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Research on the Practical Teaching Mode of the Health Education and Health Promotion Course Driven by Competitions

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Abstract

To meet the requirements of cultivating innovative and applied talents in Chinese higher education, this study constructs a "competition-driven and competition-teaching integrated" practical teaching model for the Health Education and Health Promotion course based on the "competency-based" education concept. By integrating discipline competition resources with the curriculum system, the research explores the model's connotation, objectives, implementation strategies, and guarantee mechanisms. The model has achieved significant effects from empirical data from 2019 to 2024 of Health Service and Management majors in Inner Mongolia Medical University shows that students' competition participation rate increased from 12% to 55% (average annual growth of 8%), with 5 national second prizes and 6 provincial first prizes won, and 80% of teachers transformed competition cases into teaching models and obtained 3 provincial teaching reform projects. These results verify the model's value in enhancing students' practical innovation abilities, optimizing teaching quality, and promoting school-enterprise cooperation. Combining the trends of educational reform and health discipline development in the past decade, this study proposes a teaching reform path with both theoretical depth and practical value, providing a reference paradigm for similar applied courses.

Keywords: Competition-Driven; Integration of Competitions and Education; Practical Teaching; Teaching Reform

1. Introduction

With the in-depth implementation of the "Healthy China 2030" Plan Outline, social demands for health service and management talents have shifted from single theoretical orientation to "practical-innovative-collaborative" composite capabilities. As a core course in the public health field, Health Education and Health Promotion directly influences students' competence in practical scenarios such as health intervention design and community health management

(MacKay et al., 2024). However, traditional teaching models suffer from limitations like "overemphasis on theory and neglect of practice" and "fragmented practical scenarios," making it difficult for students to transform knowledge into the ability to solve real health problems (Cao et al., 2024). For instance, Li (2021) conducted a follow-up study on 200 college students found that 67% of students who received only campus-based practical training reported "inability to handle cultural differences in community health work" when participating in real-world projects for the first time—for example, failing to effective communion for pastoral areas residences in Inner Mongolia. In terms of evaluation, Wang et al. (2024) indicated out that 82% of traditional practical courses in Chinese health-related majors rely solely on final paper-reports.

Theoretical Foundations and Practical Values of Competition-Driven Teaching is constructivist learning theory, which constructs a "three-dimensional linkage" system with "competition tasks as the carrier, ability cultivation as the core, and teaching reform as the starting point," emphasizes the cognitive construction process of "learning by doing," and discipline competitions, as authentic learning tasks, effectively stimulate students' active inquiry awareness (Dewey, 2008). In this theoretical foundation, goal dimension aligns with health industry standards and competition evaluation indicators, which is a direct application of competency-based education theory, emphasizes that talent cultivation should be oriented to "industry needs" and "practical abilities" (Li, 2021). For the content dimension, the decomposition of competition assessment points into curriculum modules is rooted in constructivist learning theory, which holds that learning is an active process of "constructing knowledge through practice" (Dewey, 2008; Wu et al., 2019). Taking the "Health Science Popularization Competition" as an example: the competition's "needs analysis" assessment point is integrated into the "Community Health Needs Assessment" curriculum module—students collect real data from pastoral areas in Inner Mongolia (e.g., elderly hypertension prevalence) and construct an understanding of "target group characteristics" through hands-on practice; the "program design" assessment point is incorporated into the "Health Promotion Program Planning" module—students design Mongolian-language health manuals based on competition requirements, transforming theoretical knowledge of "health communication" into practical skills. This integration ensures that curriculum content is not static but dynamically adjusted based on competition tasks, enabling students to "learn by doing." Finally, for the evaluation dimension, the multi-faceted evaluation approach ("competition results + process performance+ industry feedback") draws on comprehensive evaluation theory, which emphasizes "assessing all aspects of learning" rather than single results (Yao et al., 2021).

Studies at home and abroad have shown that the competition-driven model has significantly improved students' problem-solving and teamwork skills in medical education (e.g., USMLE) and engineering education (e.g., National College Students' Engineering Training Competition in China) (Corell, A et al., 2018; Maulana et al., 2024). In China, relevant research in health disciplines has also advanced, and mostly research focused on the medicine related majors or courses, Qiu et al. (2025) studied among 72 rehabilitation specialization students found that the competition-driven teaching method significantly improves students' self-ability evaluation and stimulates their interest in learning and competitive awareness. Wang et al. (2025) further confirmed the teaching mode of "promoting learning through competition and promoting teaching

through competition" is a effective method in the reform of experimental teaching in histology and embryology. Through the gradual improvement of the teaching mode through the competition, the standardization of the case simulation library and the integration of multi-scenario teaching improve students' practical ability and learning initiative. So, integrating competition elements into practical teaching is not only the practice of the educational concept of "promoting learning and teaching through competitions" but also an inevitable choice to meet industry needs in China.

2. Curriculum Positioning and Adaptability Analysis of Competition-Driven Teaching

2.1. The Interdisciplinary Attributes and Practical Orientation of the Course

The health service and management major in China is guided by the development needs of the national health strategy, adheres to the philosophy of "preventing disease before it occurs", and relies on information - driven based big data technology. It is committed to cultivating applied talents with solid theoretical foundations, strong practical abilities, and excellent communication and collaboration skills. These professionals can engage in health service and management roles across various enterprises and institutions related to the health service industry at all levels (e.g.,health management and public health), to meet the diverse societal demands for professionals in the health field.

As a core foundational course, Health Education and Health Promotion course integrates theories from multiple disciplines such as medicine, sociology, and communication, it focuses on cultivating students' comprehensive abilities using theoretical knowledge and practical skills in designing, implementing (behavior interventions), and evaluating (intervention effects) health education and health promotion programs, to address complex health challenges across diverse populations.

Through a blend of evidence-based theories (e.g., social cognitive theory, health belief model) and real-world case studies, students learn to analyze health behaviors, develop intervention strategies, and leverage communication technologies to promote individual and community well-being. As a cornerstone of health service and management programs, health education and health promotion course should balance theoretical and practical dimensions. Theoretically, it closely follows global frontiers in health education to ensure students master cutting-edge knowledge. In terms of practical skills training, it emphasizes health behavior interventions should be based on Chinese cultural background and work scenarios, enabling students to flexibly apply the learned knowledge to actual work scenarios.

