Empirical Evidence: Elementary School Design Curriculum Development Based on Associative Thinking

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Abstract: With the global emphasis on innovative design education, the cultivation of innovative talents has become a fundamental breakthrough point in China's response to the "creativity crisis" and the promotion of "Made in China" to "Intelligent Manufacturing in China". In order to fundamentally solve the problem of the lack of innovative talents in the process of talent training, improving the design consciousness and ability of young people in the basic education stage gradually highlights its necessity and urgency. The purpose of this research is to use design thinking as a methodology to support the cultivation of creative abilities, and to provide students with a systematic way of thinking and process tools through design courses to help improve students' cognitive skills and creativity. This research reviews children's cognitive sources and characteristics from the perspective of cognitive physiological grassroots development, and discusses the role of association in the design process, which serves as the support of the design process. This research proposes a curriculum design framework model based on associative thinking, and develops the curriculum accordingly. Through the practice of curriculum in multiple primary schools and the multi-dimensional evaluation of the core literacy of students participating in the design of the curriculum, the theoretical model has been shown to improve the innovation ability. This research fills the gap in domestic design education at the basic stage. The developed design curriculum and integrated design thinking model are of great academic value and reference significance to the research of domestic design education development.

Keywords: Associative Thinking, Design Thinking, Design Education, Curriculum Development, Children Cognition

1 Introduction

1.1 Current Situation of Design Education

Design education has become a critical component in fostering creativity, problem-solving, and critical thinking skills among primary school students. As global educational reforms increasingly focus on cultivating innovative talents, integrating design thinking into early education is essential for preparing students to face future societal challenges. Countries like the United States and Finland have already incorporated design thinking into their K-12 education systems [16], promoting project-based learning and interdisciplinary approaches to nurture these core competencies.

However, design education in China's primary schools remains underdeveloped. Most existing curricula focus on traditional arts and crafts, emphasizing aesthetic expression rather than practical problem-solving. This disconnect from real-world applications limits students' ability to develop critical thinking and creative skills, which are increasingly essential in a rapidly changing world.

1.2 The Relationship between Associative Thinking and Design Education

Associative thinking, a cognitive process that involves making connections between seemingly unrelated ideas, is a key element in design thinking [17]. It enables individuals to think beyond conventional boundaries and generate innovative solutions. Despite its theoretical importance, associative thinking has not been systematically introduced into primary school curricula in China. There is a clear need to integrate this concept into design education to enhance students' creative abilities and problem-solving skills from an early age.

This study addresses the gap in primary school design education by developing a curriculum framework based on associative thinking. The proposed framework emphasizes task decomposition, resource integration, prototype development, and iterative improvement. Through practical teaching experiments, this study seeks to evaluate the curriculum's effectiveness and provide insights for future curriculum development.

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1.3 Research Objective

The study has three primary objectives: to analyze the cognitive characteristics of primary school students and their potential for associative thinking; to develop a practical design curriculum framework that integrates associative thinking into classroom activities; and to evaluate the curriculum's effectiveness in fostering creativity, problem-solving skills, and collaboration through experimental teaching practices.

This research contributes to the ongoing discourse on educational reform by filling a gap in the field of primary school design education. Unlike traditional art-based approaches that focus primarily on aesthetic expression, the proposed curriculum framework emphasizes practical problem-solving and the development of critical thinking skills.

Integrating associative thinking into primary school education offers several potential benefits [1]. By teaching students to establish connections between different knowledge areas, the curriculum helps them approach complex problems more creatively and confidently. This approach aligns with global trends in educational innovation, providing a comprehensive model for promoting creative education in primary schools.

1.4 Article Structure

This paper is structured as follows. Section two provides a background on the current state of design education globally and the theoretical foundations of associative thinking. Section three outlines the research methodology, including the curriculum framework development process and experimental teaching practices. Section four presents the findings from experimental teaching sessions, highlighting improvements in students' creativity and problem-solving abilities. Section five provides an in-depth analysis of the study's findings and addresses potential limitations. Section six summarizes the key contributions of the study and offers recommendations for future research.

2 Background

2.1 Overview of Design Thinking

Design Thinking, is understood as solving problems using a designer's mindset. Starting in the 1960s [14], designers gradually began seeking methods to support design research and explore design thinking. For example, in 1969, Nobel laureate Herbert Simon, in his book The Sciences of the Artificial, discussed the logic of design. Unlike the natural sciences, which reveal the physical properties of things, design is concerned with what things should be like and how to design artificial artifacts that better meet standards [28]. The design process he proposed significantly influenced the basic form of early design thinking models.

In 1972, American designer Robert Mckim, in his book Experiences in Visual Thinking, emphasized the importance of visualization in the design process, providing more concrete elaboration on design methods within the field of engineering design. Subsequently, Stanford Professor Rolf Faste, building on Mckim's research, defined design thinking as a creative methodology and established the "Stanford Joint Program in Design" to promote it. In 1987, Peter Rowe used the term "Design Thinking" for the first time in his book of the same name (Design Thinking), marking its official adoption.

In 1991, the design consultancy IDEO was founded. Then, in 1992, Richard Buchanan, then Dean of the Carnegie Mellon University School of Design, published the article "Wicked Problems in Design Thinking," further enriching the concept of design thinking.

Stanford University specifically established design thinking courses in 2005, and the Hasso Plattner Institute of Design at Potsdam, Germany (d.school Potsdam) was also founded in 2007. Currently, the development of design thinking at both institutions is at the international forefront.

