Open Journal of Social Sciences, 2025, 13(7), 545-565
https://www.scirp.org/journal/jss
ISSN Online: 2327-5960
ISSN Print: 2327-5952

Research on the Cultivation of Computational Thinking by High School Information Technology Courses Based on DBR

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How to cite this paper: Ma, X. L., Wang, J. Y., & Fan, Y. (2025). Research on the Cultivation of Computational Thinking by High School Information Technology Courses Based on DBR. *Open Journal of Social Sciences, 13,* 545-565.
https://doi.org/10.4236/jss.2025.137030

Received: June 30, 2025
Accepted: July 22, 2025
Published: July 25, 2025

Abstract

With the widespread application of generative artificial intelligence in the field of education, the importance of cultivating computational thinking has been increasingly valued in forming talents with information literacy and independent innovation ability. However, there are still many confusions about how to cultivate students' computational thinking ability in middle school information technology courses and how to integrate computational thinking ability into basic education and teaching activities. Therefore, based on the conceptual framework of computational thinking and guided by DBR theory, this study developed a designing activity-based teaching design for the cultivation of computational thinking ability, and carried out multiple rounds of iterative teaching practice. The results of the practice show that the design ability and innovation ability, the grades of the usual works and the final test scores, the learning methods and thinking methods, the interest and attitude towards computational thinking of the students in the experimental class have all been significantly improved, indicating that the high school information technology course that incorporates computational thinking content has achieved good teaching results.

Keywords

Computational Thinking, DBR, High School Information Technology Course, Multimedia Work Design, Teaching Design

1. Introduction

In 2006, Prof. Zhou Yizhen defined computational thinking as the thinking activities that use basic concepts of computer science to solve problems, design systems, and understand human behavior (Wing, 2006). This concept not only represents a cognitive tool at the technical level, but also reflects an educational concept that aims at the comprehensive development of people and the subjectivity of learners. The introduction of computational thinking has triggered profound changes in the global education community and promoted the fundamental shift of information technology courses from skill training to thinking ability cultivation. In particular, with the breakthrough of the limitations between disciplinary paradigms motivated by generative artificial intelligence (Ma et al., 2025), computational thinking, as a key literacy in scientific education, has also received further attention.

As the key stage in the transition from basic education to higher education, high school education plays an irreplaceable and important role in cultivating students' ability to master basic principles and methods of information technology and use information technology to solve complex problems creatively. Examining the high school information technology curriculum system, "Multimedia Technology Application" is an important part of it, and its teaching content involves a lot of "design" ability training. From the perspective of cognitive science, the core essence of design ability lies in the in-depth analysis, high abstraction and innovative reconstruction of complex real-life problems. This process just reflects the essential characteristics of abstraction, which is a core element in computational thinking. However, in current teaching practice, multimedia technology courses are often limited to training at the technical operation level, lacking training in core thinking abilities such as problem analysis, solution design, and process optimization. The systematic cultivation of deep-level thinking ability is also relatively insufficient. This situation not only limits the development of students' computational thinking ability, but also restricts the full realization of the value of information technology education.

Therefore, it is not only of great theoretical value but also of urgent practical significance to explore the computational thinking elements contained in the course of "Multimedia Technology Application" and systematically cultivate students' computational thinking ability through scientific teaching design and innovative practical activities. However, this research field still faces many challenges: How to scientifically identify and effectively extract the computational thinking elements in multimedia technology courses? How to transform the abstract concept of computational thinking into specific and operational teaching strategies? How can students' thinking development be systematically supported and guided in the process of multimedia work design? How to scientifically evaluate the effect of computational thinking training? The answers to these key questions need to be further promoted on the dual paths of theoretical exploration and practical verification.

Based on the above questions, this study aims to build an innovation model for multimedia technology teaching, that integrates computational thinking based on the scientific paradigm of design-oriented research (DBR), and explore the effective path of computational thinking training through the spiral iteration of theoretical construction and practical verification. Ultimately, the comprehensive improvement of students' abstract thinking, design thinking and evaluation thinking abilities is the final target. Around the core goal, this study established the following three key research questions:

1) What computational thinking content is contained in multimedia technology courses? How can students be trained in abstraction, design, and evaluation in the process of designing multimedia works?

2) How to integrate the concepts and methods of computational thinking into the design process of multimedia technology works? How to evaluate the effectiveness of computational thinking training in multimedia technology courses?

3) Based on the DBR research paradigm, explore how to use the concept of "design" to design the teaching of multimedia technology courses, and how to integrate the concept and method of "design" into the students' inquiry process.

2. Literature Review

2.1. Current Research of Computational Thinking

The proposal of computational thinking has aroused extensive research and discussion among scholars in the computer and education fields, and has made considerable progress in theoretical research and teaching practice at a relatively fast pace.

Computational thinking has attracted widespread attention from scholars in many countries and has been recognized by many groups and organizations overseas. Since Prof. Zhou proposed the concept of computational thinking, the United States, Britain and other countries have successively launched programs and related seminars, aiming at improving the computational thinking ability of teachers and students in the K-14 stage, and also discussed the impact of computational thinking on different fields such as philosophy, physics, biology, medicine, architecture, and education (Bundy, 2007). In addition, a research team has shown that computational thinking is related to STEM interdisciplinary education, emphasizing the extensibility of the concept of computational thinking (Jiang et al., 2024).

Chinese scholars have also made some useful attempts and explorations on computational thinking. China has held a series of computational thinking-related conferences, including a series of academic seminars and forums on the topic of computational thinking. In 2023, Li Mang emphasized that the essence of computational thinking is that "people are not machines" and that attention should be paid to the essential characteristics of people in the development of computational thinking (Li & Yang, 2023). Subsequently, Zhang Yi's team constructed a computational thinking assessment scale based on the definition and training requirements of computational thinking in the new curriculum standards, providing a basis for the assessment of computational thinking levels (Zhang et al., 2024).

