome non-mathematical tasks and excessive, overly complex, and highly specialized variable factors, leaving behind the most essential, critical, located in the students' proximal development zone, and relatively complex authentic mathematical disciplinary practice activities.

(3) Scaffold for Project Implementation: In project-based learning, teachers need to provide resource scaffolds, method scaffolds, technical scaffolds, etc., according to the characteristics of the project task and students' learning situation, to construct a cognitive framework and learning steps for students. These learning scaffolds should become a part of the students' learning process, ultimately internalized by them, helping them continuously improve learning methods, learning abilities, and cognitive levels, progressing from shallow understanding of the discipline to a deeper understanding of its profound principles. To assist students in understanding the core concept of scale, namely the concept of proportionality, the teacher provided the following typical scaffolds:

- Resource scaffold: Provided architectural design blueprints of the school and the cultural construction design blueprint of the school's first-phase campus, helping students understand the application of scales in real-life situations. Special attention was given to the design of legend elements, facilitating the initial understanding of how to proportionally reduce lines or shapes.

- Method scaffold: Introduced a team Q&A sign for project-based learning. This gauge was mainly used for students to assist each other in solving problems during project progress. Through brainstorming discussions within or between groups, problems were resolved. Finally, the teacher collected and classified the questions based on their importance, displaying the valuable and enlightening Q&A signs for reference by other students.

- Technical scaffold: Included recording and uploading project logs using tablet computers, as well as voting and statistics for project works.

Providing these scaffolds effectively helps students transition from lower-order cognition to higher-order cognition in project-based learning, enabling them to gain a deeper understanding of core mathematical knowledge, and cultivate higher-level cognitive abilities.

5. Diversified Evaluation Mechanism for Project-Based Learning, Promoting Fine-grained Enhancement of Student Core Literacy

The research mainly focuses on a diversified evaluation mechanism, emphasizing formative assessment, process assessment, dynamic assessment, and supplemented by summative assessment. A specific performance module for core literacy is set within the project, studying how to use submitted evaluation works, process materials such as learning process and cooperative process, and descriptive materials of personal literacy such as student attitudes, to record, describe, and accurately reflect students' changes from different dimensions. The evaluation method is based on core literacy. Meanwhile, comprehensive evaluation from two dimensions of learning process and learning outcomes is conducted, including self-assessment, peer assessment, parent assessment, and teacher assessment, in order to optimize the objectives, content, process, and results of project-based learning.

In the process of project implementation, I employed a tripartite comprehensive evaluation method of "teacher-student-parent," aiming to comprehensively assess students' learning process and results. Through this evaluation method, teachers can not only promptly identify and address problems in project-based learning, but also understand students' performance in project-based learning. For example, in the project initiation stage, teachers can use questionnaires to understand students' mastery of "project learning knowledge already possessed," and then analyze the reasons based on the survey results and provide corresponding learning support. At the same time, teachers can also grade within the group, summarizing the scores of this group through group discussions and giving evaluations. In addition, in the process of project-based learning, teachers can also require students to regularly report on their learning progress and results, or check through extracurricular assignments. Such a comprehensive evaluation method can comprehensively understand students' learning situation, accurately grasp their performance and achievements in project-based learning.

6. Conclusion

In summary, teachers should accurately understand the connotations of major concepts, major unit teaching, and project-based teaching based on the current shortcomings in elementary school mathematics teaching. Based on this, by setting clear teaching goals and introducing project-based practice and centralized display, major concept teaching, major unit teaching, and project-based teaching are integrated, consolidating the teaching content of elementary school mathematics and constructing a perfect teaching system. This not only helps optimize the organization and presentation of the content in the mathematics curriculum but also highlights the students' subjective status, enabling them to actively participate in learning and exploration, thereby changing poor learning habits.

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