Combining current domestic and international understandings of Design Thinking, it can be summarized into three aspects:

1.A methodology supporting innovative capacity building in real-world problem contexts:The systematic nature of Design Thinking can support innovative design and problem-solving, making it a human-centered innovation methodology [4].

2. An expert mindset or strategic model in the problem-solving process:Applying Design Thinking involves thinking like a designer by learning from designers' experiences and drawing inspiration from design tools.

3. An analytical process in the problem space and an innovative process in the solution space: In generating problem solutions, Design Thinking involves creative thinking. Within the design process, it requires people to engage in critical reading, logical thinking and reasoning, and to attempt to solve complex problems [22].

From the perspective of integrated thinking methods, mindsets, and innovation processes, Design Thinking can be seen as a link connecting problem occurrence and problem resolution, and is also a thinking process that employs a series of innovative methods to solve problems.

Design Thinking can be integrated into basic education to enhance students' developmental potential:

1. Human-Centered: Compared to traditional teaching approaches, Design Thinking differs significantly in problem consideration and process analysis [5]. It is a more empathetic analytical method. It stimulates core motivation through human-centered thinking and emphasizes the process of "problem perception and understanding," "solution ideation and prototyping," and "result testing and reflection."

2. Problem-Solving Methodology:Design Thinking emphasizes abductive reasoning, forming problem solutions through integrating diverse perspectives [31].

3. Driving Innovation:Through its emphasis on empathetic cognition (often metaphorically related to engaging the right brain/holistic thinking), Design Thinking complements the forms of traditional educational models that tend to focus on analytical [27], logical approaches (metaphorically related to left-brain activities).

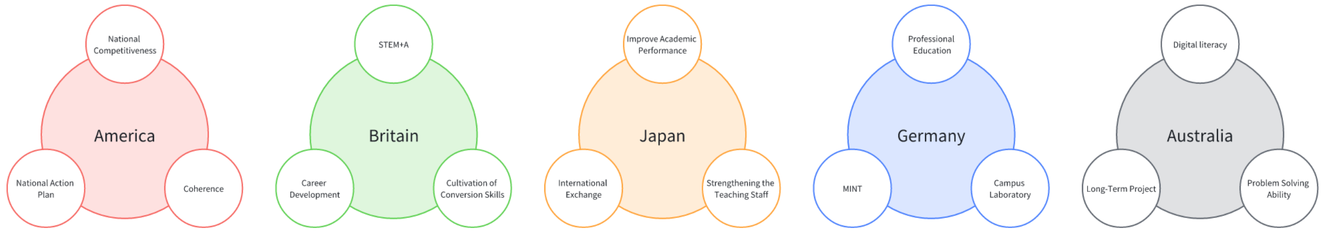

Figure 1. The Development of STEM in Various Countries.

In summary, Design Thinking education courses exhibit strong complementarity/synergy with other academic subjects, making them well-suited to be offered as general education courses.

2.2 Design Education and STEM

STEM stands for Science, Technology, Engineering and Math. The essence of STEM is integrated interdisciplinary teaching, with its core pedagogical framework centered on comprehensive curricula that emphasize the application of cross-disciplinary concepts to guide students in design innovation.

United States:To maintain national competitiveness, STEM education was proposed by the US National Science Board (NSB) in its 1986 report Undergraduate Science, Mathematics and Engineering Education and developed into a national strategy. In 2007, the National Action Plan for Addressing the Critical Needs of the U.S. Science, Technology, Engineering, and Mathematics Education System explicitly called for ensuring the coherence of STEM learning, improving STEM levels from kindergarten through college and beyond, and increasing STEM resources in K-12 education [26]. The STEM Education Act of 2015 went into effect in 2015. In 2010, Georgette Yakman, a scholar at Virginia Tech, developed the STEAM (STEM + Art) educational concept. The "A" in STEAM encompasses a broader range of humanities and arts subjects, including social studies, languages, physical arts, music, aesthetics, and performing arts. In 2018, the US government formulated Charting a Course for Success: America's Strategy for STEM Education [30]. However, at this stage, STEAM often exists more as an aspiration.

Developing STEM education to cultivate scientific and technological innovation talents has become a direct driving force for the US to maintain its global economic leadership. STEM education has also become an important strategy and pathway globally for cultivating innovative talents and reforming education systems.

United Kingdom: In 2004, the UK government published the Science and Innovation Investment Framework 2004-2014, outlining long-term strategic goals for STEM and establishing dedicated bodies to monitor the use and effectiveness of STEM funding [10]. In 2014, the STEM + ARTS = STEAM report, published by the Cultural Learning Alliance in the UK, repeatedly emphasized the need to cultivate students' creativity, analytical skills, and teach technical knowledge to foster problem-solving abilities beneficial for their careers. The UK has launched numerous STEM projects and activities, including the "Your Life" three-year plan, the "STEMNET" organization, and the "National Science and Engineering Competition," providing diverse activity formats and resource platforms to facilitate STEM education. UK STEM education development progresses in sync with global innovation, values the role of STEM plus the Arts (STEM+A) [2], places particular emphasis on cultivating problem-solving skills and transferable skills, and aims to nurture well-rounded, adaptable individuals capable of effectively responding to diverse environments and situations.

