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A Study on Methods for Cultivating Innovative Thinking in Primary and Secondary School Students

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Abstract: Under the background of the in-depth development of the knowledge economy and intensifying global innovation competition, innovative thinking has become an indispensable core literacy for high-quality talents in the 21st century. This study constructs a three-dimensional cultivation framework covering innovative personality, innovative thinking and innovative practical ability. It summarizes four core cultivation paths: building a psychologically supportive educational environment, applying structured thinking training tools, implementing interdisciplinary project-based learning, and establishing a diversified evaluation system. Targeting the practical dilemmas prevailing in current innovative education, including lagging educational concepts, disconnection of teaching arrangements across schooling stages, and imperfect evaluation mechanisms, this paper puts forward targeted optimization strategies. The strategies involve constructing a staged spiral curriculum system, developing classroom-embedded evaluation tools, and improving the tripartite collaborative education mechanism among schools, families and communities. The research findings can provide theoretical reference and practical paradigms for the standardized and high-quality implementation of innovative thinking cultivation in primary and secondary education.

Keywords: Innovative Thinking; Primary and Secondary School Students; Cultivation Strategy; Project-Based Learning; Evaluation System

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1. Introduction

Innovation capacity constitutes the fundamental core competitiveness of a nation. The report to the 20th National Congress of the Communist Party of China has elevated the cultivation of innovative talents to a national strategic level. With the advancement of cognitive psychology and neuroscience, academic circles have reached a consensus that innovative thinking is a comprehensive literacy integrating multi-dimensional cognitive capabilities and non-cognitive traits, which presents strong plasticity throughout individual growth. The inclusion of innovative thinking in the PISA 2022 assessment framework marks the transformation of innovative education from theoretical advocacy to implementable and evaluable practical practice [1].

China's basic education is undergoing an in-depth transformation from knowledge indoctrination to competencyoriented cultivation. Nevertheless, prominent practical contradictions still exist. Frontline teachers generally recognize the value of innovative thinking cultivation, yet lack operable teaching methods. Although innovative courses have been widely offered in primary and secondary schools, the absence of scientific evaluation mechanisms makes it difficult to quantify teaching effects and iterate teaching design. Based on the above research background, this paper focuses on the cultivation of innovative thinking among primary and secondary school students, explores its constituent dimensions, feasible cultivation paths, differentiated teaching strategies at different learning stages and scientific evaluation systems, and aims to break the practical bottlenecks in the implementation of contemporary innovative education [2].

2. Connotation and constituent elements of innovative thinking

2.1. From innate endowment to cultivable comprehensive literacy

Traditional educational concepts have long adhered to the "genius determinism", regarding innovative ability as an innate privilege exclusive to a small number of gifted individuals. Relevant research in cognitive psychology has subverted this one-sided cognition. Guilford first proposed that divergent thinking is the core of creativity, and subsequent longitudinal empirical studies by Torrance verified that targeted educational intervention can effectively improve individual creative ability. Neuroscience research further confirms that the generation of innovative thinking relies on the synergistic activation of multiple brain network systems [3]. Innovative thinking is a regulatable cognitive activity that can be acquired through nurture, rather than an inherent fixed trait.

Mainstream academic viewpoints have confirmed that creativity is a universal literacy accessible to all individuals. Kaufman's 4C creativity model constructs a hierarchical developmental spectrum, including personal micro-creativity, daily practical creativity, professional innovation and paradigm-leading cutting-edge innovation. Theoretically, primary and secondary education should prioritize constructing a supportive growth environment to stimulate students' basic creative potential and lay a solid foundation for their advanced innovative development in future study and career.

2.2. Three-dimensional core components: Personality, thinking and practice

According to Lin Chongde's theoretical research, innovative thinking is not a single cognitive skill but an organic dynamic system composed of innovative personality, innovative thinking skills and innovative practical ability.

Innovative personality serves as the endogenous driving force for innovative behaviors, mainly including intellectual curiosity, exploratory willingness, resilience to setbacks and critical questioning awareness. Relevant studies have shown that primary school students are born with a strong curiosity about unknown things, while their exploratory tendency gradually weakens in adolescence. It fully demonstrates that the educational environment exerts a decisive influence on the cultivation and retention of students' innovative personality.

Innovative thinking refers to the basic cognitive capability required for innovative activities, consisting of two complementary dimensions: divergent thinking and critical thinking. Divergent thinking is characterized by fluency, flexibility and originality, while critical thinking undertakes the functions of screening, judging and optimizing creative propositions. The two thinking modes operate cyclically throughout the innovation process, and metacognition plays a high-order regulatory role in the whole cognitive activity.