Typical practical scenarios of the course include community health needs surveys, science popularization program design, and chronic disease management project planning, which highly align with the assessment requirements of discipline competitions such as the "National College Students' Health Science Popularization Competition" and "Challenge Cup" (Guo et al., 2019).

2.2. Bottlenecks of Traditional Practical Teaching and Breakthrough Points of Competition Driven Models

Traditional practical teaching in the realm of health education and health promotion has long

been plagued by several inherent bottlenecks, impeding students' effective acquisition of practical skills and comprehensive development (Wei & Jiang, 2023). Traditional practical teaching often faces three dilemmas:

Scene Limitations: Campus - based practical teaching often struggles to replicate the complexity and authenticity of real - world community health intervention scenarios. For instance, laboratory settings may offer a sanitized version of health promotion planning, but they lack the dynamic nature of actual community interactions. A study by Liu (2024) indicated that students trained mainly in campus labs faced significant challenges when first exposed to real - world health projects, as they were ill - equipped to handle the diverse social, cultural, and environmental factors present in community health work.

Single Evaluation: The assessment in traditional practical teaching predominantly relies on reports and assignments. This one - size - fits - all approach fails to comprehensively capture students' practical capabilities. (Wang et al., 2024) pointed out that a student might produce an excellent written report but lack the practical skills to implement a health education program effectively. Moreover, such evaluation methods often overlook crucial aspects like students' on - site problem - solving abilities, communication skills during health promotion activities, and their capacity to adapt to unexpected situations in real - world health projects.

Insufficient Motivation: In the absence of real - world task incentives, students' enthusiasm for practical participation remains low. The lack of clear, tangible goals and external recognition in traditional practical teaching leads to a situation where students may merely go through the motions. Guo et al. (2019) found that students in traditional practical courses showed less initiative in exploring innovative health education methods compared to those engaged in competition - based learning, as the former lacked the sense of achievement and competition that drives active learning. In contrast, the competition - driven model offers distinct breakthrough points. By introducing competition tasks with clear goals, rules, and evaluation criteria, it transforms the learning experience. For example, in a health promotion competition, students are required to design and implement a complete health education project for a specific community group. This real - world - like task forces them to step out of their comfort zones and engage actively in all aspects of the project, from conducting in - depth needs assessments to implementing and evaluating the intervention. The competition - driven model also provides a platform for students to showcase their skills and receive external recognition, which significantly boosts their motivation. As demonstrated by a research showed that students participating in the "National College Students' Health Science Popularization Competition" (Liu, 2024), the motivation to compete not only enhances their practical skills but also stimulates their creativity in developing unique health education strategies.

3. Systematic Construction of the "Competition-Driven and Competition- Teaching Integrated" Teaching Model

3.1. Model Connotation and Logical Framework

The "competition - driven and competition - teaching integrated" model for the Health

Education and Health Promotion course represents a novel and comprehensive approach to practical teaching in the health discipline. This model is designed to address the long - standing disconnect between theoretical learning and real - world application, thereby enhancing students' practical skills, innovative thinking, and overall competitiveness in the health job market (Fan et al., 2020).

At its core, this model uses competition tasks as the primary vehicle for learning. By participating in health - related competitions, students are exposed to real - world scenarios and challenges that mirror the complexity of actual health projects. For example, competitions like the "National College Students' Health Science Popularization Competition" require students to design and implement comprehensive health education programs for specific target groups, such as the elderly, children, or high - risk occupational groups. This not only tests their knowledge of health education theories but also their ability to adapt these theories to practical situations, considering factors like cultural backgrounds, social environments, and individual needs (Liu & Yu, 2024).

The focus on ability cultivation is another key aspect of this model. It goes beyond the traditional rote - learning approach and instead emphasizes the development of a wide range of skills. These include problem - solving skills, where students must analyze complex health problems and design effective intervention strategies; communication skills, as they need to convey health information clearly and persuasively to different audiences; and teamwork skills, since most health - related projects require collaboration among professionals from various disciplines (Wang, 2024). For instance, in a team - based competition for designing a community - wide chronic disease prevention program, students from public health, nursing, and health communication backgrounds need to work together, each contributing their unique expertise to achieve a common goal.

Teaching reform serves as the driving force behind the successful implementation of this model. It necessitates a fundamental rethinking of the traditional teaching paradigm. Teachers are no longer the sole providers of knowledge but rather act as facilitators and mentors. They guide students through the competition process, helping them to identify problems, explore solutions, and reflect on their experiences. This shift in the teacher's role is in line with the constructivist learning theory, which posits that learning is an active process of knowledge construction by the learner, rather than a passive reception of information (Wu et al., 2019).

The model constructs a "three-dimensional linkage" system with "competition tasks as the carrier, ability cultivation as the core, and teaching reform as the starting point":

(1) Goal Dimension: In the goal dimension, alignment with health industry standards and competition evaluation indicators is of utmost importance. The health industry has specific requirements for the knowledge, skills, and qualities of its professionals. For example, the ability to conduct accurate health needs assessments, design evidence - based health promotion programs, and evaluate the effectiveness of these programs is highly valued. Competition evaluation indicators, on the other hand, often reflect these industry standards in a more practical and measurable way. By integrating them formed a three - level training goal of "knowledge - skill -

quality" . At the knowledge level, students are expected to master a comprehensive set of health education and promotion theories, including health behavior change models, health communication theories, and health policy knowledge. The skill level requires them to be proficient in skills such as data collection and analysis, program planning and implementation, and health message design. At the quality level, they should possess qualities like critical thinking, ethical awareness, and adaptability (Li, 2021).

(2) Content Dimension: In the content dimension, the decomposition of competition assessment points into curriculum modules is a key strategy. Take the "Health Science Popularization Competition" as an example. The assessment of this competition typically includes aspects such as needs analysis, where students need to identify the health knowledge gaps and needs of the target audience; program design, which involves creating engaging and effective health education materials; and communication implementation, requiring students to use various channels to deliver the health messages. These assessment points are then translated into corresponding teaching units within the curriculum. For example, the needs analysis part can be integrated into the "Community Health Needs Assessment" module of the course, while the program design can be part of the "Health Promotion Program Planning" module. This integration ensures that the curriculum content is directly relevant to the practical skills required in competitions and, ultimately, in the health industry (Gao & Wang, 2023).

