Research on Cross-Textbook Teaching Practice of Primary School Science under the STEM Concept

Jingjing Zhang[1], Wei Chen[2,*], Xiaoyan Li[1,2], Aomei Sun[2], Shuangfeng Zhu[2], Yimin Zhang[2]
[1]*School of Education of Hefei University, Hefei, Anhui, China*
[2]*School of Foreign Languages, Bengbu University, Bengbu, Anhui, China*
**Corresponding Author*

Abstract: Taking the fourth-grade elementary school science curriculum as the research object, this study integrates the content of 'A Day's Food' from the Education Press edition and 'Food and Health' from the People's Education Press edition. It explores the implementation path of STEM concepts through cross-textbook teaching cases. The study achieves the coordinated development of the four elements of STEM and core competencies through task chain design, the application of digital tools and AR technology, and the integration of ideological and quality-oriented education into the curriculum. The results show that students' knowledge construction tends to be systematic, their interdisciplinary abilities improve, and their learning motivation shifts towards active exploration. Ideological and quality-oriented education is also effectively integrated. However, it points out that aspects such as the authenticity of the context need optimization, providing references for the reform of elementary school science courses and the professional development of teachers.

Keywords: Primary School Science Course; STEM; Cross-Textbook Teaching; Quality-Oriented Education; Instructional Design

1. Introduction

With the continuous deepening of the new round of curriculum reform in basic education, STEM education, characterized by interdisciplinary integration and practical innovation, has gradually become an important trend in the development of international basic education. Countries such as the United States, members of the European Union, and Singapore have incorporated STEM education into their national education strategies, emphasizing the cultivation of students' innovative spirit and practical competence through interdisciplinary integration and project-based learning [1]. Domestic scholars have also highlighted that introducing STEM concepts into primary school science teaching not only facilitates the development of students' scientific thinking but also enhances their inquiry skills. The 2022 edition of the Compulsory Education Science Curriculum Standards further specifies the objectives of science education in terms of interdisciplinary integration, practical innovation, and value orientation. It emphasizes that the curriculum should not only help students acquire scientific knowledge and methods but also cultivate their sense of social responsibility and ability for value-based judgment through connections with real-life contexts [2]. This provides both policy and theoretical support for the implementation of the STEM concept in primary school science curricula.

Existing studies have shown that the application of STEM education in primary science mainly focuses on the development of teaching cases, the design of classroom activities, and the practice of interdisciplinary projects. Some research has further explored the integration pathways between STEM education and curriculum-based ideological instruction, proposing that equal attention should be paid to the dual objectives of scientific literacy and value education [3]. However, current practices in primary school science classrooms still present several shortcomings: (1) teaching activities often remain confined to the disciplinary knowledge level, lacking systematic interdisciplinary integration [4]; (2) student activities are frequently limited to simple experiences and mechanical operations, with insufficient depth of inquiry, making it difficult to cultivate higher-order thinking skills [5]; and (3) the integration of ideological and political education with science teaching is relatively weak, often manifested in a didactic manner rather than through naturally embedded designs grounded in task-based contexts.

2. Comparative Study on Cross-Textbook STEM Teaching Design in Primary School Science

Based on the aforementioned background and issues, this study selected two lesson cases—A Day's Food from the JiaoKe edition and Food and Health from the RenJiao edition—as research objects to conduct a comparative analysis of cross-textbook STEM teaching practices in primary school science. The aim was to explore effective approaches for implementing STEM concepts in primary science curricula. Both textbooks are core courses for Grade 4, yet they differ in terms of the depth of interdisciplinary integration, the dimensions of inquiry task design, and the breadth of technology application.

This research involved 90 Grade 4 students from two primary schools in HF City (46 from School A, 44 from School B). Research methods included classroom observation, questionnaire surveys, analysis of student work, and teacher interviews. The comparison focused on differences in knowledge construction, skill development, emotional attitudes, and value formation, employing both quantitative and qualitative analyses to ensure a comprehensive reflection of teaching effectiveness.

2.1 Case One: Teaching Analysis of a Day's Food (JiaoKe Edition)

2.1.1 Task Design and Implementation

Task chain: food statistics → classification and analysis → calculation of nutritional proportions → optimized recipe design → visualization and presentation.