Innovative practical ability refers to the capability of transforming abstract creative ideas into tangible achievements, which integrates multiple literacies such as project planning, resource allocation, tool application and collaborative communication. At present, project-based learning and maker education are the main carriers to cultivate students' innovative practical ability in basic education[4].

The three dimensions form a closed-loop growth system through dynamic interaction. An innovative personality provides the willingness for innovation, innovative thinking offers methodological support, and innovative practice supplies real, practical scenarios for innovative development.

3. Systematic cultivation approaches of innovative thinking

3.1. Cultivation of an innovative personality based on psychological safety

An inclusive and psychologically safe classroom atmosphere is the prerequisite for the development of students' innovative personality. Teachers should transform their role from a single judge of standard answers into a guide and collaborator of students' inquiry learning. It is necessary to abandon negative critical discourse and adopt heuristic questioning strategies to eliminate students' psychological concerns about exploratory trial and error. Schools can establish growth files for students to record setbacks in exploration, define exploration failures as valuable growth resources, and guide students to treat innovative trial and error rationally [5].

Hierarchical and progressive question design can effectively stimulate students' intellectual curiosity and innovative awareness. Taking the primary school science course The Three States of Water as an example, teachers can design chain questions from life phenomena to theoretical exploration, guiding students to analyze condensation phenomena, summarize formation conditions and explore artificial intervention methods. Such teaching design promotes students' transformation from passive knowledge reception to active inquiry. At the family level, parents' patient response to children's curious questions and participation in home micro-projects such as leak-proof product design can continuously protect students' creative enthusiasm and strengthen their innovative behavioral tendency.

3.2. Structured thinking training and specialized cultivation strategies

A consensus has been reached in academic circles that innovative thinking is not an innate talent for the few but can be cultivated through systematic teaching. The K12 stage is a critical period for consolidating students' innovative capabilities to meet the demands of the knowledge economy. The inclusion of innovative thinking in the PISA 2022 assessment framework shifts the educational focus from "whether creativity can be taught" to "how to implement innovative cultivation efficiently and scalably".

Innovative literacy can be divided into three interrelated dimensions: innovative personality, innovative thinking skills and innovative practical ability [6]. Innovative personality, including ambiguity tolerance, resilience and critical thinking, cannot be instilled through indoctrination but nurtured in a fault-tolerant and psychologically safe environment. Innovative thinking skills focus on the generation and optimization of ideas, with divergent thinking broadening thinking boundaries and critical thinking improving schemes. Innovative practice emphasizes the transformation of internal ideas into physical works or practical solutions, which requires holistic educational cultivation.

The cultivation of innovative thinking can be summarized into four implementation paths. First, consolidate the emotional and motivational foundation. Teachers should reduce instant judgment and listen to students' creative ideas attentively. By sharing growth experience of failures, educators can reshape the educational value of setbacks and mistakes. Families can protect children's curiosity and perseverance through micro practical projects.

Second, implement systematic thinking tool training. Visualized tools such as Six Thinking Hats, Mind Mapping and the Golden Circle Model can externalize students' implicit thinking processes. The summarized five-step creative process — problem discovery, brainstorming, scheme modeling, testing and optimization — standardizes innovative thinking paradigms. Exercises of multiple solutions to one problem can strengthen divergent thinking, and discussions on scientific controversies can cultivate students' evidence-based awareness and critical thinking [7].

Third, promote interdisciplinary project-based learning. Centering on real-life problems such as campus water conservation, students integrate multidisciplinary knowledge and complete the whole process from problem identification to achievement presentation. Project design should be stratified according to cognitive characteristics: primary school focuses on interesting practical exploration; junior high school increases data analysis and logical argumentation; senior high school carries out independent scientific research and engineering design training.

Fourth, construct a comprehensive supporting ecosystem. Maker spaces equipped with 3D printers and open-source hardware lower the threshold for creative practice. Cooperation with universities, technological enterprises and science museums provides real innovative scenarios for students. Science and technology innovation competitions motivate students' sustainable innovative development through peer demonstration and expert guidance [8].

The assessment of innovative thinking has long been a difficult issue in education. Traditional standardized tests tend to limit connotation to quantifiable dimensions and narrow the boundary of innovation literacy. Currently, growth portfolio assessment is widely adopted to record the whole process of idea evolution through manuscripts, peer feedback and reflective journals. The PISA 2022 framework adopts scenario-based tasks to evaluate idea generation and optimization from multiple perspectives. A comprehensive evaluation system should integrate process observation of innovative personality, performance assessment of thinking skills and rubric-based judgment of practical achievements.

