

Research on the development and application of lightweight artificial intelligence teaching resources for primary schools under the orientation of core competencies

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Abstract. With Artificial Intelligence (AI) incorporated into the core content of the Information Technology Curriculum Standards for Compulsory Education, primary school AI education faces problems such as severe homogenization of teaching resources, difficulty in penetrating core competencies, and disconnection between the development and application of teaching resources. To address these problems, this paper carries out practical research on stratified and lightweight teaching resources for primary education. Teachers and students from three pilot schools were selected as survey subjects, and a resource design system featuring competency orientation, stratified classification, operability, and lightweightness was constructed. Practice has proved that this system can effectively enhance students' awareness of AI ethics and teachers' practical ability to apply AI teaching resources.

Keywords: core competencies, lightweight teaching resources, grade-level segmentation, primary school artificial intelligence

1. Introduction

1.1. Research background

Artificial intelligence is increasingly becoming the core of productivity, and the state has deeply implemented the strategic action of educational digitalization, taking artificial intelligence as the core of education-driven development. *The Information Technology Curriculum Standards for Compulsory Education (2022 Edition)* has incorporated artificial intelligence into the core teaching modules, marking its official entry into the stage of standardized popularization. At present, primary education faces difficulties in both the supply of educational resources and their application in classrooms. Existing resources are severely homogenized, mostly focusing on the inculcation of knowledge while rarely penetrating the competency dimension. Classroom application also faces the problem of difficult implementation, with low resource utilization that can hardly support the cultivation of core competencies.

1.2. Domestic and international research status

Artificial intelligence education abroad started earlier and its education system has begun to take shape, placing greater emphasis on models that integrate practice into core competencies and focusing on penetrating core competencies through life-oriented and gamified design patterns [1]. Although developed countries such as the United States, the United Kingdom, and Japan have sound systems for cultivating competencies in this way, such models are mostly based on their own national education systems and are poorly adapted to China's context. Domestic research focuses on resource development and the exploration and application of resources, but the resources are severely homogenized and a systematic and complete system of core competencies has not yet been formed [2-4].

1.3. Research content

Focusing on primary school teaching resources under core competencies, this paper designs a resource framework and, based on the complete line of thinking of "system construction - resource development - pilot optimization - optimization summary", solves the difficulty of establishing core competencies in primary education and promotes the high-quality development of primary education.

An integrated system that places core competencies at the forefront and combines them with practical implementation is constructed to solve the problem of disconnection between core competencies and teaching resources, and to establish a mechanism of resource development, classroom application, and feedback optimization, so that resources can truly be put into practice.

2. Core concepts and theoretical basis

2.1. Definition of core concepts

The content studied in this paper involves the basic concepts of the four core competencies of information technology, primary school artificial intelligence education, lightweight educational resources, and the integrated resource application model.

2.1.1. *The four core competencies of information technology*

The four core competencies of information technology [5, 6] include computational thinking, innovation awareness, digital literacy, and information ethics. Computational thinking refers to the thinking activities in which students use computer science to solve problems and design systems. Innovation awareness refers to the curiosity and creative problem-solving ability that students exhibit in the process of learning artificial intelligence. Digital literacy refers to students' ability to use digital tools to effectively evaluate, use, and create information. Information ethics refers to the moral norms and codes of conduct that students should abide by in the information society.

2.1.2. *Primary school artificial intelligence education*

Primary school artificial intelligence education is popularized general AI education carried out for all students in grades 1-6, enabling students to experience AI scenarios through experiential and gamified teaching activities and to develop enlightenment education during the experience. Its difference from the secondary school stage is that it does not involve complex coding and places greater emphasis on the experience process and the penetration of core competencies in a humanistic environment, a way that is more adapted to the concrete cognitive patterns of primary school students.

2.1.3. Competency-oriented lightweight educational resources

The competency-oriented lightweight educational resources [7] mentioned in this paper are a fusion of the three concepts of competency orientation, lightweightness, and educational resources. Competency orientation determines the value orientation of resources, that is, resource development takes core competencies as the starting point rather than knowledge transmission as the ultimate goal. Lightweightness means that the operation of resources does not depend on expensive equipment; teachers can operate them directly without investing a large amount of resources, and existing resources can be integrated for immediate implementation. Educational resources are supportive materials provided to teachers in the teaching process, not the main teaching content such as lesson plans that replace the taught content.