Japan: In the early 21st century, Japan began focusing on STEM education to improve students' academic performance. The Japanese government tends to strengthen STEM education through two main approaches: traditional reforms and innovations in basic education (such as increasing class hours and content for STEM subjects [29], establishing special funds, and enhancing teacher development) and international cooperation (including developing student exchange programs and teacher overseas training).

Germany:Germany's STEM equivalent is MINT (Mathematik - Math, Informatik - Informatics, Naturwissenschaften - Natural Sciences, Technik - Technology). Germany has introduced a series of policies to support MINT education [19], closely linked to vocational goals. It integrates curricula and enhances campus laboratory sessions to cultivate outstanding students who can pursue further studies and careers in mathematics, informatics, science, and technology-related fields.

Australia: Australian STEM education ranks above the global average. The National Innovation and Science Agenda published by the federal government in 2015 mentioned the "Digital Literacy and STEM Plan for all Australians," encouraging student and community engagement in science, technology, engineering, and mathematics while improving digital literacy. In 2016, the Education Council's National STEM School Education Strategy 2016 outlined long-term plans encouraging students to engage more with STEM subjects [20]. The Australian government believes STEM education fosters students' critical and imaginative thinking, enriches their integrated knowledge capacity, and enhances problem-solving abilities.

From the development experiences of STEM education in various countries, its full implementation is a systematic project requiring the joint participation and collaboration of governments, society, and schools. Overall, STEM education in China is still in its early stages. Research at the theoretical level primarily involves learning from foreign experiences and interpreting relevant reports. At the practical level, effectiveness varies significantly by region; curricula lack systematic planning on a macro level, and concrete implementation plans are often missing. Furthermore, engineering and technology components within STEM education are highly practical, requiring adequate hardware and laboratory environments for implementation. Additionally, there is a shortage of specialized STEM teachers and teacher training mechanisms. For many frontline teachers, while they may grasp the broad educational concepts and vision, they often lack specific, replicable, and effective implementation methods and approaches [8].

STEM education is an educational model proposed by the United States based on its national context and has gained prominence worldwide. John Maeda, former President of the Rhode Island School of Design, believes that all outstanding innovations come from bringing together elements from different fields. In 2011, he led the "STEM to STEAM" initiative, coining the slogan "STEM + ART = STEAM," where "A" represents "ART & Design," with "ART" standing for the arts and humanities, and "Design" referring to design thinking.

Examining the characteristics and development trajectories of countries leading in STEM education reveals that the originally distinct yet interconnected "meta-disciplines" of Science, Technology, Engineering, and Mathematics (STEM) have evolved into the STEM education model through an integrated and innovative development approach. An increasing number of countries are progressively strengthening STEM education as a crucial pathway for their talent strategies. Nations pin their hopes of cultivating versatile talents meeting contemporary demands on STEM education, leveraging it to foster students' interdisciplinary thinking and comprehensive abilities, thereby enhancing national competitiveness.

Simultaneously, reviewing the STEM development paths across nations indicates a shift: beyond implementing STEM education in basic education stages, countries are moving from primarily focusing on science and mathematics education models towards advocating for the integration of humanities and arts knowledge. There is growing recognition and emphasis on the value of the arts in science education and basic education, leading to exploration into art-integrated interdisciplinary models within STEM education and deeper fusion models of art and science. This convergence of art and technology aligns with the developmental essence of industrial design. Therefore, the current mainstream global advocacy for STEM education emphasizes science-and-technology-focused STEM thinking while balancing and integrating disciplines. From this STEM perspective, integrating the arts into other STEM fields leverages synergy between disciplines. This "Arts + Science" fusion model shares similarities with design education in industrial design. The global trend of STEM evolving into STEAM in various countries underscores the importance of integrating design education into basic education and reflects the broader trend of educational innovation demanded by social transformation and development in the new era.

Compared to the traditional curriculum objective-driven learning approach, STEM is more task-driven, fostering more dialogue with practice rather than merely focusing on acquiring knowledge and skills. Both STEM education and design education focus on authentic problem contexts, emphasizing the cultivation and enhancement of real-world problem-solving capabilities. However, they differ in the broad scope of the problems they address. STEM education primarily tackles problems at the "object-object" level, focusing on efficiency-driven issues, emphasizing the use of technology to enhance efficiency; all innovations revolve around achieving efficiency, aligning with STEM's origins. The development trend towards "STEM+A" indicates shortcomings in the implementation of the originally US-contextualized STEM model concerning education itself. Education is fundamentally human-oriented, while STEM places excessive emphasis on efficiency, lacking sufficient attention to the "human" element. The introduction of the STEAM concept aims to restore disciplinary balance. However, within STEAM, the focus on the "human" factor hasn't been elevated to a significantly important position; it primarily exists as a supplementary concept to the existing disciplines.

Beyond the "STEM+A" approach, other methods of reforming STEM education exist. For instance, the previously mentioned REDlab's d.loft STEM Learning curriculum series uses hands-on practices and interactive learning activities based on design thinking to cultivate deep engagement with STEM knowledge domains and spark interest in related careers [3]. This program offers learners a systematic model using authentic problem-solving contexts as the learning pathway and design thinking as the guiding strategy for learning activities. In this project practice, STEM provides the content knowledge, design thinking serves as the process tool, and together they facilitate the organization and execution of projects.