(3) Evaluation Dimension: The evaluation dimension of this model features a multi - faceted approach. It goes beyond the traditional single - dimensional evaluation methods, such as relying solely on written exams or course assignments. Instead, it incorporates "competition results + process performance + industry feedback" as the evaluation criteria. Competition results are an obvious indicator of students' practical abilities in a competitive environment. However, process performance is equally important. This includes students' performance during the competition preparation process, such as their ability to work in a team, their problem - solving strategies, and their progress in implementing the competition tasks. Industry feedback provides an external and practical perspective. For example, if students' competition works are implemented in real - world health projects, the feedback from industry professionals, such as health managers in community health centers or health educators in non - profit organizations, can offer valuable insights into the practicality and effectiveness of the students' work. This multi - faceted evaluation mechanism provides a more comprehensive and accurate assessment of students' learning outcomes and practical capabilities (Yao et al., 2021).

3.2. Objectives of the Practical Teaching Model

The core objective of the "Competition-Driven and Competition-Teaching Integration" practical teaching model is to cultivate students' innovative and practical abilities while enhancing their comprehensive qualities. By organically combining competition elements with teaching resources, teaching processes, teaching evaluations, and ability cultivation, it can effectively stimulate students' learning interests, enthusiasm, and innovation. At the same time, it also promotes the transformation of the teaching model towards informatization, the development of teaching methods towards diversification, and the shift of teaching evaluation towards a process - oriented approach. It deeply integrates scientific research thinking, basic theories, and

professional skills into practical teaching, guiding students to carry out active and research - based learning and master self - learning and professional skills.

In the process of "promoting learning through competitions", students participate in various competition activities, learn knowledge, exercise skills, and cultivate interests though practice, achieving a close combination of theoretical knowledge and practical applications, improving learning effects, and promoting personal development. In this process, teachers are involving in the entire process of the competition, which enhances their innovative teaching innovation awareness, improves their teaching abilities, optimizes the teaching quality and effect, and creates a positive learning environment. Additionally, this model uses students' competition activities as a bridge to build school-enterprise collaboration platforms, it also helps students to better understand the job market, make career plans in advance, cultivate employ-ability and entrepreneurship and confidence, and enhance their employ-ability, discover entrepreneurial opportunities, and truly achieve "promoting learning, teaching, and employment through competitions" as shown in table 1.

Table 1. Hierarchical Design of Teaching Objectives

Objective Level	Specific Connotation	Corresponding Competition Ability
Basic level	Master core skills such as health needs assessment and intervention program design	Competition proposal writing ability
Advanced Level	Possess teamwork, project management, and on-site response abilities	Competition roadshow and defense ability
Innovative Level	Form evidence-based health problem-solving thinking	Competition result transformation and innovation ability

3.3. Implementation Paths and Strategic Innovations

With the rapid development of the information society and the Internet + era, traditional educational concepts and teaching models no longer meet the modern education development needs. However, the current practical education of many professional courses has not yet formed a systematic curriculum and teaching system at the macro-educational level.

3.3.1. Deep Integration of Curriculum Content and Competition Tasks

The deep integration of curriculum content and competition tasks is a cornerstone of the "competition - driven and competition - teaching integrated" model. Taking the "National College Students' Health Management Case Competition" as a vivid example, this integration process unfolds in a systematic and meticulous manner (Shojaeezadeh, D., & Heshmati, H, 2018).

Pre - stage Docking: In the initial pre - stage, educators must conduct a comprehensive and in - depth analysis of competition rules. For the "National College Students' Health Management Case

Competition", understanding the specific requirements for case design, data collection, and intervention implementation is crucial. Once these requirements are clear, they can be effectively translated into curriculum units. For instance, the "chronic disease management case design" requirement of the competition aligns closely with the "Chronic Disease Health Education" chapter in the curriculum. By integrating the competition - specific content into this chapter, students are exposed to real - world - like case - based learning within the context of their regular curriculum. This not only enriches the teaching content but also makes it more relevant and practical, as students are now learning with the ultimate goal of participating in a competitive event in mind (Wu et al., 2019).

Mid - stage Implementation: During the mid - stage, the learning process takes on a more hands - on and project - based approach. Students form groups, mirroring the team - based nature of most real - world health management projects. They then embark on a comprehensive journey that includes "case investigation - plan design - simulated intervention". In the case investigation phase, students need to gather relevant data, which may involve conducting surveys, interviews, or analyzing existing health records. For example, when dealing with a chronic disease management case, they might survey patients' lifestyle habits, medical histories, and current treatment adherence. Based on this data, they move on to the plan design stage, where they formulate a detailed health management plan, taking into account factors such as the patients' needs, available resources, and the latest evidence - based practices. Teachers play a pivotal role during this process. They provide guidance based on the competition scoring criteria, helping students to understand what is expected of them in terms of quality, innovation, and practicality. This guidance ensures that students' work is not only in line with the academic requirements but also competitive in the context of the competition (Guo et al., 2019).

Post - stage Transformation: The post - stage is where the fruits of students' labor are refined and presented on a larger stage. Excellent course assignments, which are the result of the mid - stage implementation, are carefully optimized to be transformed into competition works. This transformation process may involve further data validation, refinement of the intervention strategies, and improvement of the presentation format. Once optimized, these works can be submitted to provincial and national competitions. This not only gives students a chance to showcase their skills and knowledge but also provides them with valuable feedback from a broader audience, including industry experts and peers from other institutions. The experience of participating in these competitions further enhances their practical abilities and understanding of the health management field (Li, 2021).

3.3.2. Interdisciplinary Collaborative Teaching Mechanism

Interdisciplinary Collaborative Teaching Mechanism Form a "competition tutor team" composed of teachers from public health, health communication, statistics, and other professions to carry out collaborative guidance for complex competition tasks (such as health big data analysis competitions). For the "National College Students' Preventive Medicine Skills Competition" as an example, the specific operation guidelines are follows from collaboration frequency, communication method, and responsibility boundaries.

For collaboration frequency, there are there phases in this part, the Pre-competition preparation (2–3 months before the competition), hold weekly joint guidance meetings (90 minutes per meeting) to review students' progress. Mid-competition implementation (1 month before the competition) phase, conduct biweekly on-site or online meetings to solve urgent problems to meet students' competition requirements. Finally, Post-competition summary (1 week after the competition), every participants, no matter teachers or students, hold a one-time joint meeting to summarize experience and update teaching materials.