2.2. Cultivating Computational Thinking Ability through Information Technology Course

The information technology curriculum in China's middle schools has gone through three stages since its inception, from focusing on professional computer education to focusing on popular computer literacy and then on information literacy education. Its development has been deeply influenced by foreign countries. Since 2011, the United Kingdom, the United States, Australia and other countries have successively announced computational thinking education standards and made computational thinking an important part of their information technology courses (Niu & Liu, 2013). In 2023, Alajlan et al. (2023) identified 13 teaching and learning strategies suitable for cultivating computational thinking skills through computer education in the K-12 stage, demonstrating the importance of finding and determining suitable teaching methods for cultivating computational thinking in computer education.

With the rise of computational thinking education in basic education, China has also attached more and more importance to the key position of computational thinking training in information technology courses. Prof. Ma et al. have explored the effective strategies for cultivating computational thinking ability on the platform of information technology courses, and proposed that students' computational thinking awareness and computational thinking ability should be cultivated from six dimensions (Ma et al., 2015). Su Qing et al. established a computational thinking project-based learning model for high school information technology courses, and proved that computational thinking can be effectively cultivated in high school information technology courses through empirical research (Su et al., 2022). Zhu Sha et al. proposed the GAiSOLEs teaching model for cultivating students' digital literacy based on generative artificial intelligence, and finally proved that the course teaching under this model can significantly improve the level of computational thinking dimension in digital literacy (Zhu et al., 2025).

2.3. Developing Teaching Activities for Cultivating Computational Thinking Based on DBR

Design-based research (DBR) is also known as design experiment, design research, development research, development research etc. It originated from the field of learning science research and has been highly praised by many educational scholars since it was proposed. In summary, DBR takes the problems in real teaching situations as the starting point, and continuously intervenes in the teaching process by using some methods to achieve the purpose of solving problems and generate new and improved educational theories.

In 2022, considering that computational thinking is a key ability to solve STEM problems, Zhou Pinghong et al. proposed a STEM engineering design teaching model for the cultivation of computational thinking. Through the design process of building and testing models, optimizing solutions, and evaluating and improving, the team finally measured that STEM teaching under the proposed model can significantly improve students' STEM attitudes and computational thinking abilities (Zhou et al., 2022). Shen Shusheng et al. specifically studied scenario design to provide a basis for the formation and application of computational thinking in artificial intelligence courses (Shen & Weng, 2023). "Evaluation", as a key link in DBR activities and teaching practice, plays an important role in the actual implementation of computational thinking in information technology courses. Feng Youmei et al. explored the evaluation system of computational thinking level in information technology courses with the core scale of "knowledge" and then explained the new logic of designing a computational thinking evaluation system oriented to "knowledge" (Feng et al., 2025). Considering that computational thinking cultivation may involve online learning, the online learning motivation evaluation model constructed by Ma Xiulin's team can provide support for motivation evaluation in large-scale online learning fields, and also facilitate the evaluation of students' learning motivation in teaching activities (Ma et al., 2024).

3. Research Design

3.1. Research Methods

The study organizes the research process with the design-based research (DBR) paradigm. Meanwhile, it organizes and demonstrates the effectiveness of the research teaching practice activities with quasi-experimental research methods. Questionnaire surveys, interviews, observations are used to support specific links in the research.

1) Design-based research: This method serves as an overall research framework and integrates the design concept into teacher and students' activities.

2) Quasi-experimental research method: After constructing a high school information technology teaching model based on computational thinking, the teaching content is designed according to the corresponding teaching strategies and teaching evaluation methods. The experimental teaching is carried out on the research subjects to verify the effectiveness of the teaching model and teaching design proposed in the research.

3) Questionnaire survey method: A questionnaire test on computational thinking ability level is conducted before and after the course. The purpose is to verify the teaching effect by comparing and analyzing the results of multiple surveys.

4) Interview method: During the iterative experiment, the teacher and 3 - 6 randomly selected students are interviewed to learn about their experience and suggestions about the course, which can serve as the basis for the design and implementation of the next round of experiments.

5) Observation method: Collect process data by observing the performance of teachers and students in class and the problems they face during the experiment, and discuss with teachers in a timely manner after class to seek solutions to the problems.

3.2. Study Subjects

This study selected two classes of the second grade from The High School Affiliated to Renmin University of China as the research subjects, with 112 students in the experimental class (35 boys and 77 girls) and 109 students in the control class (37 boys and 72 girls). The pre-test was conducted through the Questionnaire on Computational Thinking Quality of Middle School Students, and the chi-square test was used to analyze the differences in computational thinking quality between two classes. The results showed that the Sig values of the experimental class and the control class in three dimensions, including computational thinking awareness, computational thinking methods, and computational thinking ability, were all greater than 0.05, which means there was no significant difference. It also indicates that two classes were confirmed as parallel classes, providing reliable baseline data for subsequent experiments. Therefore, in order to better verify the multimedia technology courses' actual teaching effect on the cultivation of computational thinking, the computational thinking training model based on DBR and the corresponding course design content proposed in this study were introduced and strictly practiced in the experimental class's teaching, while the control class still carried out traditional teaching mode without the proposed content.