2.3 The Role of Associative Thinking in Design Education

Association is a vital cognitive mechanism for acquiring world knowledge [11]. It refers to the unique physiological reactions and thought processes triggered in the human brain when stimulated by external information. Association enables two distinct concepts to connect through cognitive linkage, sparking mental operations and establishing relationships to generate novel ideas. In micro-level studies of children's learning, association manifests as one of the fundamental intrinsic variations evident across all learning stages and every analytical level. Knowledge is constructed through accumulated experience, with newly acquired information connecting to prior knowledge. This learning method involving interrelated concepts is termed associative learning [12]. Association can be classified and analyzed along three dimensions:

1. Artistic Association vs. Scientific Association.Based on cognitive composition within modules, association falls into two categories:

Artistic Association: An organic integration of imagery, abstraction, and intentionality.

Scientific Association: Employs scientific thinking rooted in logic—the coordination of theory and evidence [15].

Note: In scientific association, children are often constrained by cognitive biases, adjusting external information to fit existing schemas (e.g., ignoring inconsistencies or selectively distorting information). In artistic association, excessive emphasis on aesthetics and emotional analogies can confine associations to superficial levels, limiting deeper exploration of intrinsic meaning.

2. Classification by Generation Mechanism: Contiguity, Similarity, Contrast and Causality.Based on how associations arise:

Contiguity Association: Association triggered by temporal or spatial proximity between two or more things.

Similarity Association: Association based on resemblances in form, properties, or function.

Contrast Association: Association arising from differences in form, properties, or function.

Causal Association: Crucial for problem-solving in learning; frequency increases with age. For given tasks, guiding students to explain why correct answers are right and wrong answers are erroneous proves more effective than merely stating answers or providing feedback.

3. Free Association vs. Forced Association.Based on behavioral approach:

Free Association: Spontaneous, unrestricted connections used to inspire creative ideas in general invention contexts.

Forced Association (Focus Method): Proposed by scholar Hvard; narrows conceptual gaps between ideas through structured brainstorming from a single starting point. Widely applied in promoting new products, technologies, and innovative thinking.

Association is foundational to thought processes. In contemporary design education, students often begin addressing a design problem by referencing past case studies, adapting solutions from prior examples—an instructional model grounded in associative combination theory. From a semantic network perspective, innovation in design emerges when unique associations between knowledge modules are identified and applied. The ability to diverge and connect information diversely is a key source of creative problem-solving in design [21].

Associative thinking manifests distinctly across domains:

1.Scientific Thinking: Characterized by rational logic, hypothesis testing, and knowledge innovation (Inhelder & Piaget note that this emerges only at the formal operational stage).

2.Artistic Thinking: Rooted in emotional intuition, symbolic expression, and formal innovation.

3.Design Thinking: Serves as a connective framework, integrating associative processes to address contextualized problems through knowledge application and product innovation. Design uniquely confronts complex, multi-factorial real-world challenges requiring synthesis of disparate information and management of interdependent variables. Philosophical and Neuroscientific Perspectives

Philosophically, within nature and society's intricate systems, constant conceptual associations in the human brain interlink all phenomena, transforming relationships into novel ideas—laying the material foundation for creation.

Neuroscientifically, because brain function depends on established neural pathways (or "wiring"), creating a familiar "connected" environment helps children comprehend their surroundings. Pruning neural connections strengthens preserved pathways, enhancing the brain's adaptability to new information.

Enhancing Associative Thinking and Improving associative cognition is multidimensional:

Level 1: Strengthen divergent/convergent thinking fluency and uniqueness to broaden cognitive scope and deepen thought.

Level 2: Facilitate cross-modal analogical transfer (language, imagery, objects, space) to boost information acquisition and transmission efficacy.

Level 3: Amplify hands-on application in problem-solving to rapidly materialize theoretical knowledge, identify logical linkages, and refine associative capacity.

2.4 The Role of Association

As early as 1890, William James explained attention, memory, imagery, and reasoning in The Principles of Psychology. "Cognition" refers to "the processes in the mind that transfer, modulate, narrate, store, retrieve, and utilize information [6]." Here, "information" denotes "knowledge," and the human act of inductively reorganizing knowledge, gathering and nesting it according to practical circumstances, constitutes cognition. In 1950, Alan Turing, the father of computer science, proposed the famous metaphor that "the human brain is a computer," illustrating that both computers and the human brain are information-processing units [25]. Furthermore, neuroscience has confirmed that knowledge is stored in memory as chunks. Association is a crucial cognitive factor in the operation of knowledge in the human brain.

In 2002, LeDou pointed out that newly formed connections based on experience are not entirely "new components"; they integrate with pre-existing connections [24]. The brain generally follows similar processing patterns, but experience causes branching in the connections between neurons, ensuring individual differences. Only by building on earlier connections and incorporating new modifications formed during development can individuals gradually tackle more complex problems.

Acquisition and Transformation of Knowledge: Children are constantly engaged in the process of acquiring information and transforming it into integrated knowledge. When external information enters the brain, the brain matches it against existing experience and knowledge modules. If the new information aligns with existing cognitive frameworks, the brain actively collects and integrates it into the existing knowledge structure. If the new information deviates from or contradicts existing concepts, the brain processes, filters, and reprocesses it. The outcome may involve discarding erroneous information (through rejection or forgetting) or revising existing knowledge modules to form new cognitive frameworks.

Memory and Storage of Knowledge: Memory is a fundamental function upon which many general cognitive functions rely. The composition of knowledge in memory has been described as "chunked elements connected in a web-like organization within the mind." These chunks consist of perceptions and concepts formed through various associations. Connections between chunks can arise in several ways:

1.Spatiotemporal Proximity: When two pieces of information are close in time or space, they form an association.