For communication methods, in the first task is forming "competition tutor team" including participating students and instructor teams, teachers from diverse fields such as public health, health communication, and statistics. Establish a dedicated WeChat group (for Chinese universities) or Microsoft Teams channel for the tutor team and students. For the cross-regional collaboration (e.g., between Inner Mongolia Medical University and experts from Beijing), conduct monthly video conferences using Tencent Meeting. And some Cloud (Tencent Cloud, Alibaba Cloud) are used to share all the information needed for the competition.

For responsibility boundaries, the complexity of health-related issues necessitates an interdisciplinary approach, and the "competition - driven" model responds to this need through the establishment of an interdisciplinary collaborative teaching mechanism, which is designed to break down the silos between different academic disciplines and leverage the expertise of various professionals to better guide students in competition - related tasks (Liu et al., 2024).

In the "National College Students' Preventive Medicine Skills Competition", public health teachers, with their in - depth understanding of disease prevention strategies and health systems, are responsible for guiding students in confirming target group and designing effective intervention plans. Statistics teachers then design a sampling plan for needs assessment in charge of "data validity"—e.g., guiding students to use correctness of statistical methods in competition reports. And communication teachers focus on "expression effectiveness"—e.g., optimizing the language of health science popularization materials (e.g., translating professional terms into Mongolian colloquialisms for pastoral areas) and training students' on-site defense skills (Wang et al., 2024).

This collaborative approach ensures that students receive comprehensive guidance, covering all aspects of the competition task. The combined efforts of these teachers create a rich learning environment where students can integrate knowledge from different disciplines, which is essential for solving real - world health problems.

3.3.3. Construction of School - Enterprise Collaborative Practice Platforms

The construction of school - enterprise collaborative practice platforms is another strategic innovation of the competition - driven model. By collaborating with community health service centers, health management institutions, and other relevant industry entities, schools can create "competition practice bases" that bridge the gap between academic learning and real - world application.

These practice bases serve as the perfect testing ground for students' competition - related ideas

and projects. For example, in the "Community Health Promotion Competition", students may design innovative health promotion programs for specific community groups, such as promoting physical activity among the elderly or improving nutrition awareness among children. These programs can then be implemented in the community health service centers that are part of the practice base. The advantage of this "real - world" implementation is two - fold. Firstly, it allows students to see the actual impact of their programs, which helps them to better understand the challenges and opportunities in community health promotion. They can observe how the community members respond to their interventions, whether the programs are effectively reaching the target audience, and what adjustments may be needed. Secondly, the implementation in real - world settings provides an opportunity for industry - professional evaluation. Industry mentors, who are experienced health managers or educators in the community health service centers, can work closely with university teachers to evaluate the effectiveness of the students' projects. Their practical insights and on - the - ground experience can offer valuable feedback to students, helping them to improve their skills and refine their future projects. This school - enterprise collaboration not only enhances the practical value of competition results but also provides students with a unique learning experience that is essential for their future careers in the health field (Tang et al., 2024).

3.3.4. Competition-Teaching Integration: Diversifying Practices and Enhancing Comprehensive Abilities

The course "Health Education and Health Promotion" not only emphasizes the cultivation of students' theoretical knowledge and professional skills, but also pays more attention to comprehensive literacy. The requirements of various competitions at all levels for students' comprehensive ability are in line with the curriculum training goals, which provides a good opportunity for the integration of competition and education.

Skill competitions expand practical teaching platforms of the talent training program,While the practical teaching mode of competition and education integration focuses on guiding students to promotes independent, exploratory and collaborative learning, and highlights the cultivation of students' comprehensive professional ability. In the process of guiding students to participate in the competition, the teaching team pays more attention to cultivating students' ability of innovation, teamwork and on-the-spot adaptability, which prompts the teaching team to consciously carry out teaching reform and improve professional ability and teaching level. After that, the teacher team optimized the teaching methods and formed a positive interaction with the students through the exchange and reflection of the competition experience. Realizing the "competition-driven learning" and "integration of competition and education" to achieve the effect of mutual benefit of teaching.

In terms of "competition-driven learning" practical teaching methods, that transforms competition into a two-way interactive (teacher-student) teaching method. This requires the teaching team should always pay more attention on the development of professional courses, accurately grasps the actual needs of the major professional, realizing the organic combination of theoretical knowledge and reality needs, and dynamically optimize the teaching content. At the same time, the practical part of this course is innovatively combined with summer practice, and

through the interactive form of "going out" (teachers leading students into health management industry institutions) and practice experts "inviting in" (hiring practice experts to share experience), it makes up for the limitations of students' on-campus practice, promotes the deep integration of competition, teaching reform and talent training, and comprehensively improves students' professional comprehensive ability.

Meantime, the practical part of this course is innovatively combined with the students' summer practice, and through the interactive form of "going out" (teachers leading students into health management industry institutions) and practice experts "inviting in" (hiring practice experts to share experience), it makes up for the limitations about the practice only on the campus, and promotes the deep integration of competition and teaching reform and talent training, finally comprehensively improves students' professional comprehensive ability.

4. Implementation Effects and Influence Mechanisms of the Teaching Model

4.1. Enhanced Student Autonomy and Innovative Practice

The implementation of the competition - driven and competition - teaching integrated model has transformed from depending on teacher teaching theory in classroom to student-centered and teacher-guided models, and the scope of practical teaching has been extended from the classroom and campus to the summer practice and competition venues, has brought about remarkable improvements in students' abilities, so as to realize the effective connection between practical skills and professional skills. The implementation of the practical teaching model of "promoting learning through competition and integrating competition and education", has greatly stimulated students' enthusiasm and innovation in learning, allowing students to fully tap their potential in project training.

Since 2019, the teaching team has introduced competitions elements into practical teaching of the "Health Education and Promotion" course, remodeling teaching form, transforming traditional teacher-students interaction, and establishing a collaborative learning mechanism. The implementation effects of the model were verified through a tracking study included 150 students majoring in Health Service and Management at Inner Mongolia Medical University (China) from 2019 to 2022, covering 4 consecutive cohorts (2019: 30 students, 2020: 40 students, 2021: 40 students, 2022: 40 students) with the gender ratio was 23.3% male (35 students) and 76.7% female (115 students). All students completed the "Health Education and Promotion" course and participated in the model's practical teaching activities, and all of them participated in a questionnaire survey, which conducted to detected the competition participant status. The competition participation rate increased from 32% in 2019 to 85% in 2022, with an average annual growth of 18%. The teaching team with students had participated in national/provincial competitions (e.g., the National College Student Health Science Competition, Health Science Popularization Competition, Sand Table Competition) and received excelling results (won 5 national second prizes and 6 provincial first prizes), with the practice participant quality improved by 40% compared with that before the model implementation.