3.3. Core Guiding Ideology

This study focuses on cultivating high school students' computational thinking abilities in three aspects including design, abstraction, and evaluation. The embodiment of computational thinking in computer curriculum reform and construction will ultimately be realized in the cultivation of the ability to abstract knowledge, operations, and strategies, while ability standards with certain goals and directions are the concretization of the cultivation process. This cultivation based on abstract ability standards can be summarized into three dimensions, including knowledge reorganization and structuring, technical operation and control and problem-solving strategies. Specifically, the design ability in computational thinking abilities can be cultivated mainly through knowledge reorganization and structuring. The abstraction and evaluation aspects require the integration of technical operation and control as well as problem-solving strategies, since the cultivation process is iterative.

3.4. Research Process Design

The teaching design of this study will draw on and refer to the three dimensions of computational thinking, while following the general process of design-based research. The research will be conducted from five aspects including analysis, design, implementation, evaluation and improvement.

1) The learners form and develop computational thinking skills during independent "design".

Teaching is a two-way interactive process, including both teachers' teaching and students' learning. Teachers conduct teaching by designing teaching content, teaching strategies and teaching evaluation, while students need to develop their design and computational thinking abilities in the process of completing tasks. The learner's "design" process is shown as Figure 1.

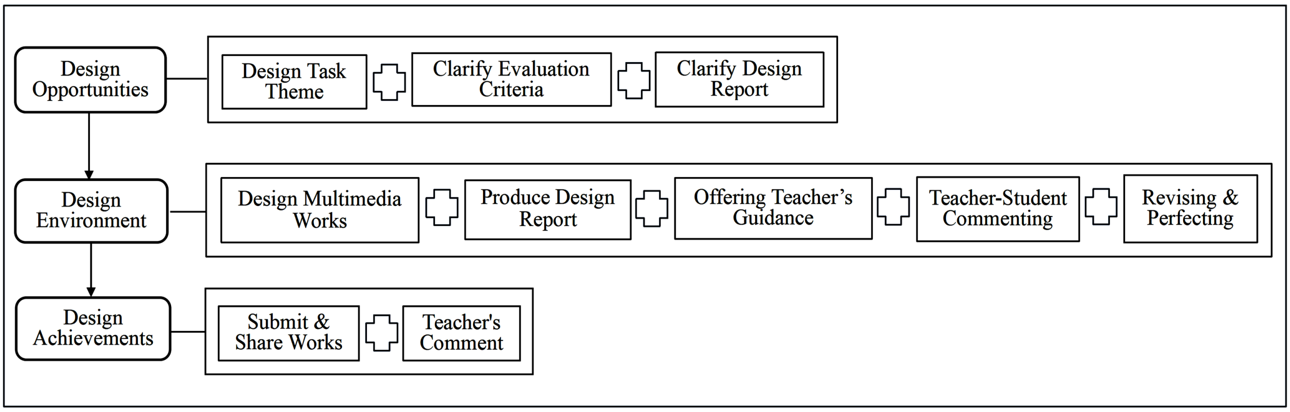

Figure 1. Learner's design process.

2) Teachers' design of teaching content, teaching strategies and teaching evaluation.

Researchers and practitioners design teaching content, teaching strategies and teaching evaluation based on relevant teaching theories and computational thinking concepts. After implementation, they modify and improve based on feedback and start the next round of new practice. Through multiple rounds of iterations, a relatively complete and reliable high school information technology computational thinking training model is constructed. The specific design is shown as Figure 2.

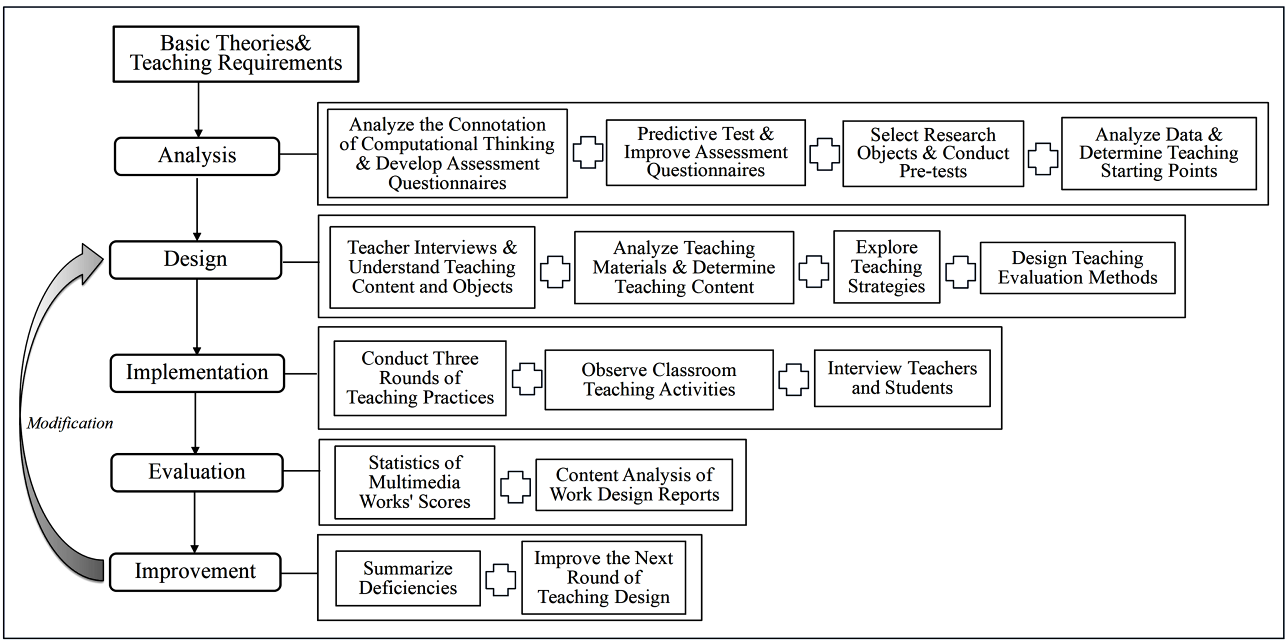

Figure 2. Research design based on DBR.