2.Frequency of Co-occurrence: When two pieces of information frequently appear together, they form an association.

3.Similarity or Contrast: When two pieces of information are similar or diametrically opposed, they form an association.

4.Causal Relationship: When one piece of information can be derived from another, they form an association.

While conventional learning is thought to rely on prior knowledge and experience to form new associations [7], Hermann Ebbinghaus, the first to scientifically study chunked connections in memory, argued that memory is a series of processes that receive and store experiences for later recall. By studying how meaningless syllables form memory connections without prior knowledge or learning experience, he demonstrated that the strongest associations are determined by spatiotemporal proximity—events closely linked in space and time are more easily connected and remembered [9].

Search and Application of Knowledge: In 1971, Atkinson and Shiffrin proposed a flowchart illustrating the flow of information from the environment through sensory registers to short-term memory. Several control processes determine whether information should be stored in long-term memory or merely used to generate immediate responses [23]. In the design process, systematic storage of information in knowledge chunks through behavioral design, along with the use of modular functions, can integrate more knowledge, thereby facilitating associations and forming new connections. This accelerates recall and enables faster responses when encountering new problem environments by quickly gathering information and retrieving related knowledge.

Early semantic network theory, one of the most influential models, depicted memory as a network of nodes, where each node represents a concept, word, or perceptual feature. Connections between nodes are formed by "associations" or relationships that link them. When a node is activated, it propagates activation along the network paths to other connected conceptual nodes [13]. Thus, knowledge is acquired through associations, stored in the brain as interconnected chunks, and retrieved via existing associations.

In summary, within cognitive mechanisms, the organization and acquisition of knowledge rely on "association," as do recall and retrieval. In other words, "association" plays an indispensable and essential role in the operational processes of cognitive functions, serving as a critical factor in the brain's knowledge operations. When a unique connection is formed, innovative outcomes naturally emerge.

2.5 Development of Design Education

Design education has gained significant attention in recent years as an effective way to equip students with essential twenty-first-century skills. Many countries have made design thinking a key component of their K-12 education systems, promoting project-based learning and interdisciplinary approaches to foster creativity and innovation. For example, the Next Generation Science Standards in the United States incorporate design thinking principles to promote hands-on learning and problem-solving across multiple subjects.

In Finland, design education is integrated into various subjects, encouraging students to engage in practical projects that require creative thinking and collaboration. These initiatives aim to cultivate students' ability to approach problems from multiple perspectives and develop innovative solutions to address real-world challenges. Associative thinking is a cognitive process that involves connecting seemingly unrelated ideas to generate new insights and solutions. It plays a crucial role in creativity, enabling individuals to think beyond conventional patterns and explore diverse problem-solving approaches.

In educational settings, associative thinking helps students establish connections between different knowledge areas, leading to more innovative and practical solutions to complex problems. Research suggests that children possess a natural capacity for associative thinking, which can be further developed through targeted educational interventions.

Integrating associative thinking into primary school design education can enhance students' ability to approach challenges creatively and improve their overall learning outcomes. By encouraging students to think beyond the boundaries of individual subjects, associative thinking promotes a more holistic and interdisciplinary learning experience.

Despite the proven benefits of design thinking, there are several challenges to its implementation in primary schools, particularly in China. One major challenge is the lack of teacher training and resources. Many teachers are unfamiliar with design thinking principles and lack the skills to effectively guide students through design-based activities.

Another challenge is the rigid structure of traditional curricula, which leaves little room for creative exploration. In many cases, design education is limited to art classes, where students focus on aesthetic expression rather than practical problem-solving. To address these challenges, there is a need to develop structured design curricula that align with students' cognitive development and educational needs.

This study proposes a structured curriculum framework that integrates associative thinking into primary school design education. The framework emphasizes task decomposition, prototype development, and iterative feedback, providing students with practical tools to approach real-world problems creatively and confidently.

By adopting a structured approach, the curriculum ensures that students are guided through the design process in a way that enhances their cognitive and practical abilities. Furthermore, the curriculum aims to foster critical thinking, collaboration, and communication skills, which are essential for success in the twenty-first century.

3 Methods

This study adopted a comprehensive methodology, utilizing multiple data collection and analysis techniques to evaluate the effectiveness and feasibility of the associative thinking curriculum. The following outlines the design and implementation of the research methods:

3.1 Research Design

The study aimed to develop and implement a primary school design curriculum framework based on associative thinking, assessing its impact on students' creativity. An experimental comparison design was used, dividing participants into an experimental group and a control group. The experimental group engaged in the associative thinking curriculum, while the control group received traditional instruction. The experiment lasted one semester, with diversified data collected and analyzed to evaluate the curriculum's outcomes.

3.2 Participants

The participants included 80 students from grades 3 to 5 across four primary schools in Zhejiang Province, evenly divided into the experimental and control groups (40 students each). Variables such as age, gender, and academic performance were controlled to ensure a high degree of homogeneity between the two groups.

3.3 Curriculum Development

The curriculum was developed based on design thinking theory and the associative thinking model, tailored to the cognitive characteristics and learning needs of primary school students. The curriculum aimed to enhance creativity and holistic competencies by guiding students in solving problems using associative thinking. It consisted of the following core modules:

1.Associative Thinking Training: Activities such as minigames and scenario simulations to stimulate students' associative abilities.

2.Design Practice: Application of associative thinking in design tasks, such as creating a "Shape of Sound" model.