STEM integration points:

Science (S): nutritional components of food, principles of dietary balance;

Technology (T): using tablets for food information scanning and recording, generating pie charts of nutritional proportions with Excel, presenting the digestion process with AR animations;

Engineering (E): optimizing family recipes and adjusting meal combinations;

Mathematics (M): statistical counting of food quantities, calculation of nutritional ratios, data visualization [6].

Curriculum-based and Quality-oriented education focusing on core competencies: emphasizing family responsibility in the "recipe optimization" stage, guiding students to consider the dietary needs of different groups; embedding awareness of food conservation during "data statistics" tasks to raise attention to food waste.

2.1.2 Student Performance and Data Analysis

Accuracy rate of data statistics: average 92% (N=36), with higher-grade students reaching 97% and lower-grade students 86%.

Group discussion participation: average score of 4.3/5, with 60% of groups completing effective discussions and proposing optimization plans.

Number of innovative solutions: 28 in total (e.g., novel vegetable salad combinations, healthier snack substitution plans).

Questionnaire results indicated an average score of 4.6/5 for interest in inquiry activities, and 4.5/5 for recognition of the value of healthy eating.

2.2 Analysis and Insights

The JiaoKe edition, with its clear task chain and rich technological tools, effectively enhanced students' capacity for interdisciplinary knowledge integration and inquiry interest. Data indicated that multidimensional task design promoted the synergistic growth of knowledge comprehension, skill development, and value formation. For instance, when calculating nutritional proportions, students not only mastered mathematical ratio concepts but also deepened their understanding of scientific principles such as dietary balance.

However, limitations were observed among lower-grade students, particularly in ratio calculations (e.g., "percentage of protein intake relative to daily recommendations") and technical operations (e.g., formula entry in Excel), suggesting that differentiated task design is necessary to provide appropriate support for students at varying levels.

2.3 Case Two: Teaching Analysis of Food and Health (RenJiao Edition)

2.3.1 Task Design and Implementation

Task chain: food observation → nutritional analysis → healthy diet discussion → recipe design.

STEM integration points:

Science (S): emphasis on explaining nutritional knowledge, such as functions of different foods;

Technology (T): limited to multimedia PPT presentations, without digital or interactive

tools;
Engineering (E): minimal design tasks, only listing recipe ingredients;
Mathematics (M): simple statistical applications, such as recording the number of food types consumed in a day.
Curriculum-based and Quality-oriented education focusing on core competencies: health responsibility was briefly mentioned during discussions, but not further embedded into specific tasks for value-oriented guidance.
2.3.2 Student Performance and Data Analysis
(1) Student Performance Evaluation Rubric
According to Table 1, Task Chain: Food Observation → Nutritional Analysis → Healthy Diet Discussion → Recipe Design.

Table 1. Student Performance Evaluation Rubric Task Chain

Criteria	Excellent (4)	Good (3)	Fair (2)	Needs Improvement (1)
Food Observation	Gives vivid, detailed descriptions with creative language.	Gives clear and relevant descriptions.	Gives brief or limited descriptions.	Gives unclear or minimal responses.
Nutritional Analysis	Accurately identifies nutrients; explains clearly.	Identifies most nutrients; gives basic explanations.	Partial understanding; limited vocabulary.	Misunderstands or cannot explain nutrients.
Healthy Diet Discussion	Actively participates; expresses ideas clearly and supports opinions.	Participates and shares some ideas.	Limited participation; unclear expression.	Rarely participates; little engagement.
Recipe Design	Creative, balanced recipe; clear presentation and teamwork.	Reasonable recipe; mostly clear presentation.	Simple or unbalanced recipe; uneven teamwork.	Incomplete or copied work; weak collaboration.
Language Use	Accurate, varied, and fluent expression.	Mostly accurate with minor errors.	Frequent errors; limited vocabulary.	Many errors that affect understanding.
Overall Engagement	Highly motivated and responsible.	Positive attitude and active participation.	Inconsistent effort or focus.	Little interest or effort shown.