2.1.4. Integrated resources

Integrated resources aim to break the mutual separation between resource development and classroom application. Their integration is reflected in three dimensions: goal-content integration, development-application integration, and implementation-evaluation integration. Goal-content integration means that core competency goals are integrated into resource content to avoid disconnection between resources and goals. Development-application integration means that resource developers and teachers act as collaborators to continuously optimize resources in teaching. Implementation-evaluation integration means that evaluation tools include resource packages, and evaluation results are fed back in real time to make teaching adjustments.

2.2. Theoretical basis

This paper selects several theories related to primary school artificial intelligence education for analysis, so as to support the development of the research content of this study.

2.2.1. Constructivist learning theory

Constructivism originates from Piaget's theory of cognitive development and emphasizes that learning is not the one-way inculcation of knowledge but the active construction of meaningful cognitive processes by learners based on their original experience. For the research in this paper, this theory can provide experience-based resource design and carry out stratified framework design according to different age groups.

2.2.2. Theory of core competency penetration

The theory of core competency penetration holds that core competencies need to be penetrated into the teaching process of all subjects. For the research in this paper, this theory supports stratified resource framework design and integrated classroom application, and provides theoretical support for the implementation of resources.

2.2.3. Theory of digital educational resource development

The theory of digital educational resource development is a cross-disciplinary theoretical system that integrates multiple theories. This theory emphasizes that digital resources should be designed as adapted teaching resource carriers according to learners' cognitive characteristics, teaching content, and digital technology. With regard to the research in this paper, this theory combines the principles of lightweight resource development and resource granularity design to decompose resources into forms such as micro-lectures, providing support for the subsequent design of course resources.

3. Status survey and problem analysis

3.1. Survey design

3.1.1. Survey subjects

This survey takes the current situation of both the supply and demand sides of artificial intelligence educational resources in primary schools in Chengdu as its goal, takes into account regional and individual differences, and covers two major groups: teachers and students.

Full-time and part-time teachers of information technology courses were selected as the main survey subjects, with the sample covering different years of teaching experience and different professional titles. Questionnaires combined with interviews were adopted to gain an in-depth understanding of resource selection and the acceptance of existing resources. For students, those in the lower grades (grades 1-2), middle grades (grades 3-4), and upper grades (grades 5-6) were selected as survey subjects of the three age groups, with a focus on collecting data such as students' learning experience with artificial intelligence and their preferences for AI materials.

3.1.2. Survey instruments

Based on the current situation of primary school artificial intelligence teaching resource development, this paper determines four sets of survey instruments: a teacher resource demand questionnaire, a student learning experience questionnaire, a teacher interview outline, and a classroom observation record form, to collect substantive data from teachers and students. The teacher resource demand questionnaire is aimed at full-time and part-time primary school teachers and consists of four parts: basic teacher information, the current status of AI teaching support, the demand for using teaching resources, and the guarantee demand for teaching resources. The student learning experience questionnaire is mainly designed for students in the middle and upper grades and mainly contains three parts: students' daily use of AI tools, the use of teaching resources in classroom teaching, and the forms in which artificial intelligence is received. The teacher interview outline involves one-on-one interviews with representative core teachers, with interview dimensions covering the difficulties teachers encounter in carrying out AI teaching, suggestions for the design of supporting teaching resources, and the implementation of teaching resources. The classroom observation record form is mainly used to record the entire process, including a basic information column, a resource application column, a classroom competency implementation observation column, and a problem recording column.

3.1.3. Survey implementation

This survey adopts an implementation process of "stratified sampling - phased data collection - data archiving and sorting", and is carried out in combination with the survey instruments mentioned above. Data processing adopts a method of integrating quantitative data with subjective data. Quantitative data are processed and analyzed using EXCEL and SPSS, including descriptive statistics, correlation and regression analysis, and difference testing.

3.2. Analysis of survey results

Through questionnaires, interviews, classroom observations, and other forms, this survey analyzes the results from three aspects: the current status of artificial intelligence teaching resources in schools, teachers' ability to use AI resources, and students' AI learning experience.

In terms of the current status of artificial intelligence teaching resources in schools, primary schools have abundant AI materials, but the overall systemicity is insufficient, lacking stratified design by grade level, and different types of materials are not supported by corresponding supporting implementation resources. In terms

of teachers' use of AI resources, teachers have basic abilities to use AI tools but lack the ability to further process them, and they expend a great deal of effort in coordinating various resources for information penetration in the classroom. In terms of students' AI learning experience in the classroom, the higher the acceptance of lightweight resources such as micro-lectures and paper-based task sheets by students, while traditional resources provide insufficient support for core competencies such as AI knowledge popularization and information ethics.