3.Feedback and Reflection: Teacher evaluations and student self-assessments to help students summarize their design experiences.

3.4 Data Collection

A variety of methods were employed to comprehensively evaluate the curriculum's effectiveness:

1.Questionnaires: Administered pre- and post-course to assess students' interest, engagement, and improvement in creativity.

2.Classroom Observations: Documentation of teacher behaviors and student performance to analyze critical aspects of course implementation.

3.Student Work Assessments: Evaluation of students' design outputs for creativity and quality.

4.Interviews: Semi-structured interviews with teachers and students to gather insights and suggestions regarding the course implementation.

3.5 Data Analysis

Data analysis was conducted primarily using SPSS software, including:

1.Descriptive Statistics: Analysis of questionnaire data to evaluate the curriculum's impact on students' interests and abilities.

2.Differential Testing: T-tests to compare the experimental and control groups' creativity assessment scores, verifying the curriculum's effectiveness.

3.Qualitative Analysis: Thematic analysis of classroom observation records and interview content to extract key experiences and challenges in course implementation.

3.6 Experimental Procedure

Experimental Procedure:

1.Preparation: Pre-implementation training for experimental group teachers to familiarize them with the curriculum content and teaching methods. Development of teaching resources, including student handbooks and classroom observation forms.

2.Implementation: Experimental group students participated in six modules of the associative thinking curriculum over one semester, with each module lasting 1–2 weeks. The control group followed traditional lessons.

3.Mid-term Evaluation and Adjustment: Midway through the experiment, adjustments were made to the curriculum based on classroom observations and teacher feedback to better meet students' needs and objectives.

4.Conclusion: At the end of the semester, data from questionnaires, interviews, and work evaluations were collected for a comparative analysis of the experimental and control groups.

4 Results

The proposed design curriculum based on associative thinking was tested in multiple primary school settings to evaluate its effectiveness in improving students' creativity, problem-solving skills, and overall engagement. This section presents the results of the experimental teaching practices, including students' performance improvements, teacher feedback, and

Performance Indicator	Pre-Test Score (Average)	Post-Test Score (Average)	Improvement Rate
Creativity	3.4	4.5	0.32
Problem-Solving Ability	3.1	4.3	0.39
Teamwork Skills	3.6	4.4	0.22

Table 1. Comparison of Pre-Test and Post-Test Scores.

a comparative analysis between traditional and new design methods.

4.1 Improvements in Student Performance

The experimental results showed that students who participated in the associative thinking-based design curriculum demonstrated significant improvements in various aspects of learning. These aspects include creativity, hands-on practice abilities, and teamwork.

Students' creativity levels saw the most substantial improvement, with many participants demonstrating a newfound ability to establish connections between unrelated ideas and apply them to solve real-world problems. Their hands-on practical abilities also improved due to the curriculum's emphasis on iterative design and prototype testing.

Teachers observed that students were more willing to engage in collaborative tasks after participating in the curriculum. The emphasis on teamwork and peer assessment helped them improve their interpersonal and communication skills.

4.2 Project Outcomes and Student Works

Throughout the course, students completed several design projects that required them to apply associative thinking. These projects included designing practical household items, solving everyday problems, and creating prototypes using low-cost materials.

1.A foldable desk lamp designed to save space in small homes.

2.An adjustable bookshelf that can be easily reassembled based on user needs.

3.A recyclable bag made from old clothes to promote sustainable living practices.

The variety and practicality of student projects reflected their ability to apply associative thinking effectively. Teachers noted that students began to think more critically about everyday problems and sought innovative solutions that were both functional and environmentally friendly.

4.3 Teacher Feedback and Observations

Teacher feedback collected through interviews and observation sessions indicated that the curriculum had a positive impact on classroom dynamics and learning outcomes. Teachers reported that students were more engaged, motivated, and enthusiastic about participating in design activities.

Several key observations were made during the experimental teaching phase:

1.Active Participation: Students showed a higher level of engagement compared to traditional art classes. They were more willing to share ideas, discuss solutions, and provide feedback to peers.

2.Creativity Boost: The introduction of associative thinking techniques helped students break free from conventional thinking patterns. They became more comfortable experimenting with unconventional ideas and solutions.

3.Improved Problem-Solving Skills: The iterative nature of the curriculum encouraged students to learn from failures and continuously refine their designs, which enhanced their problem-solving abilities.

4.4 Comparative Analysis Between Experimental and Control Groups

A comparative analysis was conducted between the experimental group, which participated in the associative thinking-based curriculum, and the control group, which followed traditional design education methods.

The results revealed that the experimental group outperformed the control group in task completion, design originality, and collaboration. Students in the experimental group were more likely to complete their projects on time, propose innovative ideas, and work effectively in teams.

4.5 User Testing and Iterative Feedback

The curriculum's development process involved continuous feedback and iteration. After each project session, students and teachers provided feedback, which was used to refine the teaching methods and project guidelines.

This feedback loop ensured that the curriculum remained flexible and adaptive to students' needs. Adjustments were made to simplify complex tasks, introduce more interactive elements, and incorporate digital tools to enhance the learning experience.

4.6 Summary of Experimental Results

In summary, the experimental results confirmed the effectiveness of the associative thinking-based design curriculum in enhancing students' creativity, problem-solving skills, and collaboration abilities. The curriculum successfully shifted the focus from aesthetic expression to practical problem-solving, making it more relevant to students' everyday lives.