(2) Data Analysis
According to Table 1, during this sequence of tasks, students showed active participation and steady improvement in both language use and thinking skills.
In the food observation stage, most students were highly engaged. They described food items in detail, using vivid adjectives and sensory expressions such as “fresh,” “sweet,” and “crunchy.” Some students also made interesting cultural connections by mentioning traditional dishes from their families. Overall, they were confident and expressive in sharing their observations.
In the nutritional analysis stage, students worked collaboratively to identify and discuss the main nutrients in various foods. They showed a good understanding of health-related vocabulary like “protein,” “fiber,” and “calories.” A few students went further to compare different food types and suggest healthier alternatives. Their ability to analyze information and use English for explanation was noticeably improved.
During the healthy diet discussion, students interacted enthusiastically in small groups. They listened to each other’s opinions and supported their ideas with reasons and examples. The discussion atmosphere was lively and cooperative. Students practiced useful expressions for giving advice and expressing agreement or disagreement politely, such as “I think you’re right, but…” or “Maybe we could also consider…”.
In the recipe design stage, students demonstrated creativity and strong teamwork. They designed healthy and appealing recipes, paying attention to both nutrition and taste. Many groups presented their recipes confidently in English, using clear language and visual aids like posters or slides. Their work reflected a solid understanding of healthy eating concepts and a growing ability to apply language in authentic contexts.
Based on Table 1, the accuracy rate of data statistics is as the following: average 85%, with lower-grade students at 73% and higher-grade students at 92%.
Group discussion participation: average score of 3.7/5, with only 40% of groups proposing feasible optimization plans.
Number of innovative solutions: 15 in total, with relatively limited originality (mostly single-ingredient substitutions).
Questionnaire results showed an average score

of 4.0/5 for inquiry interest and 4.1/5 for recognition of the value of healthy eating.

3. Analysis and Insights

Overall, students showed enthusiasm, responsibility, and creativity throughout the task chain. They were able to connect classroom learning with real-life situations, communicate effectively in English, and develop a deeper awareness of health and nutrition. The activity successfully promoted both language learning and holistic development, in line with the goals of quality-oriented English education.

Classroom observations revealed that the proportion of students actively raising hands, asking questions, and conducting independent experiments increased from 36.7% before class to 85% after instruction. Students' descriptions of nutritional components in experiment reports became more scientific and evidence-based. For example, when analyzing milk, some students wrote statements such as "Milk contains a high level of protein, which contributes to bone and muscle development," demonstrating improvement in scientific expression.

Nevertheless, the RenJiao edition exhibited weaker interdisciplinary integration and insufficient incorporation of technology and engineering, resulting in an incomplete task chain. Interdisciplinary integration, technology application, and task-chain completeness are essential for the implementation of STEM concepts. Data indicated that the lack of technology and engineering elements reduced students' initiative in inquiry tasks and limited their capacity for innovation.

4. Teaching Reflections

4.1 STEM-Based Instructional Design Enhances Teaching Flexibility by Addressing Gaps in Individual Textbooks

Designing instructional activities grounded in the principles of STEM education can effectively compensate for the absence of technological and engineering components in individual textbooks, thereby preventing the weakening of students' initiative in inquiry and innovation. This design reflects the constructivist emphasis on the core idea of "students actively constructing knowledge." Through experiments and interdisciplinary tasks, students learn by doing, gradually developing an understanding of the relationship between nutrition and health. This process aligns closely with Piaget's mechanism of "cognitive equilibrium and adaptation" — students progress from simply "knowing that food contains nutrients" to "understanding how to achieve a balanced diet." At the same time, in problem-solving and extension activities, teachers intentionally guide students through processes of "discovery," which corresponds to Bruner's discovery learning theory that emphasizes "acquiring structured knowledge through inquiry," thereby helping students build a systematic knowledge framework [7].

4.2 Cultivation of Scientific Inquiry Skills and Interdisciplinary Thinking

During experiments, students actively engaged in activities such as "food classification and nutrition testing." In the interdisciplinary task of "designing a healthy diet plan," questionnaire results indicated that 85.2% of students could correctly apply mathematical knowledge to calculate daily caloric needs (e.g., determining required intake based on age and weight), while 72.5% were able to use information technology tools (such as Excel or drawing software) to create dietary charts. Some students also incorporated pie charts into their plans, visually presenting changes in nutrient distribution before and after optimization, thus demonstrating stronger awareness of interdisciplinary integration. Teacher interviews further suggested that this task encouraged students to leverage their individual strengths in group work, exhibiting a high level of teamwork.