3.3. Summary of problems

The survey reveals problems at the following three levels. In terms of resource development, resource development is severely homogenized, with most content being similar, and resources are not designed according to age groups. In terms of resource application, the supporting instructions for resource application lack implementation guidance, and the utilization rate of resources by teachers and students is low throughout the entire teaching process.

4. Construction of the educational resource development system

4.1. Basic principles

This paper follows the following basic principles: competency orientation, stratified classification, operability, and lightweightness. The competency orientation principle places the cultivation of competencies at the front end of AI teaching, integrates value guidance into all teaching links, and completes the edification of digital ethics with teaching resources as the carrier. The stratified classification principle follows the laws of primary school students' cognitive development to realize differentiated resource supply, and at the same time classifies resources according to their usage scenarios, so that teachers can combine and use them according to the specific classroom situation. The operability principle combines the concrete thinking characteristics of primary school students, takes into account the implementation of resources, and realizes students' active participation in the classroom. The lightweightness principle does not rely on excessive specialized and integrated resources; teaching activities can be carried out with computers and paper-based materials.

4.2. Framework of the development system

Relying on the competency orientation principle and the stratified classification principle, this paper constructs a resource development system framework of "competency goal decomposition - teaching content subdivision - resource type matching - evaluation and feedback", and the specific framework is shown in Figure 1.

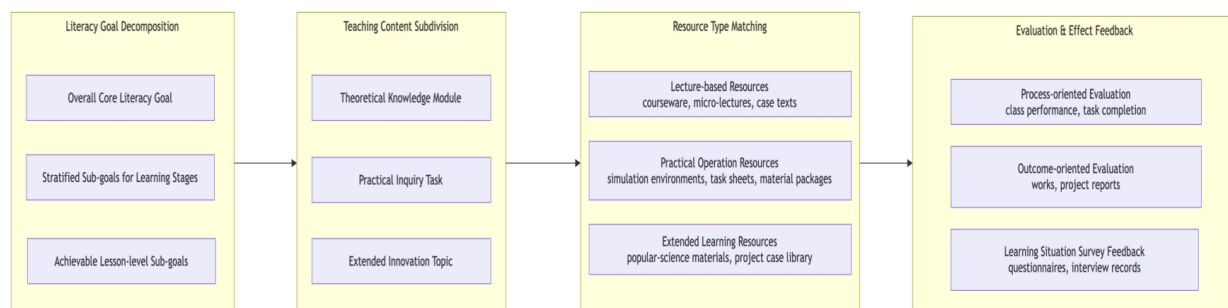


Figure 1. Framework of the development system

In the competency goal decomposition layer, the four core competency dimensions of computational thinking, innovation awareness, digital literacy, and information ethics run through the whole process. According to Bruner's theory of cognitive development, core competencies are divided into three stages of enlightenment - experience - application, corresponding to the three segments of primary school, with the lower segment focusing on digital perception, the middle segment on problem decomposition, and the upper segment on algorithm design.

In the teaching content subdivision layer, based on the decomposed core competency indicators, the AI-related content for each grade segment is determined, and the core ideas of artificial intelligence are transformed into life scenarios and subject activities that primary school students can understand.

In the resource type matching layer, according to the core competency goals and the characteristics of teaching scenarios, the most suitable teaching resources are matched. Five types of lightweight resources mainly need to be matched (classroom teaching courseware, micro-lectures, practical activity handbooks and task sheets, group activity plans, and supporting guidance materials for teachers), forming a process of core competencies, teaching content, and resource matching.

In the evaluation and feedback layer, core competency assessment runs through the entire teaching process. First, the outcomes that need to be formed to achieve the competency goals (such as work plans) are determined, then evaluation tools (such as evaluation scales) are designed, and finally the evaluation results are placed into each resource package, so that teachers can continuously optimize the teaching process when matching resources in teaching.

4.3. Development of stratified teaching resource packages

Based on the above resource development principles and following the cognitive characteristics of the lower, middle, and upper grade segments, a lightweight AI teaching development plan is formed. The development of resource packages for each grade segment is introduced in detail below.