Competition-driven learning builds student confidence and problem-solving skills, and also

enhances innovation through real-world challenges. The 2022 student team designed the Science Popularization Manual for Hypertension Prevention and Treatment among Elderly People in Pastoral Areas based on curriculum practice results in the "National College Students' Health Science Popularization Competition", which combined the cultural characteristics of the Mongolian language, won the national second prize, and was adopted and promoted by the Inner Mongolia Health Commission.

4.2. The Teacher Teaching and Professional Development Promotion

The competition - driven teaching model also has a profound impact on teachers, leading to a two - way promotion of their teaching and professional development. Teachers achieve the integration of "teaching - research - practice" through competition guidance, which enriches their professional experience and improves their teaching quality (Mu et al., 2025).

Teaching Method Innovation: As many as 87% of teachers have transformed competition cases into teaching materials, which has led to the development of new and more effective teaching methods. For example, they have introduced "scenario simulation" and "project - based learning" methods. In scenario simulation, teachers create real - world - like health - related scenarios for students, such as simulating a community health intervention project. This method allows students to practice their skills in a more immersive environment. Project - based learning, on the other hand, enables students to work on long - term projects similar to those in competitions, where they can integrate knowledge from different courses and develop problem - solving skills. These new teaching methods are more in line with the practical - oriented nature of the health discipline and have been well - received by students, as they make the learning process more engaging and relevant (Xiao & Zhao, 2024).

Research Ability Improvement: Based on the teaching research results formed by competition guidance, teachers have achieved significant progress in their research. They have obtained 3 provincial teaching reform projects, which are focused on further optimizing the competition - driven teaching model. Additionally, they have published 7 related papers, contributing to the academic discussion on innovative teaching methods in the health discipline. For example, some of these papers explore the effectiveness of different competition - based teaching strategies, while others discuss how to better integrate competition tasks with curriculum content. These research achievements not only enhance the teachers' academic status but also provide valuable insights for the continuous improvement of the teaching model (Mu et al., 2025).

Practical Experience Accumulation: Through school - enterprise cooperation competition projects, teachers have had the opportunity to participate in 12 real health management projects. This practical experience is invaluable as it allows teachers to stay updated with the latest industry trends and challenges. For example, in a project related to chronic disease management in a community health service center, teachers can observe firsthand the practical problems faced by health workers and the needs of the community. This practical knowledge can then be brought back to the classroom, making their teaching more practical and relevant. Moreover, the experience also helps teachers better understand the requirements of the health industry for students' skills, enabling them to adjust their teaching content and methods accordingly.

5. Reflection and Prospect: Model Optimization and Future Development

5.1. Existing Challenges and Improvement Directions

Unbalanced Competition Resources: Universities in China other than those located in Beijing (the capital of China), often face significant disadvantages in accessing competition information and establishing strong enterprise cooperation. For example, compared to universities located in economically developed regions with abundant resources, non - capital universities may have limited exposure to the latest competition announcements, industry - led competitions, and opportunities for in - depth collaboration with leading health enterprises. This resource gap can hamper students' ability to participate in high - quality competitions and gain valuable industry experience. To address this, the establishment of a regional competition resource sharing platform is crucial. Such a platform could centralize competition information, including upcoming events, competition guidelines, and case studies of past winning entries. It could also facilitate communication and cooperation among universities, enterprises, and industry associations in the region, enabling non - capital universities to access resources that were previously out of reach (Yang, 2022).

Differences in Student Participation: A notable issue is the varying levels of student participation. Some students, burdened by academic pressure or lacking confidence in their abilities, are less likely to engage in competition - based learning. In traditional educational settings, students may be more accustomed to a structured, exam - focused learning environment, making them hesitant to step into the more dynamic and competitive realm of health - related competitions. To counter this, a "stepped competition participation mechanism" should be designed. For instance, starting with class - level preliminary competitions, where the competition tasks are relatively simple and designed to build students' confidence and basic skills. These could progress to school - level semi - finals, with gradually increasing difficulty and complexity. This approach allows students to gradually adapt to the competitive environment, develop their skills over time, and increases the likelihood of broader participation (You, 2024).

Improvement of the Evaluation System: The current competition evaluation system, while effective to some extent, has room for improvement. It predominantly focuses on the final results of competitions, overlooking the rich learning process that students go through. For example, students may make significant progress in their problem - solving skills, teamwork, and iterative thinking during the competition preparation phase, but these efforts are not fully reflected in the evaluation. To rectify this, "process evaluation" indicators should be added. This could include tracking students' plan iteration records, which show how they respond to challenges and adjust their strategies. Team contribution assessment, which evaluates each member's role in the team, such as leadership, communication, and technical contributions, should also be an integral part of the evaluation system. By incorporating these process - related indicators, a more comprehensive and accurate assessment of students' learning and development can be achieved (Xiang et al., 2024).

5.2. Future Research and Practice Directions

Looking ahead, several promising research and practice directions can further enhance the

competition - driven teaching model in the health education and promotion field.

Digital Transformation: The rapid advancement of technology offers new opportunities for the integration of digital elements into the competition - driven model. Combining virtual reality (VR) technology, for example, can construct "virtual health competition scenarios". In these scenarios, students can simulate complex health intervention projects in a virtual environment that closely mimics real - world situations. They can interact with virtual patients, community members, and health professionals, practice their communication and intervention skills, and receive immediate feedback. This not only breaks through the time and space limitations of traditional competitions but also provides a safe and cost - effective way for students to gain practical experience. For instance, in a virtual community health promotion project, students can test different intervention strategies without the constraints of physical resources or real - world risks (Saroha S, 2025).

Long - term Mechanism Construction: To solidify the positive impact of the competition - driven model, it is essential to explore its incorporation into the professional talent training plan on a long - term basis. This would involve integrating competition - related activities and learning objectives throughout the four - year undergraduate study. For example, in the first year, students could be introduced to basic health - related competitions as part of their general education courses, to develop an initial understanding of the practical application of health knowledge. As they progress to higher years, the competition tasks could become more complex and specialized, aligning with their major courses. This continuous exposure to competition - driven learning would help students develop a more comprehensive and in - depth set of practical skills, innovation abilities, and a better understanding of the health industry's demands (Wang, 2024).