3.5. Multimedia Technology Course Design for Computational Thinking Cultivation

In order to better carry out computational thinking training teaching experiments for the research objects, this study explored and designed the multimedia technology course for computational thinking training from three aspects, including teaching content, teaching strategy and teaching evaluation.

1) Teaching content design: The teaching practice of this research is mainly carried out in the basic information technology course "Multimedia Technology Application (Advanced)" of The High School Affiliated to Renmin University of China, which mainly includes two modules, image production and audio and video editing. Therefore, it is necessary to focus on infiltrating the course content to cultivate the thinking habit of "task decomposition" based on the concept of layers, the thinking habit of "concrete-abstract-concrete" based on dynamic brushes, and the iteration and improvement method based on comprehensive large tasks, so as to encourage students to think and solve problems from the perspective of computational thinking.

2) Teaching strategy design: Compared with traditional multimedia technology course teaching, the teaching experiment requires teachers to re-examine the course teaching strategy from the perspective of computational thinking. For example, with the help of novel and interesting and task-driven teaching cases, teaching can be carried out through the four links of "task decomposition-task design-task reflection-task optimization", which can not only stimulate students' interest, but also enable teachers to track the process of students' thinking formation.

3) Teaching evaluation design: Teaching evaluation is an important part of testing teaching effectiveness. Teachers can rate students' self-filled multimedia work design reports and use the "Middle School Students' Computational Thinking Quality Questionnaire" to evaluate students' computational thinking ability at the current teaching stage, so as to clarify the specific foothold for the next step in cultivating students' computational thinking development.

3.6. Computational Thinking Training Model Based on DBR

Through the analysis of teaching content and objects in the early stage, as well as the design of teaching content, teaching strategies and teaching evaluation, it is feasible to integrate computational thinking into the teaching and learning of current multimedia technology application course. Therefore, the study will follow the principles of information technology computational thinking teaching under the DBR concept and construct a high school information technology computational thinking training model based on DBR.

The construction of the DBR-based high school information technology computational thinking training model should be based on the general implementation process of design-based research. In this model, teacher activities mainly include five parts, including pre-class preparation, case teaching, tasks designing, online tutoring, and summary and comments. Student activities are divided into four steps, including case learning, tasks clarification, tasks completion, and evaluation and reflection.

Teachers should create a good design environment for learners. Under the guidance of design-based concepts, they should use relevant methods of computational thinking (abstraction and decomposition, design, and evaluation) to inspire students' computational thinking in the designed teaching tasks and good learning situations. Teachers should also guide students to experience the general process of design through designing multimedia works, so as to improve their abstraction and decomposition ability of problems, as well as their design ability and evaluation ability.

Under the guidance of teachers, students use computational thinking methods to analyze tasks and solve problems. Finally, teachers should summarize the effects and shortcomings of each round of teaching practice in a timely manner, and improve the next round of teaching design based on classroom observations, students' works and their design process record sheets. Students will further modify and improve their works based on the comments and suggestions of teachers and classmates, and then upload the final version of the works and design process record sheets to the learning platform. The DBR-based high school information technology computational thinking training model is shown as Figure 3.

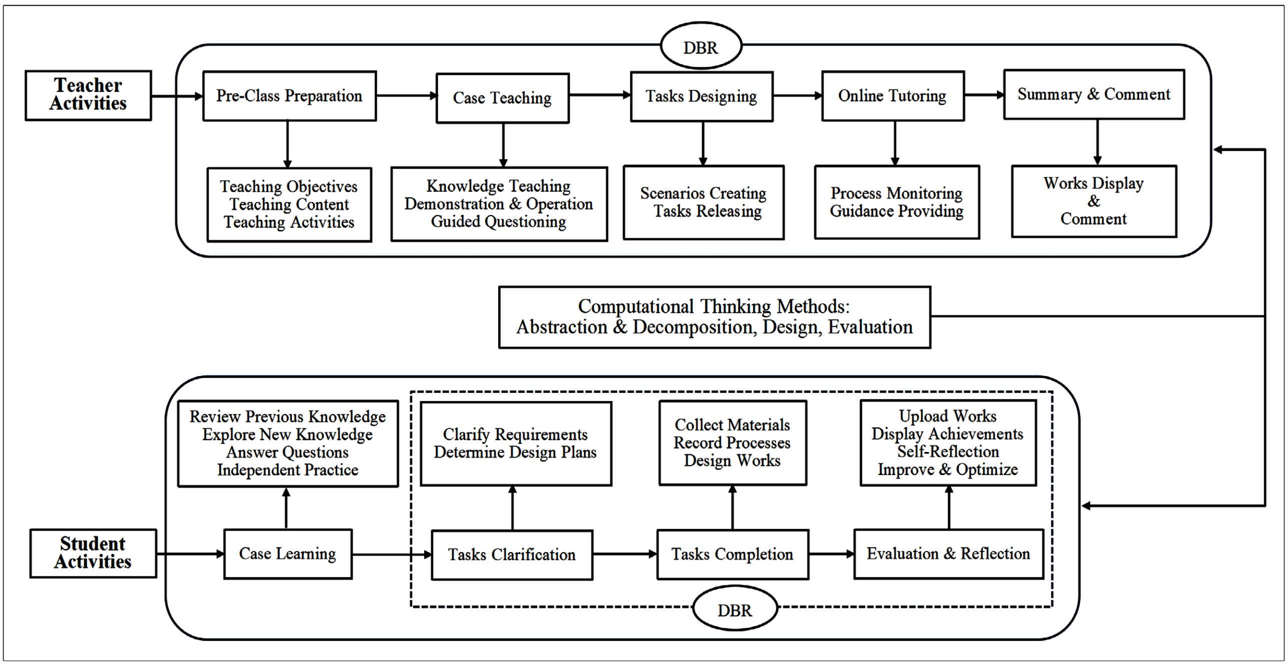

Figure 3. Computational thinking training model based on DBR.