4.3.1. *Resource package for the lower grades*

Aimed at students in grades 1-2, it focuses on perception and experience, allowing students to gain an initial perception of the content of artificial intelligence. The materials mainly consist of simple tasks such as cartoon illustrations and coloring, helping students understand the artificial intelligence around them in daily life.

4.3.2. *Resource package for the middle grades*

Aimed at students in grades 3-4, it mainly focuses on understanding and trying. The resources mainly consist of flowcharts and paper-based deduction, using only paper, pens, and computers for classroom logical deduction, guiding students to solve problems through layer-by-layer reasoning.

4.3.3. *Resource package for the upper grades*

Aimed at students in grades 5-6, based on innovation and information ethics, it guides students to view artificial intelligence technology correctly. The resources mainly consist of project task sheets and critical discussion courseware, and students complete creative AI design according to paper-based plans.

5. Practical verification

5.1. Construction of the application model

This paper constructs an integrated application model of "competency goals - resource application - classroom implementation - competency evaluation - feedback optimization". Taking core competencies as the goal, this model runs through the entire teaching application process and, based on the carrier of resource application,

uses competency evaluation and feedback optimization to truly implement core competencies in specific classroom scenarios.

In order to better integrate artificial intelligence courses into the teaching process and combined with the differentiated characteristics in teaching, three basic course types are formed: new-lesson courses, practical activity courses, and project expansion courses, ensuring the integration of resources and courses. New-lesson courses mainly help students establish the basic concepts of artificial intelligence, practical activity courses focus on developing students' computational thinking and innovation awareness, and project expansion courses require students to solve real problems.

5.2. Pilot implementation process

In order to truly reflect the actual effects, this paper selects three pilot schools, covering the complete grade segments of lower, middle, and upper levels. Through a stratified sampling strategy, the adaptability of lightweight resources in different teaching environments is fully verified, ensuring the validity of the experimental verification.

Based on Kemmis's action research model, this paper adopts two rounds of cyclical action research in each pilot school. The entire process is "first-round classroom practice - problem collection - resource iteration - second verification". The first-round classroom practice requires teachers to select appropriate teaching resource packages to carry out AI teaching and complete classroom observation records at the same time. Then, in the problem collection stage, the completed observation records are collected, and common and individual problems are sorted out in combination with interview content. Finally, in response to the collected problems, the existing resource packages are readjusted and the relevant guidelines are adjusted accordingly. In the second verification stage, the optimized resource packages are redistributed to each pilot school to verify the teaching effects of this round.

5.3. Analysis of practical effects

Based on the above implementation process, outcome materials such as classroom observation records, student questionnaires, and teacher interview records are obtained. The relevant results are sorted out below from the perspectives of both teachers and students.

5.3.1. *Comparison of students' cognition before and after*

5.3.1.1. *Computational thinking comparison*

Students in the pilot class are significantly better than those in the control class in problem analysis, logical reasoning, and other aspects. Students in the control class can only identify simple problems and have difficulty in decomposing artificial intelligence problems in daily life, while students in the pilot class can decompose problems one by one and break them down step by step.

5.3.1.2. *Digital literacy comparison*

The digital adaptation ability of the control class is weak, while the pilot class can clearly perceive and discover the artificial intelligence applications around them and can clearly describe the benefits and shortcomings brought by artificial intelligence.

5.3.1.3. *AI ethics comparison*

The control class has a one-sided understanding of artificial intelligence, while students in the pilot class can identify AI false information and propose codes of conduct for the standardized use of intelligent products, with significantly improved awareness of information and self-protection.

5.3.2. Comparison of teachers' resource design

Based on lesson plans and classroom records, it is found that teachers' resource design ability has been significantly improved. Teachers can screen and distinguish corresponding resources according to stratified competency goals and can independently adjust the resource package configuration in the classroom. Teachers' classroom teaching implementation ability has also been significantly improved, and they can skillfully master various teaching methods such as new-lesson courses. Teachers' competency-oriented thinking has also gradually taken shape. They can clarify the stratified goals of core competencies at the lesson preparation stage and design teaching goals around AI information ethics.

6. Conclusion

This paper focuses on practical problems such as the homogenization of primary school AI teaching resources, weak competency penetration, and the difficulty of resource implementation. Using field surveys, questionnaires, and action practice, it designs a lightweight resource design system. It can be found from the pilot verification that the teaching resource design system proposed in this paper is applicable to most types of schools and helps to improve students' awareness of AI ethics and teachers' ability to practically apply teaching resources.

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