Cross - cultural Comparison: Given the global nature of health issues, comparing and analyzing the competition - driven teaching models of health disciplines at home and abroad can provide valuable insights. Different countries may have unique approaches to integrating competitions into health education, influenced by their educational systems, cultural values, and industry needs. For example, some countries may emphasize community - based competitions, while others may focus more on research - oriented competitions. By studying these differences, it is possible to extract optimization paths suitable for China's national conditions. This could involve adapting successful international practices, such as innovative competition formats, evaluation methods, or industry - university cooperation models, to the Chinese health education context, while also sharing China's own successful experiences with the international community.

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Strengthening Neuro-Oncology Training in China: Current Status and Opportunities

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Abstract

This review examines the current status and future opportunities for strengthening neuro-oncology training in China. With the rising burden of gliomas, brain metastases, and other central nervous system tumors, there is an urgent need to cultivate specialized clinicians capable of addressing the complexity of modern neuro-oncological care. However, existing training models in China, primarily rooted in general neurosurgery, are insufficient for preparing physicians for the interdisciplinary demands of neuro-oncology, which span neurology, oncology, radiation therapy, and molecular pathology. Drawing on established frameworks from the United States and Europe, the review proposes a China-specific roadmap that includes launching standardized fellowship programs, developing competency-based curricula, and integrating training with clinical research platforms. It also highlights the potential of continuing education, online learning, and international collaborations to supplement formal training and address regional disparities. Emphasis is placed on establishing accredited national trial hubs, promoting translational research, and creating “train-the-trainer” mechanisms to build local faculty capacity. By implementing these strategies, China can not only improve patient outcomes but also emerge as a global contributor to precision neuro-oncology.

Keywords: Neuro-Oncology; Medical Education; Fellowship Training; Multidisciplinary Care

1. Introduction

The burden of neuro-oncological diseases, such as glioma, metastases, and other primary brain tumors, has been steadily rising in China, with the incidence being 7.40 per 100,000 persons and the estimated new cases up to 101200 (Han et al., 2024; Ding & Wang, 2011). Each type of these tumors has its own unique characteristics in terms of growth pattern, location, and biological behavior, leading to widely varying management approaches (Louis et al., 2021). For example, in most cases of meningioma, which typically expand in a well-circumscribed manner, surgical resection alone is often sufficient (Goldbrunner et al., 2021). In contrast, glioma, accounting for a significant proportion of brain malignancies, is characterized by an infiltrative nature, heterogeneity, and adaptive resistance. Consequently, its treatment usually demands a multidisciplinary strategy integrating surgery, radiotherapy, chemotherapy, as well as emerging targeted and immunotherapies (Weller et al., 2021; Stupp et al., 2005). Neurosurgeons are often at the forefront of these treatment regimens, except for radiation therapy. Meanwhile, surgeons from other specialties mainly concentrate on surgical interventions, and oncology specialists formulate subsequent therapeutic strategies for neoplastic diseases related to their respective fields. In the era of molecular pathology, neurosurgeons ought to have a good command of neuro-oncology medical knowledge to facilitate the development of individualized treatment plans. However, the existing training models for neurosurgeons in China do not sufficiently address the complexity of comprehensive care, necessitating significant improvements to enhance patient outcomes (Wang & Zhang, 2020). Herein, we conduct a retrospective analysis of the underlying issues within oncology development in Mainland China, review the advancements in neuro-oncology training achieved in Western countries, and explore potential strategies for enhancing the current training program (Jensen et al., 2006).

2. Current State of Neuro-Oncology Education in China

Neuro-oncology is an interdisciplinary field that requires a comprehensive understanding of neurosurgery and oncology. Physicians need to master a vast amount of knowledge, including the anatomy and physiology of the nervous system, imaging diagnosis of neurological diseases, the pathological mechanisms of tumors, and various treatment methods. The knowledge is not only extensive but also highly specialized, demanding professional training and long-term learning. However, there is a prevalent shortage of specialized neuro-oncology departments in almost all hospitals in China (Wang & Zhang, 2020). The lack of an independent institutional identity is strongly associated with no standardized and adequate training curriculum for young doctors and fewer opportunities for specialized educational activities, which exacerbates the situation of the shortage of professional talent (Lu-Emerson et al., 2025). Though some top-tier hospitals in big cities like Beijing, Shanghai, and Guangzhou might have a group of doctors with a focus on neuro-oncology, the number of dedicated neuro-oncology units remains limited (Valvi et al., 2023; Liu et al., 2023).

Currently, the approach to cultivating neuro-oncologists primarily relies on neurosurgery training. The training model for neurosurgical postgraduates has increasingly become more

standardized, with a seven-year training program broken into 2 blocks having been nationally adopted (Xu et al., 2016). In the initial stage, trainees titled residents spend 3 years rotating through general surgery and its subspecialties, orthopedic surgery, anesthesiology, urology, pathology, radiology, critical care medicine, and surgical intensive care. This three-year foundational training fosters the development of generalist medical knowledge and basic surgical skills. Completion of the foundation block and passing a national standardized examination, residents can earn a certificate and become eligible for the advanced stage. Then, trainees will be promoted to attending and receive 4 years of dedicated neurosurgery training. Year 1 includes rotations in neurology, neuropathology, neurophysiology, neuro-intensive care, microsurgical neurosurgical anatomy, and microsurgical skill laboratory. In the second and third year, rotations through six subspecialties of neurosurgery are mandatory, including neurotrauma, tumor, vascular, spine, and a choice of one elective rotation in pediatrics and functional, and one from skull base surgery and neuro-intervention. Each subspecialty rotation lasts four months, and during this period, trainees are concurrently responsible for outpatient and emergency consults. Year 4 consists of a one-year period, termed the chief resident, handling the entire service. However, the seven-year training program is adaptive to cultivate neurosurgeons but not neuro-oncologists. Significant challenges faced by neuro-oncology trainees in neurosurgical training (Shi et al., 2025). Primarily, neurosurgery encompasses a wide range of highly specialized areas, and each subfield requires a deep understanding of unique pathologies and treatment modalities. Moreover, limited time is allocated for rotations in each subspecialty, resulting in insufficient depth of experience in a single area (Zhang & Li, 2025). On the other hand, the development of surgical technical skills is always traditionally prioritized in training, which sometimes overshadows other aspects of disease management. As is known, neuro-oncology is a rapidly evolving field, with frequent advancements in molecular diagnostics, targeted therapies, and immunotherapies (Aquilanti & Wen, 2023). Keeping up with these developments while simultaneously mastering other subspecialties adds another layer of difficulty for trainees (Aquilanti & Wen, 2023). More importantly, neuro-oncology is inherently multidisciplinary, requiring close collaboration with medical oncologists, radiation oncologists, pathologists, and other specialists (Pillay et al., 2016). However, neurosurgical training programs may not always provide sufficient exposure to these collaborative practices, hindering the development of the holistic approach necessary for effective neuro-oncology care (Khalafallah et al., 2021; De Swart et al., 2021).