4. Teaching Practice of DBR-Based Computational Thinking Cultivation Model

4.1. The First Round of Teaching Practice: Multi-Layer Operation Teaching Practice Based on Task Decomposition

4.1.1. Teaching Objectives and Implementation

This round of teaching takes "Public Welfare Poster for Haze Weather" as the theme. Through the concept of Photoshop layers, students are guided to experience task decomposition thinking and convert complex tasks for the entire image into multiple subtasks for each layer, thus forming a computational thinking mode of "top-down, from complex to simple, and decomposition step by step".

The teaching implementation adopts a three-stage design. In the first stage, the limitations of single-layer processing are demonstrated through negative cases. During the process, the concept of layers is introduced, and the layered production process of the contrast effect between the blue sky and haze in Tiananmen Square is demonstrated. In the second stage, learning tasks are assigned. Students are required to design public welfare posters around the theme of "anti-haze" using the layered design method and submit a detailed work design report. In the third stage, independent evaluation and reflection are carried out, which aims to train students' evaluation and expression abilities through the display and sharing of poster works.

4.1.2. Teaching Effect and Analysis

From class observation, students' participation is relatively high, and most students are able to process layers based on the idea of task decomposition. However, students' active performance in class is not significantly reflected in the improvement of the quality of their works. The evaluation results of the works show that the pass rate of the works reached 87.5%, but only 5.39% of the works scored above 80 points. 50% of the works scored in the range of 60-70 points.

The further specific analysis found that the vast majority of students used multiple layers to store image content separately, reflecting the task decomposition thinking mode. However, their work design reports were generally brief and failed to fully reflect the design ideas and processes. Further analysis of the content of work design reports found that 59% of the content involved design concepts, 25% described operational skills, and only 16% reflected the idea of multi-layer task decomposition.

4.1.3. Reflection and Improvement Strategies

Based on classroom observations and interviews with teachers and students, this round of experiment had the following problems. First, students spent too little time on making design reports, and the lack of systematic design led to a lot of reworks. Second, the resource management and evaluation functions of the online learning platform were not fully utilized. Third, teachers and students paid too much attention to the work itself and ignored the process of students' thinking formation.

In response to the above problems, an improved teaching practice plan has been proposed. Through preliminary investigation of the task themes that students are interested in, it is determined that the themes of the second round of teaching practice will be poetry illustrations, postcard making, and landscape beautification. The evaluation criteria for students' works are clearly informed, and it is emphasized that the design report will account for 40% of the score. Students are guided that they should make full use of the learning platform for resource sharing and interactive evaluation, while teachers should implement a teaching process that focuses on students' thinking activities, and give students ample space for thinking and exploration.

4.2. The Second Round of Teaching Practice: Dynamic Brush Based on "Concrete-Abstract-Concrete" Process

4.2.1. Teaching Objectives and Implementation

In the high school multimedia technology course, the concept of "dynamic brush" in PS reflects the thinking mode of abstracting common features from specific problems to build models, and then applying them to specific problem solving. It shows the thinking process from specific to abstract and then to specific.

This round of teaching designed a task with the theme of "I love Beijing Tiananmen" based on the concept of dynamic brush. By integrating the computational thinking method of "concrete-abstract-concrete" into the learning of dynamic brush knowledge points, it aims to achieve dual teaching goals. First, to enable students to master the basic properties of the brush panel and advanced property settings such as shape dynamics and color dynamics, and then understand the use and operation skills of dynamic brushes. Second, to cultivate students' understanding of the thinking method from specific to abstract and then to specific, so that they can "abstract" and "model" practical problems and form corresponding thinking habits.

The teaching process is divided into three stages. First, the teacher guides students to think about the commonality and individuality of balloons by showing an image of Tiananmen Square with balloons of different sizes and colors, aiming to make students understand the logical thinking of "from specific balloons to balloon templates and then deriving balloons from templates" and strengthen their understanding of the "abstract" and "modeling" thinking patterns. Secondly, the teacher assigns learning tasks, requiring students to use dynamic brushes to select real objects in life to abstract into pattern models. Students need to enrich and beautify the background image by changing the size and color of the specific patterns derived from the models, and submit a design report of the work that reflects the design ideas. Finally, through learners' self-evaluation and reflection, the teacher comments on students' works on the MOODLE platform especially focusing on the evaluation from the "concrete-abstract-concrete" process of dynamic brushes. Mutual evaluation among students is encouraged.

4.2.2. Teaching Effect and Analysis

This round found that students' enthusiasm for completing multimedia works has increased significantly, and the number of innovative works has gradually increased. In three teaching activities, more than half of the submitted works achieved excellent scores of more than 80 points. The distribution of work scores shows that the overall quality of multimedia works designed by students has improved, especially the number of works with scores between 90 - 99 points has shown a clear increasing trend.

Through the content analysis of the work design report, it was found that about 80% of the learners were able to make work design reports according to the requirements. The students had a clear understanding of the process of work formation and could clearly explain the embodiment of the "concrete-abstract-concrete" design idea. In addition, students were able to design a variety of models such as swallows and snowflakes starting from the specific objects around them, and their ability to diverge thinking and connect with specific things was exercised.

However, a typical student work design report shows that some students clearly mastered the "abstract" and "modeling" design ideas of dynamic brushes and could correctly use dynamic brushes to complete the work design, while the other part of the students did not have a deep understanding of the design ideas embodied in dynamic brushes, needing to strengthen the integration and cultivation of computational thinking.