The findings suggest that integrating associative thinking into primary school education can significantly improve students' cognitive abilities and engagement in design activities. Furthermore, the feedback provided by teachers and students

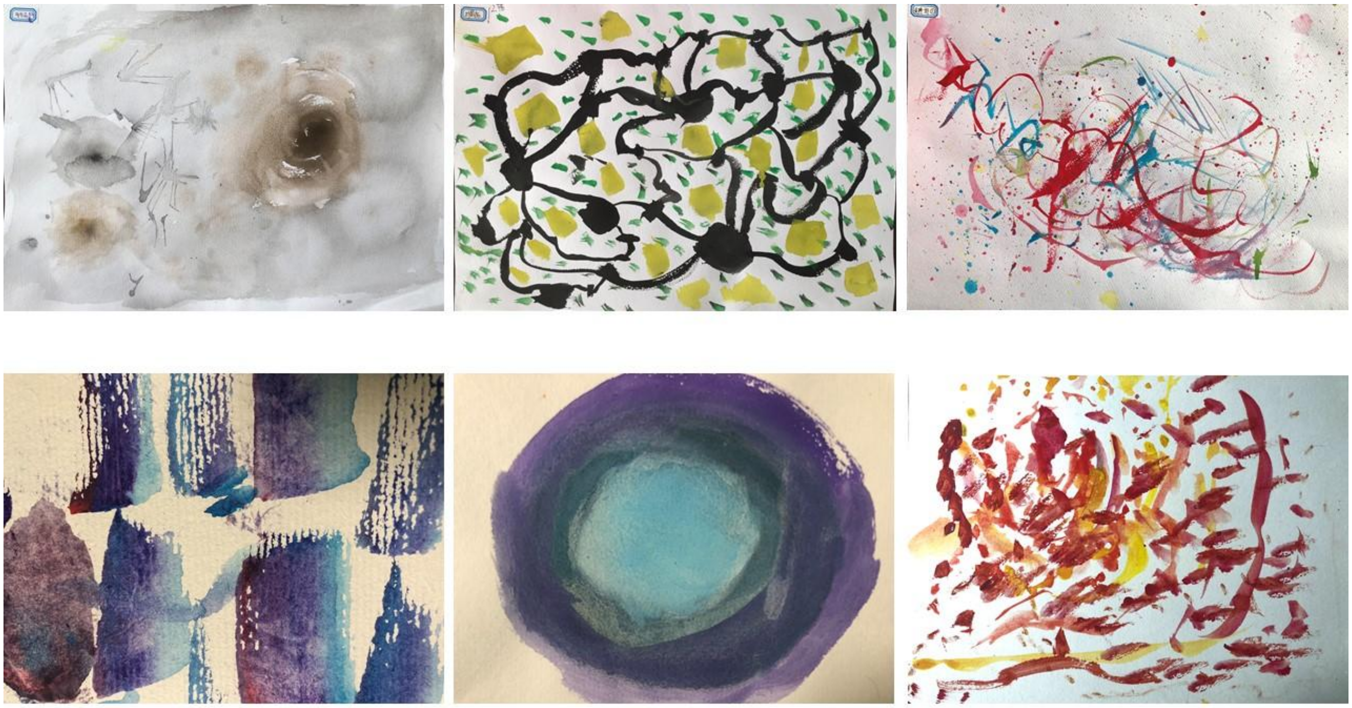

Figure 2. Examples of Student Works.

Indicator	Experimental Group	Control Group	Significance
Task Completion Rate	92%	78%	$p < 0.05$
Design Originality	4.6/5	3.8/5	$p < 0.01$
Collaboration	4.4/5	3.7/5	$p < 0.05$

Table 2. Comparison of Experimental and Control Groups.

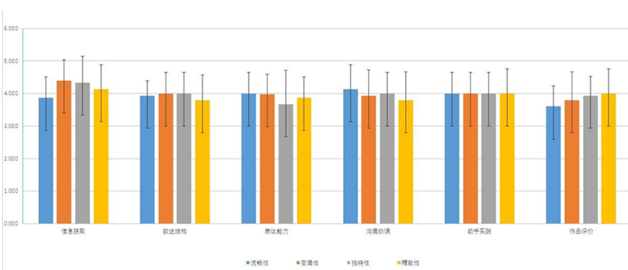

Figure 3. User Feedback Loop.

highlights the importance of continuous iteration in curriculum development to meet the evolving needs of learners.

5 Discussion

This study developed and implemented a primary school design curriculum based on associative thinking, demonstrating its significant effects on enhancing students' creativity and design thinking. This section focuses on the implications of the findings, the impact on existing educational models, and the role of associative thinking in primary school design education.

5.1 Significance of the Research Findings

The findings indicate that the design curriculum based on associative thinking not only proposes an innovative educational model at the theoretical level but also demonstrates significant teaching effects in practice. Firstly, the curriculum helps students establish a fundamental framework for design thinking. After participating in the program, students exhibited improved observational skills, associative thinking, and problem-solving abilities. This suggests that structured teaching activities can facilitate the transition from perceptual cognition to rational thinking, thereby enhancing students' overall competencies.

Secondly, the practical application of the curriculum at the primary school level provides a valuable reference for the innovative development of basic education in China. In a system primarily centered on subject knowledge, this curriculum fills the gap in innovation education. By implementing the curriculum, students not only learned to apply design thinking to real-world problems but also strengthened their teamwork and communication skills. This approach aligns with the national agenda of cultivating innovative talent and holds broad application potential.