Deficiencies still exist in current innovative education. Teachers generally recognize innovative cultivation in theory, but lack time, evaluation support, and feasible teaching methods for classroom implementation. Innovative activities gradually weaken from primary to senior high school due to the lack of curriculum connection across stages. Existing evaluation tools are insufficient in operability and increase teachers' administrative burden. Future research can focus on the developmental trajectory of innovative literacy, personalized innovative learning design driven by artificial intelligence, and empirical research on home-school-community collaborative education.

The cultivation of innovative thinking is essentially a profound transformation of educational philosophy, rather than simply adding new courses. It shifts the educational orientation from rewarding the reproduction of standard answers to encouraging diversified creative generation. Respecting students' creative ideas and exploring in-depth based on classroom questions can make innovative growth a normal part of daily teaching.

3.3. Interdisciplinary project-based learning: Integration of knowledge, cognition and practice

Project-based learning (PBL) starts with real-life practical problems, guides students to conduct long-term independent inquiry and team collaboration, and ultimately produces implementable public achievements. It conforms to the iterative logic of innovative practice and serves as the core carrier for innovative thinking cultivation. A primary school in Beijing carried out a campus water-saving system design project, integrating knowledge of science, mathematics and art. Students independently formulated optimization schemes, with their problem awareness and collaborative capabilities significantly improved.

Interdisciplinary teaching breaks the knowledge barrier of traditional single-discipline teaching. Based on the STEM education framework, the expanded STEAM framework integrates artistic and humanistic literacy, enabling students to combine logical reasoning with creative expression in problem-solving. Project difficulty and cycle are designed hierarchically according to cognitive differences: primary school projects last 1 to 2 weeks, focusing on experiential exploration; junior high school projects increase task complexity and require basic data analysis; senior high school projects are aligned with formal scientific research and engineering design to realize full-cycle innovative practical training [9].

Interdisciplinary integration builds a comprehensive problem-solving framework for students, and the collision of multi-field knowledge stimulates innovative cognition. For instance, interdisciplinary exploration combining artistic expression with optical principles can transform abstract scientific concepts into visualized creative achievements. Practical projects such as environmental water purification system design cover literature review, team discussion, scheme formulation and iterative optimization, effectively polishing students' innovative practical ability.

To maximize the educational value of PBL, teachers should create an open classroom atmosphere that tolerates reasonable trial and error and advocates innovative exploration. Schools shall be equipped with standardized maker spaces and experimental resources, regard exploration failures as an indispensable part of growth learning, and grant students the initiative of autonomous learning to transform cognitive challenges into innovative breakthroughs.

In summary, hierarchical heuristic questioning, standardized thinking training and open interdisciplinary project-based learning jointly form a complete innovative cultivation system. Systematic implementation can consolidate students' core innovative literacy and enhance their comprehensive competitiveness to adapt to global development.

3.4. Ecosystem construction: Resource platform and social collaborative support

On-campus maker spaces provide basic technical support for transforming students' creative ideas into physical prototypes. Schools should avoid formalistic construction that overemphasizes hardware allocation while ignoring curriculum matching. Off-campus resources such as university laboratories, technological enterprises and science museums provide real innovative practice scenarios, where in-depth experiential participation rather than superficial observation is the core educational value. Science and technology innovation competitions, represented by youth science and technology innovation contests, undertake the functions of evaluation, incentive, and teaching promotion. The complete project research and expert evaluation in competitions strengthen students' innovative identity and self-confidence in practical innovation.

4. Construction of an evaluation system for innovative thinking cultivation

4.1. Development and limitations of standardized innovative assessment

The Torrance Tests of Creative Thinking are widely used to assess the fluency, flexibility and originality of innovative thinking, while the Williams Creativity Test covers both cognitive and affective developmental dimensions. Nevertheless, such classic standardized tools present prominent limitations in domestic educational practice, including poor contextual adaptability, cultural bias and single-dimensional evaluation indicators. Domestic scholars are committed to developing localized assessment tools adapted to the developmental characteristics of Chinese primary and secondary school students.

4.2. Formative assessment and developmental portfolio evaluation

Different from summative evaluation, which focuses on final results, formative assessment emphasizes the whole-process tracking of students' innovative thinking development in inquiry practice. Student developmental portfolios act as the core carrier of formative evaluation, collecting whole-process evidence including research topics, revised schemes and exploration reflection records. The electronic portfolio system adopted by some junior high schools intuitively presents students' growth trajectory from weak questioning ability to independent research topic formulation. Compared with single quantitative scoring, descriptive process evaluation provides targeted teaching guidance for students' innovative growth. The PISA 2022 innovative thinking assessment framework also advocates integrating innovative cultivation and evaluation into daily teaching of all disciplines to realize whole-process and all-round educational assessment.