Another pathway to becoming a neuro-oncologist involves transitioning from a background in neurology or medical oncology. This route offers a distinct perspective and skill set that complements the traditional neurosurgical training pathway, particularly in the non-surgical aspects of neuro-oncology care. Specifically, neurologists who transition into neuro-oncology bring a deep understanding of the nervous system, including its anatomy, physiology, and pathophysiology. Their expertise in diagnosing and managing neurological disorders, such as seizures, cognitive impairment, stroke, and nervous system infections, is invaluable in the care of patients with brain tumors. Neurologists are also well-versed in interpreting neuroimaging studies and managing neurological complications of cancer and its treatments, such as chemotherapy-induced neuropathy or radiation-induced cognitive decline. However, transitioning neurologists lack standardized training in oncology principles, including tumor biology, systemic therapies,

and comprehensive treatment planning based on personalized biomarkers. Medical oncologists who move into neuro-oncology bring a strong foundation in cancer biology, systemic therapies, and the management of metastatic disease. Their experience with chemotherapy, targeted therapies, and immunotherapies is critical for treating primary and metastatic brain tumors. Oncologists are also skilled in managing the side effects of cancer treatments and providing palliative care. However, they may be required to have a good level of comfort with neurology-specific topics, such as neuroanatomy, neuroimaging, and the management of neurological symptoms unique to neuro-oncological diseases. Generally, this transforming pathway is valuable but difficult, especially in conditions without appropriate fellowship training, and the number of successfully transformed neuro-oncologists remains relatively small (Hayse, 2025).

3. International Neuro-Oncology Training Models

Neuro-oncology has evolved into a distinct multidisciplinary domain that bridges neurosurgery, neurology, medical oncology, and radiation oncology (Wen et al., 2008). Training pathways worldwide reflect this complexity, requiring physicians to develop a robust understanding of both surgical and non-surgical treatments for central nervous system (CNS) tumors (Malbari et al., 2020; Di Bonaventura et al., 2025). Over the past decades, the United States (U.S.) and several European countries have led the formalization of neuro-oncology curricula, accreditation standards, and research infrastructures, providing valuable models that can inform developing programs elsewhere (Jensen et al., 2006).

3.1. United States

In the U.S., aspiring neuro-oncologists can enter the field through different primary specialties, most commonly neurosurgery, neurology, or medical oncology, before pursuing formal fellowship training (Gonzalez Castro et al., 2022). For those taking the neurosurgical route, the typical pathway begins with four years of medical school, followed by a seven-year neurosurgery residency (Ng et al., 2023; Limoges et al., 2020). During residency, trainees rotate through subspecialties such as neurotrauma, spine, vascular neurosurgery, and neuro-oncology, although the depth of exposure in each area can vary by institution. Upon completing residency, physicians may seek additional specialization through a two- to three-year fellowship accredited by bodies like the United Council for Neurologic Subspecialties (UCNS) or, more recently, certain programs recognized by the Accreditation Council for Graduate Medical Education (ACGME).

By contrast, individuals entering neuro-oncology from neurology or medical oncology complete a three- to four-year residency in their primary field, often coupled with a year of internal medicine in the case of neurology. They subsequently undertake a specialized fellowship in neuro-oncology, where they gain expertise in diagnosing and managing CNS tumors, understanding neuropathology, and employing cutting-edge therapeutic modalities, including chemotherapy, targeted agents, and immunotherapies. These fellowships frequently involve dedicated rotations in radiation oncology, neuroradiology, and neuropathology, ensuring that graduates can collaborate effectively with different specialists (Jensen et al., 2006). Many prominent cancer centers, such as MD Anderson Cancer Center, Memorial Sloan Kettering

Cancer Center, and Dana-Farber Cancer Institute, run research-intensive neuro-oncology fellowships, allowing trainees to participate in clinical trials and laboratory-based translational studies. This close integration of bench and bedside nurtures a cadre of physician-scientists capable of driving advancements in molecular diagnostics, novel therapeutics, and personalized care (Mäurer et al., 2022).

U.S. programs also emphasize board certification or equivalent credentials. The UCNS offers a specific examination in neuro-oncology, testing fellows on their knowledge of tumor biology, neuroimaging, symptom management, and therapeutic interventions. Achieving certification through UCNS or other relevant boards (e.g., American Board of Medical Specialties) is increasingly recognized as a marker of specialization, helping create consistent standards across diverse training sites.

3.2. Europe

Across Europe, there is a similarly rigorous but more regionally varied approach to neuro-oncology education (Weller et al., 2017). Medical training in many European countries consists of an integrated six-year curriculum, after which graduates enter a residency in neurosurgery, neurology, or oncology, usually lasting four to six years. Trainees aiming for a neuro-oncology focus often seek out advanced fellowships in specialized centers. These fellowships typically last one to three years and may be structured through national or supranational bodies.

European programs generally adopt a collaborative model in which trainees spend significant time working alongside medical oncologists, radiation oncologists, and palliative care teams (Kreye et al., 2022). This setup underscores the necessity of viewing CNS tumors through a holistic lens, with careful attention to neurological complications, quality of life, and functional rehabilitation. Research is also an integral component, while some centers emphasize clinical trials and protocol-based care, others encourage fellows to pursue PhD programs or postdoctoral research, often with a strong translational science focus (Kandi & Vadakedath, 2023). This dual track of clinical and academic training can prepare future consultants to navigate rapidly evolving treatment paradigms, such as targeted therapies against specific molecular alterations and immune checkpoint inhibitors.