5.2 Impact on Existing Educational Models

Traditional primary school education often centers on teacher-led instruction, with students passively receiving knowledge. The design curriculum developed in this study adopts a student-centered teaching model, emphasizing active exploration and problem-solving. This shift offers new perspectives for classroom teaching in basic education. The findings reveal that by setting task-oriented contexts and guiding students through associative training, students participate more actively in classroom activities, leading to significantly improved learning outcomes.

Furthermore, the curriculum redefines the teacher's role in education. Teachers no longer serve merely as transmitters of knowledge but as facilitators and mentors in the learning process. By providing problem contexts, guiding associative thinking, and offering feedback on students' design outcomes, teachers help students continually refine their ideas. This role transformation not only enhances classroom interaction but also offers new avenues for professional development in teaching.

5.3 Core Role of Associative Thinking

As the central concept of the design curriculum, associative thinking plays a vital role. By guiding students to establish connections between ideas and objects [18], the curriculum stimulates their creative thinking. This training method not only helps students develop more innovative solutions but also cultivates their ability to think divergently in complex problem-solving contexts. The study found that associative thinking is particularly well-suited for primary school students. At this developmental stage, students possess strong imaginal thinking capabilities, and training in associative thinking further helps them transition from perceptual to more logical design thinking.

Additionally, associative thinking enables students to overcome cognitive fixations. During the curriculum, activities such as keyword and shape associations allowed students to approach problems from diverse perspectives. This skill is beneficial not only for design education but also for learning across other disciplines.

5.4 Feedback from Curriculum Practice

The curriculum practice benefited not only students but also received high praise from teachers and schools. Teachers noted that the curriculum's innovative content effectively sparked students' interest in learning and increased classroom engagement and interaction. Some schools reported that the showcase sessions during the curriculum received positive feedback from parents and reinforced their confidence in adopting innovative education approaches.

Students also expressed their enthusiasm for activities such as observation, associative thinking, and hands-on practices. This participatory teaching model significantly enhanced their learning motivation and sense of achievement. Moreover, students noted that the curriculum not only equipped them with new skills but also gave them fresh insights into everyday problems.

6 Conclusion

This study developed a primary school design curriculum framework based on associative thinking, aiming to enhance students' creativity and problem-solving abilities. Through literature review, course development, and teaching practices, the research validated the practical value of associative thinking in design education and demonstrated the effectiveness of the proposed curriculum.

6.1 Contributions to the Study

The primary contribution of this study lies in introducing associative thinking into primary school design courses. By providing students with a cognitive tool to establish connections between different knowledge domains, the curriculum helps stimulate their innovative capabilities. The framework covers key components such as task breakdown, resource integration, and prototype design, enabling students to progressively master essential design thinking skills through structured activities.

The experimental results show that students participating in the curriculum demonstrated significant improvements in creativity, hands-on abilities, and teamwork skills. They displayed greater confidence in tackling complex problems, showcasing stronger innovative thinking and logical reasoning abilities. Additionally, teachers reported that the course design was practical and easy to implement, effectively engaging students in learning activities.

The study also proposed a multidimensional assessment system covering aspects such as information retrieval, narrative skills, and practical execution abilities. This system provides teachers with comprehensive tools to evaluate students' performance and offers opportunities for students to continuously improve during the learning process.

6.2 Limitations and Future Directions

Despite achieving notable results, this study has certain limitations. First, the sample size used in the experiment was relatively small, which may affect the generalizability of the findings. Future research should expand the sample size to include a wider range of schools from different regions and backgrounds to verify the applicability of the curriculum framework.

Second, this study primarily focused on offline teaching environments and did not fully explore the integration of digital tools. With the rapid development of educational technologies, future studies could investigate how to combine curriculum content with digital teaching platforms to enhance both learning experiences and teaching effectiveness.

Moreover, the current assessment system leans heavily towards outcome evaluation, with insufficient emphasis on process evaluation. Future research could further improve the assessment framework by incorporating more process-oriented indicators to better track students' behavioral changes and cognitive development during the learning process.

6.3 Recommendations for Educational Practice

Based on the research findings, several recommendations for educational practice are proposed:

1.Enhance Teacher Training:

Teachers play a crucial role in implementing design courses. Therefore, it is essential for educational authorities to provide specialized training in design thinking and associative thinking to equip teachers with the necessary knowledge and skills to guide students effectively.

2.Promote Interdisciplinary Course Integration:

Design courses should not exist in isolation. They should be integrated with subjects such as science, technology, engineering, and mathematics (STEM) to help students apply cross-disciplinary knowledge to solve real-world problems and develop their comprehensive competencies.

3.Optimize the Assessment System:

Future course assessments should place greater emphasis on process evaluation, encouraging students to reflect on and adjust their learning during the course. Peer assessment can also be introduced to enhance students' collaboration and communication skills.

6.4 Summary

This study developed a primary school design curriculum framework based on associative thinking, providing new theoretical and practical insights for design education. The research shows that introducing associative thinking can significantly improve students' creativity and problem-solving abilities, offering a practical course model for primary design education.

Future research could further explore the broader application of the curriculum, the integration of digital teaching tools, and the optimization of assessment systems. The ultimate goal is to help students apply design thinking in real-life scenarios, enhancing their innovation awareness and adaptability when facing complex problems, and nurturing creative and competent individuals for society.

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