4.2.3. Reflection and Improvement Strategies

Through classroom observation and work evaluation analysis, the following problems exist in this round of research. First, students are not clear about their learning goals, especially the goal of cultivating computational thinking. Moreover, there are obvious differences in the efficiency of students completing tasks, and students with poor foundations do not have enough time. Third, the design ability and time control ability of middle and lower-level students need to be strengthened.

In response to these problems, the corresponding teaching practice has been improved. Firstly, clearly write computational thinking training into classroom teaching objectives and inform students. In addition, pay attention to student differences, adopt student mutual assistance methods and encourage students who complete faster to help students with learning difficulties. It is of great significance that teachers pay more attention to the design activities of middle and lower-level students, and actively ask about the design progress and provide timely guidance. These improvement measures provide important references for the optimization of the next round of teaching practice.

4.3. The Third Round of Teaching Practice: Comprehensive Design Ability Training Based on Complex Tasks

The third round of teaching practice is based on the practice of the first two rounds. It uses the "Idols Are Coming" theme poster design as a carrier to construct comprehensive and complex tasks, aiming to achieve in-depth cultivation and transfer application of computational thinking ability through high-level design activities.

4.3.1. Teaching Objectives and Implementation

This round focuses on the comprehensive application level of computational thinking training, which is specifically reflected in using abstract and modeling ideas to plan and design the overall work, using task decomposition strategies to deal with complex design problems, and having the reflective ability to evaluate and optimize the work. The course content objectives are positioned at the comprehensive application of multimedia technology, including the task decomposition of multi-layer operations, the proficient application of image beautification technology, and the creation of complete works that meet the requirements of the theme.

The teaching implementation adopts a three-stage model of "problem driven-design practice-reflection optimization". In the first stage, students are guided to decompose tasks and conduct abstract modeling through theme analysis to form a design plan. In the second stage, students are required to conduct independent design practice based on the plan and simultaneously complete a design report to record the thinking process. In the third stage, reflection optimization is achieved through work display and peer evaluation. The whole process emphasizes the explicit application of computational thinking methods.

4.3.2. Teaching Effect and Analysis

The teaching effect evaluation adopts multi-dimensional data analysis. In terms of the quality of works, the average score of 112 poster works reached 88.13 points (standard deviation: 6.27), which was significantly improved compared with the second round. More than 80% of the works reached the excellent level. The key factor in the improvement is that students can effectively use the technical foundation accumulated in the early stage, and at the same time show stronger independent learning ability and peer collaboration awareness.

The design report analysis shows that students expressed their design ideas, operation methods and design concepts most fully, reflecting the change from "thinking while doing" to "planning-implementation-reflection" thinking mode. The quality of students' works using the design report template is significantly better than those who did not use it, confirming the positive effect of pre-design planning on the quality of the work. This finding verifies the effectiveness of abstraction and decomposition strategies in computational thinking in complex task processing.

Classroom observation data show that students have undergone significant changes in problem-solving strategies, from relying on teacher guidance to independent online exploration and peer assistance. It reflects the profound impact of computational thinking training on learning methods. The participation of middle-level students has increased significantly, showing a higher willingness to express and stronger critical thinking ability.

4.3.3. Reflection and Improvement Strategies

This round of practice verified the effectiveness of the computational thinking training model based on DBR theory in complex task scenarios. Through comprehensive design tasks, students not only mastered technical skills, but more importantly, formed a systematic problem-solving thinking framework. Subsequent surveys showed that 93% of students believed that their design ability had been significantly improved, and 87% of students were able to consciously use task decomposition and abstract modeling methods to deal with complex problems.

Practice has proved that organically integrating computational thinking concepts into subject teaching and designing complex tasks in real situations can effectively promote the development of students' high-order thinking ability. This provides an operational practical path for the cultivation of computational thinking in the basic education stage.

5. Analysis on the Effect of Multimedia Technology Teaching Practice for Cultivating Computational Thinking

5.1. Analysis of the Effect of Cultivating Computational Thinking Ability

After three months of teaching experiments, a questionnaire survey on computational thinking quality was conducted on students in the experimental class and the control class (112 and 109 valid questionnaires, respectively). The questionnaire was designed from three dimensions, computational thinking awareness, computational thinking methods, and computational thinking ability. Computational thinking awareness refers to students' understanding of computational thinking, including its significance, the connection between computational thinking and problem-solving, and the necessity of offering courses regarding computational thinking, etc. Computational thinking methods refer to the thinking approaches such as abstraction, decomposition, and modeling when solving complex tasks. This dimension mainly includes students' understanding of computational thinking methods and the frequency of their application of computer knowledge. Computational thinking ability refers to students' capacity to flexibly apply computational thinking methods to solve practical problems. It mainly focuses on students' thinking paths when addressing thematic issues in multimedia technology courses. Options for each question under each dimension were represented by A, B, and C, respectively, according to the degree of compliance with the computational thinking method from weak to strong.

5.1.1. Computational Thinking Awareness

The computational thinking awareness dimension mainly investigates students' cognition of the importance of computational thinking, the understanding of its relevance to problem solving, and their judgment on the necessity of opening related courses. The statistical results of the questionnaire survey in this dimension are shown in Table 1. The survey results show that the computational thinking awareness level of students in the experimental class is significantly higher than that in the control class.

The data showed that 66.3% of the students in the experimental class reached the highest level of computational thinking awareness, while only 36.5% of the students in the control class did so. More than 80% of the students in the experimental class had a correct understanding of computational thinking, which is they understood it as a thinking process that uses abstraction, modeling etc. to solve problems. However, more than half of the students in the control class still believed that computational thinking was only applicable to computer majors or programmers.