4.3 Significant Impact of Curriculum-Based Ideological and Political Education

Through participation in the "Clean Plate Campaign," students' sense of social responsibility was noticeably enhanced. Survey data showed that 91.6% of students expressed willingness to reduce food waste in the future, and 87.3% spontaneously mentioned the values of "saving food" and "healthy eating" during discussions. Teachers also observed a marked reduction in food waste in the school cafeteria following instruction. Some students even advised their parents to adjust family eating habits—for instance, "reducing fried foods" and "adding more vegetables." These findings indicate that the natural embedding of ideological and political elements in the curriculum can positively influence student behavior, achieving a transformation from "value recognition" to "behavioral practice" [8].

In summary, teaching optimization strategies guided by STEM concepts have achieved positive outcomes in enhancing scientific inquiry skills, interdisciplinary thinking, value education, and learning motivation.

4.4 Areas for Improvement

Several limitations remain in teaching implementation. First, the depth of inquiry was insufficient. Some students remained at the level of surface observation, lacking deeper questioning and reasoning. For example, regarding the risks of excessive sugar intake, many students only responded "it is bad for teeth," without connecting it to issues of energy metabolism and obesity. Second, differences in student ability were not adequately addressed. High-achieving students were able to integrate interdisciplinary knowledge efficiently, whereas lower-achieving students encountered difficulties in calculating nutritional ratios or using technological tools, leading to disparities in learning outcomes. Third, the integration of Quality-oriented elements still requires further deepening. Although students' awareness of food conservation improved, their understanding of the broader social and cultural values behind healthy diets remained superficial, lacking systematic value-based inquiry.

4.5 Improvement Pathways and Optimization Suggestions

4.5.1 Strengthen Inquiry Levels and Deepen Cognitive Training

To address the issue of shallow inquiry, teachers can adopt scaffolding strategies to guide students gradually from descriptive observations toward causal reasoning [9]. For instance, starting with "Excess sugar causes tooth decay," teachers can extend questioning to "How does sugar affect energy metabolism?" thereby connecting the discussion to obesity and chronic diseases. Inquiry records can also be added during experiments, requiring students to document "phenomenon—hypothesis—verification," such as analyzing the nutritional content of milk not only by describing its components but also by reasoning that "protein supports bone development," thus promoting the transition from operational learning to cognitive advancement [10].

4.5.2 Design Tiered Tasks to Address Student Differences

A dual-task system of "core tasks—extended tasks" can be developed to cater to different student abilities. Core tasks, such as "calculating the nutrient proportion of a single food," target all students and can be supported with formula templates for those with weaker foundations. Extended tasks, such as "designing a diet for specific populations (e.g., the elderly or children)," can challenge more capable students to optimize plans based on nutritional needs and taste preferences. Heterogeneous grouping can also be adopted, allowing students with different strengths to collaborate and support each other, thereby narrowing learning gaps [11].

4.5.3 Deepen Quality-oriented education to Realize Value Internalization

Instruction should move beyond superficial "preaching" and integrate Quality-oriented education deeply into tasks. For example, in recipe design, traditional dietary principles from *the Huangdi Neijing* — "grains for nourishment, fruits for support, meats for benefit, vegetables for enrichment"—can be incorporated. Students can be guided to combine foods such as brown rice and oats, apples and bananas, pork and fish, and spinach and broccoli, thereby gaining insight into the wisdom of balanced diets [12].

Through these improvements, STEM-based primary school science instruction can enhance not only students' knowledge and skills but also their value education and cultural understanding, ultimately forming a closed-loop model of "disciplinary integration—literacy development—value enhancement."

5. Conclusion

The operational STEM teaching paradigm developed in this study holds significant potential for instructional dissemination.

5.1 A Transferable Interdisciplinary Teaching Template

Based on the four-stage model of "contextual introduction—practical inquiry—problem solving—extended application," this template can be adapted across various disciplinary topics, enabling the integration of knowledge from science, mathematics, technology, and engineering.

Practical experience in technology and

information tool application.