4.3. Multi-dimensional evaluation indicator system

A scientific evaluation system of innovative thinking corresponds to the three-dimensional cultivation framework. In terms of innovative personality, long-term classroom observation and behavior tracking are adopted to assess students' sustained inquiry interest, curiosity retention and frustration resilience. In terms of innovative thinking skills, standardized innovative tasks are applied to measure thinking fluency, flexibility, originality and critical analytical capability. In terms of innovative practical achievements, differentiated criteria are formulated for different project types: research-oriented projects are evaluated from the perspective of topic innovation and methodological rationality, while design-oriented projects focus on scheme originality and functional implementation completeness.

All assessment results require comprehensive analysis and interpretation. The core purpose of evaluation is to identify students' developmental strengths and deficiencies and formulate targeted cultivation strategies, rather than simply labeling or grading students.

5. Optimization and perfection of the innovative thinking evaluation system

5.1. Teachers' professional development and educational literacy improvement

The effective implementation of the innovative thinking evaluation system depends on teachers' professional assessment literacy. Educational administrative departments and schools should carry out targeted professional training to improve teachers' ability to identify students' creative potential, deliver constructive feedback, and integrate innovative thinking cultivation and evaluation into the whole curriculum teaching process [10].

5.2. Educational assessment empowered by information technology

The in-depth integration of educational information technology and teaching assessment makes up for the deficiencies of traditional evaluation modes. Digital education platforms provide convenient channels for students' collaborative inquiry and idea exchange, realizing real-time feedback on learning effects. Intelligent data analysis systems automatically collect and analyze students' developmental data, helping teachers dynamically track changes in innovative literacy and accurately identify weak links in innovative cultivation.

5.3. Collaborative participation of family and community

The cultivation of innovative thinking breaks the boundary of classroom teaching and requires tripartite coordination among schools, families and communities. Schools should actively integrate social educational resources to build an innovation-oriented, collaborative educational atmosphere. School-based parent workshops and thematic seminars can improve parents' cognition of innovative education and equip them with scientific family education strategies to stimulate children's creative potential, thus forming a consistent collaborative educational consensus.

5.4. Dynamic iteration and adaptive optimization of the evaluation system

The innovative thinking evaluation system is not static and needs dynamic optimization in line with educational reform and social development demands. Educational researchers and frontline teachers shall regularly revise assessment tools and indicator systems according to updated educational theories and practical needs, so as to maintain the scientificity, adaptability and effectiveness of the evaluation system in long-term educational practice.

6. Research limitations and prospects

Current cultivation of innovative thinking among primary and secondary school students still faces practical bottlenecks. Firstly, there is a prominent disconnection between theory and practice. Most teachers lack an in-depth understanding of systematic innovative cultivation methods, resulting in the dilemma of theoretical advocacy without effective practical implementation. Secondly, innovative education at different schooling stages lacks effective continuity, forming an obvious funnel effect: students' innovative curiosity peaks in primary school, declines in junior high school, and is severely restricted by academic pressure in senior high school. Thirdly, the evaluation ecosystem of innovative education remains imperfect, and portfolio evaluation suffers from subjective scoring bias. In addition, systematic research on supporting guarantee mechanisms for innovative education is still insufficient [11].

Future research can be expanded in four core directions. First, conduct longitudinal tracking research to explore the developmental rules of innovative thinking among primary and secondary school students. Second, develop lightweight classroom-embedded assessment tools to realize convenient and real-time evaluation of innovative literacy. Third, apply artificial intelligence technology to construct personalized, innovative learning paths for differentiated student cultivation. Fourth, strengthen empirical research on the home-school-community collaborative mechanism to improve the whole-process innovative education system.

7. Conclusion

The cultivation of innovative thinking in primary and secondary education represents a fundamental paradigm transformation of educational concepts. It requires a shift from traditional knowledge indoctrination and standardized answer replication to student-centered competency cultivation and innovative inquiry [12]. Despite the gap between the theoretical system and the practical effect, encouraging students to express independent viewpoints, iteratively optimizing innovative schemes, and adjusting teaching flexibly based on students' inquiry all symbolize the germination of innovative education. Continuous attention to such innovative developmental moments can steadily consolidate the national reserve of innovative talents and fulfill the fundamental mission of basic education in supporting the national innovative development strategy [13].

Disclosure statement

The author declares no conflict of interest.

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