Table 1. Post-test survey results: computational thinking awareness dimension.

Serial Number	Option A		Option B		Option C	
	Experimental Class	Control Class	Experimental Class	Control Class	Experimental Class	Control Class
a1	3.6%	11.0%	37.5%	59.6%	58.9%	29.4%
a2	2.7%	11.0%	33.9%	49.5%	63.4%	39.4%
a3	9.8%	14.7%	33.0%	58.7%	57.1%	26.6%
a4	4.5%	13.8%	28.6%	43.1%	67.0%	43.1%
a5	8.0%	20.2%	7.1%	35.8%	84.8%	44.0%
Overall	5.7%	14.1%	28.0%	43.5%	66.3%	42.4%

By comparing the pre- and post-test data, it was found that the number of students who thought it was very necessary to offer computational thinking-related courses increased by 326.7% (15 people in the pre-test and 64 people in the post-test). Post-class interviews showed that most students in the experimental class showed a strong interest in using computational thinking methods to solve problems, while students in the control class had a neutral attitude towards this. It indicates that the multimedia technology course based on computational thinking effectively enhanced students' computational thinking awareness.

5.1.2. Computational Thinking Methods

Computational thinking methods are the core of computational thinking qualities. This dimension includes the degree of understanding of computational thinking methods, the frequency of computer use, and the application of computer knowledge.

As shown in Table 2, the students in the experimental class have a significantly better grasp of computational thinking methods than the control class. 60.3% of the students in the experimental class reached the highest level, while only 29.6% of the students in the control class did. Specifically, more than 50% of the students in the experimental class can clearly state common computational thinking methods and have formed the habit of using computational thinking methods to learn multimedia technology courses, such as planning the design process of the work in advance, designing and modifying the work according to the design ideas, and actively thinking and exploring when encountering problems. In contrast, most students in the control class are accustomed to imitating the teacher's case, and their design works are stereotyped, lacking creativity and personal thinking.

Table 2. Post-test survey results: computational thinking method dimension.

Serial Number	Option A		Option B		Option C	
	Experimental Class	Control Class	Experimental Class	Control Class	Experimental Class	Control Class
b1	17.0%	42.2%	32.1%	47.7%	50.9%	10.1%
b2	0.9%	4.6%	14.3%	23.9%	84.8%	71.6%
b3	17.9%	47.7%	31.3%	46.8%	50.9%	5.5%
b4	4.5%	7.3%	41.1%	61.5%	54.5%	31.2%
Overall	10.0%	25.5%	29.7%	45.0%	60.3%	29.6%

The pre-test results showed that in the item "can often apply the computer knowledge learned in life and study", fewer students in the experimental class chose option C than in the control class, while the post-test results were the opposite. It indicates that multimedia technology course based on computational thinking is conducive to students' learning and actively using computer knowledge to solve practical problems.

5.1.3. Computational Thinking Skill

Computational thinking ability is the fundamental goal of the training. The items in this dimension include multimedia production methods, mastery of information technology course difficulties, and recognition of the importance of learning content. The post-test statistical results of this dimension are shown in Table 3.

Table 3. Post-test survey results: computational thinking ability dimension.

Serial Number	Option A		Option B		Option C	
	Experimental Class	Control Class	Experimental Class	Control Class	Experimental Class	Control Class
c1	5.4%	27.5%	13.4%	33.0%	81.3%	39.4%
c2	2.7%	2.8%	19.6%	24.8%	77.7%	72.5%
c3	9.8%	45.9%	17.0%	27.5%	73.2%	26.6%
c4	44.6%	39.4%	26.8%	37.6%	28.6%	22.9%
c5	8.0%	11.9%	23.2%	38.5%	68.8%	49.5%
Overall	14.1%	25.5%	20.0%	30.3%	65.9%	44.2%

As can be seen from Table 3, multimedia technology teaching that incorporates computational thinking content significantly improves students' computational thinking ability. 65.9% of students in the experimental class reached the highest level, which is significantly higher than 44.2% in the control class. More than 80% of students in the experimental class chose to use the method of abstraction and decomposition to complete the task when making poster works, and most students were able to use computers to solve problems when they encountered difficulties in learning multimedia technology. It demonstrates that they had the ability to effectively use computational thinking methods to solve problems. Through work analysis and student interviews, it was found that the multimedia work design ability, problem abstraction ability, and work evaluation ability of students in the experimental class were significantly improved.

5.2. Evaluation and Analysis of Multimedia Works

After three rounds of teaching practice, the results of five multimedia works of students in the experimental class were investigated and counted as follows.

As can be seen from Table 4, the lowest score, highest score and average score of the five themes all show an increasing trend, reflecting that with the improvement of teaching design, computational thinking concepts can be better integrated into classroom teaching. Also, students gradually adapt to this teaching model, and their design ability and problem-solving ability continue to improve.

Table 4. Descriptive statistics of the works' performance.

	Theme	Average Score	N	Standard Deviation	Minimum Score	Highest Score
First Round	Anti-Haze Welfare Poster	67.25	112	8.25	50	92
	Poetic and Picturesque	79.02	112	9.10	55	94
Second Round	I Love Beijing Tiananmen	82.68	112	8.57	62	95
	Exclusive Postcard	84.61	112	8.85	64	96
Third Round	Idols Are Coming	88.13	112	6.27	71	98

Since the scores of works 1 and 5 satisfy the normal distribution, and the experimental subjects and the number of people in teaching practice are consistent, the paired sample T test method is used to detect the difference in the scores of the first and third rounds of works. The result is shown in Table 5.

Table 5. Paired samples t test of works 1 and 5.