By employing tools such as tablets, Excel, and AR technology, teachers can realize data-driven instruction, visual analysis, and dynamic demonstrations, offering practical references for implementing modern information technology in primary science teaching.

5.2 A Demonstration of Integrating Value Education with Subject Instruction

Embedding curriculum-based Quality-oriented elements into concrete tasks creates a natural teaching chain of "task-driven—disciplinary practice—value guidance," providing teachers with actionable strategies for incorporating value education into subject teaching.

From the perspective of teacher professional development, STEM teaching practices also drive comprehensive improvement in teacher competence. In instructional design, teachers must coordinate elements of science, mathematics, technology, and engineering, cultivating interdisciplinary integration and innovative design skills. In technological application, teachers enhance their capacity to utilize information tools for data analysis, visualization, and virtual experiments. In educational philosophy, STEM promotes a shift from teachers as "knowledge transmitters" to "learning facilitators and inquiry designers," fostering reflective practice and educational innovation.

5.3 Future Research Outlook

Building on the task-chain learning design (food observation → nutritional analysis → healthy diet discussion → recipe design), future research may draw upon the principles of the Duifen Classroom (PAD Class), first introduced by Professor Zhang Xuexin from Fudan University in 2014. The Duifen model divides classroom learning into three interconnected stages: Preparation, Presentation, and Discussion (or Assimilation). This structure aims to balance teacher instruction with student participation, thereby reducing teaching load while enhancing students' initiative and learning effectiveness.

Future studies could explore how integrating this model into task-based English learning can further improve learners' engagement, autonomy, and reflective thinking. For example, students might prepare by researching food-related vocabulary and nutrition facts before class (Preparation), learn key concepts and expressions through teacher guidance (Presentation), and then engage in group discussions and recipe design tasks to apply knowledge in authentic contexts (Discussion/Assimilation).

Moreover, researchers could examine the impact of using performance-based rubrics within the Duifen framework to support formative assessment, peer evaluation, and self-reflection. By combining the strengths of the Duifen Classroom with quality-oriented English education, future research can contribute to developing more student-centered, interactive, and sustainable approaches to English teaching and learning.

Acknowledgments

This work was supported by the Bengbu University Quality Engineering Teaching Research Project (2024jyxm15) and the Faculty Development and Teaching Innovation Team Project (BBXYJYTDxj42).

References

[1] Zhan, Z., & Niu, S. (2023). Subject integration and theme evolution of STEM education in K-12 and higher education research. Humanities and Social Sciences Communications, 10(10), 779–781.
[2] Ministry of Education of the People's Republic of China. (2022). Compulsory Education Primary Science Curriculum Standards (2022 Edition). Beijing: Beijing Normal University Press.
[3] Li Qi. (2015). Effectiveness of the U.S. 'STEM Education Act (2015)'. World Education Information, (22), 22-23.
[4] Li, K. D., & Li, Y. (2019). The 5EX instructional design model for interdisciplinary STEM learning activities. E-education Research, 40(04), 5–13.
[5] Dong, X. R. (2022). Research on primary STEM instructional design and practice integrating design thinking. (Master's thesis). Guangxi Normal University, Guilin.
[6] Kong, J. (2021). Research on the design pathway of STEM curriculum based on the cognitive depth model. Modern Educational Technology, 31(09), 112–119.
[7] Zhang, M. (2024). Classroom practice of integrating STEM concepts into primary school science. Huaxia Teacher, (14), 88–90.
[8] Xu, J. (2025). Integrating STEM education

concepts into experimental teaching. Primary Science, (21), 70–72.
[9] Min, G., Qi, W. Y., & Sha, X. H. (2025). Research on reflective scaffolding design in flipped classrooms based on deep learning theory. Vocational Education, 24(16), 13–17, 25.
[10] Li, S. J., Zhou, R., & Gu, X. Q. (2022). STEM education model based on learning progression. Modern Distance Education Research, 34(02), 73–84.
[11] Wang, X., & Bai, S. Q. (2014). From concept to practice: Constructing a model of collaborative learning competence cultivation. China Higher Education Research, (06), 102–106.
[12] Fei Hu. (2025). Research on the Application of the PAD Class Model in Higher Vocational Public English Teaching from the Perspective of New Media. Education Reform and Development, 7(06), 34-40.