		Pairwise Difference			t	df	Sig. (2-tailed)
		Mean	Standard Deviation	Standard Error of the Mean			
Pair 1	Works 1 - 5	−20.87500	8.99762	0.85020	−24.553	111	0.000

Since the scores of works 3 and 4 do not meet the normal distribution, the Wilcoxon rank sum test is used to test the overall distribution of the scores of the three-multimedia works in the second round of teaching practice, and the associated samples are still used in the test. The test results in **Table 6** show that the P values between the three-multimedia works are all less than 0.05, indicating that there are significant differences.

Table 6. Non-parametric tests on the performance of three multimedia works.

	Work 4 - Work 3	Work 3 - Work 2	Work 4 - Work 2
Z	−8.723a	−8.854a	−9.211a
Asymptotic Sig. (2-tailed)	0.000	0.000	0.000

From the above data analysis, it can be concluded that the multimedia work design ability of the experimental class students has been significantly improved before and after the multimedia teaching practice based on computational thinking. The high school information technology computational thinking training model based on DBR can effectively promote the development of students' design ability.

5.3. Final Test Results and Analysis

In order to comprehensively evaluate the teaching effect of multimedia technology course based on computational thinking, the final test scores of the experimental class (112 students) and the control class (109 students) were compared and analyzed. The final test was conducted in the online form, including objective questions (10 multiple-choice questions, 20 points) and subjective questions (2 comprehensive questions on image editing and production, 80 points). After the test was completed, the scores of students in each part of the questions were calculated. The statistical results of the final test scores of the experimental class and the control class are as shown in **Table 7**.

Table 7. Statistics of final test scores of experimental and control classes.

Category	Class	Number of People	Average Score	Standard Deviation
Objective Questions	Experimental Class	112	14.71	3.17
	Control class	109	12.72	3.29
Subjective Questions	Experimental Class	112	75.21	5.96
	Control Class	109	72.09	9.98
Total Score	Experimental Class	112	89.93	7.65
	Control Class	109	84.81	10.86

The statistical results show that the experimental class scored significantly higher than the control class in objective questions, subjective questions and total scores, and the standard deviation was smaller than that of the control class, indicating that the experimental class students' scores were more concentrated and their overall level was higher.

In order to further determine whether there is a significant difference in the final test scores between the experimental class and the control class, and to verify the effectiveness of the multimedia technology course teaching based on computational thinking, the final test scores of the two classes were analyzed for significance. Since the objective question scores, subjective question scores, and total scores of the experimental class and the control class did not meet the normal distribution, the Mann-Whitney U test was used to conduct a non-parametric test on the scores of each part of the two classes. The results are shown in **Table 8**.

Table 8. Non-parametric tests of final test scores (experimental class-control class).

Test Statistics			
	Objective Questions	Subjective Questions	Total Score
Mann-Whitney U	4144.000	5066.500	4068.000
Z	−4.189	−2.214	10063.000
Asymp. Sig. (2-tailed)	0.000	0.027	0.000

The test results show that the significance test probabilities of objective questions, subjective questions and total scores are 0.000, 0.027 and 0.000 respectively, all less than the significance level of 0.05. Thus, it confirms that there is a significant difference in the final test scores between the experimental class and the control class. This further verifies that the multimedia technology course based on computational thinking can effectively support classroom teaching and significantly improve students' academic performance.

Combined with classroom observation and post-class student interviews, the experimental class students' interest in multimedia technology courses and design ability are significantly higher than those of the control class, which further confirms that the multimedia technology course teaching that integrates computational thinking training has a significant positive effect.

Three rounds of teaching practice show that the computational thinking training model based on DBR has a significant positive impact on the cultivation of learners' computational thinking quality. Learners have undergone positive changes in computational thinking cognition, problem thinking methods and solutions, gradually developing the habit of using computational thinking methods to solve problems. Computational thinking ability and design ability have been effectively trained and improved.

6. Summary and Reflection

This study sorts out and explains the relationship between computational thinking and information technology education, design and computational thinking.

High school multimedia technology courses are taken as a carrier to form a high school information technology computational thinking training model based on DBR. In order to clarify the practical application of computational thinking training in teaching, the study carries out three rounds of teaching practice and verifies the effect of teaching practice through classroom observation, statistical work quality, analysis of work design report content, questionnaire survey, interview.

Based on the above teaching practice, the study mainly draws four conclusions that answer the three questions posed in the introduction as a whole. First, it is feasible to integrate computational thinking training into the work design activities of high school multimedia technology courses, and the effect is quite significant. Second, the teaching content, teaching strategies and teaching evaluation methods of high school multimedia technology courses that incorporate computational thinking concepts can effectively cultivate students' computational thinking abilities such as abstraction, decomposition, design and modeling. Third, requiring students to submit work design reports that record the design ideas and processes of the works can effectively cultivate students' abstract induction and self-evaluation abilities. Fourth, the computational thinking training model based on DBR is effective in cultivating learners' computational thinking abilities such as abstraction, design and evaluation in high school multimedia technology courses. In conclusion, as one of the important subjects for cultivating computational thinking, teachers should integrate the design abilities (including abstraction, modeling, implementation, evaluation and reflection, etc.) into daily teaching activities, and improve teaching design through multiple rounds of practice, ultimately forming a stable computational thinking cultivation mode.

Although the results show that multimedia technology courses incorporating computational thinking content can achieve good teaching results, this study still has certain limitations. For example, since the study only carried out teaching practice in "Multimedia Technology Application (Advanced)" course of grade two students in a single target school, whether the teaching model constructed and the teaching design proposed in this study are applicable to other high school information technology courses can be further practiced and explored in future research. This will not only provide a stronger confirmation of the research results, but will also deepen the research in the field of computational thinking education.

Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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