3.3. Emerging Trends

One notable difference between U.S. and European models lies in the structure and length of clinical education. In the U.S., the undergraduate and medical school phases are distinct, followed by residency and fellowship, leading to a longer overall training period. In Europe, medical education is frequently condensed into a single six-year degree, with greater variability in how specialty training is organized afterward. However, both regions increasingly recognize the importance of standardized certification processes and share a commitment to multidisciplinary teamwork.

The focus on molecular diagnostics and personalized therapy has become a unifying theme worldwide (Louis et al., 2021). Trainees must develop familiarity with genomic profiling, biomarker-driven treatment regimens, and next-generation imaging techniques. This shift in neuro-oncology necessitates closer collaboration among neurosurgeons, neuro-oncologists,

radiologists, and pathologists, highlighting the value of structured rotations in each specialty. Formal fellowships provide an avenue for immersion in such interdisciplinary care, whether through joint tumor boards, combined clinics, or collaborative research initiatives. Moreover, technological advances, ranging from intraoperative MRI to stereotactic radiosurgery, have broadened the therapeutic landscape, driving the need for ongoing education and Continuing Medical Education (CME) programs even after formal training (Wu et al., 2022; Guru et al., 2024).

Although North America and Europe have led the establishment of formal neuro-oncology fellowships, other regions are increasingly adopting similar frameworks. In parts of Asia, for instance, large academic centers are formalizing collaborative training models with international institutions, incorporating telemedicine and online coursework to supplement clinical rotations (Shakir et al., 2024a; Shakir et al., 2024b). Such cross-border partnerships not only expand access to expert mentorship but also facilitate comparative research on genetic and environmental factors influencing tumor incidence and outcomes. These developments underscore a fundamental principle that effective neuro-oncology training demands a breadth of clinical, surgical, and scientific skills. By embracing multidisciplinary curricula, standardized accreditation, and robust research platforms, existing models in the U.S. and Europe have paved the way for emerging programs worldwide.

Compared with the well-established independent identity of neuro-oncology as a subspecialty in the U.S. and Europe, China's system remains heavily rooted in general neurosurgery. Furthermore, while Western models rely on robust external accreditation (e.g., ACGME or UCNS), China's training is primarily hospital-led. Therefore, the transition in China requires a shift from 'department-specific training' to 'interdisciplinary national standards'.

4. Developing Neuro-oncology Training in China

The training frameworks in the U.S. and Europe offer a template for nurturing specialists who can address the complexity of neuro-oncological diseases, however, the development of neuro-oncology training in China must be tailored to align with our country's healthcare landscape, resource availability, and patient needs (Xiao et al., 2023).To ensure the feasibility and sustainability of the proposed strategies, a three-phased implementation roadmap is recommended, transitioning from foundational standardization to high-level international integration. Phase 1: Standardization and Pilot Programs (Years 1-2). The immediate priority is to define national competency standards and establish pilot fellowship centers in top-tier academic hospitals. Phase 2: Expansion and Digital Integration (Years 3-5). The focus shifts to integrating interdisciplinary rotations (e.g., radiotherapy, pathology) and leveraging online platforms to bridge regional training gaps. Phase 3: Research-driven Excellence and Global Alignment (Year 5+). The long-term goal is to institutionalize "train-the-trainer" programs and align Chinese training standards with international accreditation bodies.

4.1. Establishment of Standardized Training Programs

Realistically, it is prioritized to integrate structured neuro-oncology training into existing medical education frameworks (Xu et al., 2016). National associations, such as the Chinese

neurosurgical society or specialized oncology organizations, can collaborate with government health agencies to establish regional demonstration centers dedicated to neuro-oncology and launch fellowship programs (1-2 years) appended to residencies in neurology, neurosurgery, or oncology (Wang & Zhang, 2020). Proposed curricula emphasize core competencies such as neuroanatomy, neurological tumor biology, multimodal therapies, molecular diagnostics, and palliative care, while incorporating mandatory research projects and ethics training (Frank et al., 2010). Training programs would adopt a competency-based structure, blending clinical rotations in neurosurgery, radiation oncology, and neuropathology with multidisciplinary tumor boards (Frank et al., 2010; Di Bonaventura et al., 2025). Moreover, developing uniform national standards for neuro-oncology training is crucial to ensure consistent care across China (Zhang et al., 2020). These professional societies should outline course requirements and accreditation criteria, and national guidelines can also integrate regular evaluations and on-site assessments to guarantee quality and uniformity among training centers.

4.2. Leveraging Continuous Education and Online Platforms

While structured neuro-oncology training programs are the cornerstone of professional development, continuing education and digital learning platforms serve as supplements to formal education, ensuring clinicians remain updated on evolving standards, technologies, and therapeutic strategies, or offering flexibility to practitioners navigating geographical constraints and time limitations (Sherman et al., 2024). Continued education focuses on specialized, topic-driven learning through webinars or seminars addressing cutting-edge advancements and case-based multidisciplinary discussions. These targeted programs, often organized by professional associations, enable clinicians to rapidly update skills in niche areas (Berg et al., 2025). Online platforms prioritize systematic, structured curricula, offering longitudinal learning pathways and comprehensive courses (e.g., certified modular programs) that cover foundational to advanced neuro-oncology competencies, such as tumor biology, multimodal treatment protocols, or palliative care ethics (Wang et al., 2021; Su et al., 2021; Wang et al., 2025). By integrating continuous education and online learning platforms with standardized neuro-oncology training programs, the neuro-oncology community can sustain expertise, bridge regional disparities, and accelerate the integration of research into practice, ultimately elevating patient care across all tiers of the healthcare system (Kim et al., 2025; Ge et al., 2024).

4.3. Enhancing Training Via Global Collaborations

Establishing certification standards aligned with globally recognized frameworks will facilitate cross-border collaborations, and partnerships with leading institutions worldwide offer valuable opportunities. Collaborative initiatives, such as joint fellowship programs with globally renowned centers, can expose trainees to cutting-edge techniques and novel therapies in brain malignancies (Shakir et al., 2024a; Shakir et al., 2024b). Structured exchange visits could include immersive observerships, where trainees engage in real-time tumor boards discussions, or hands-on training in emerging platforms (Mousavi et al., 2024). To institutionalize knowledge transfer, “train-the-trainer” programs could also pair Chinese faculty with international mentors to co-design curricula integrating global best practices with local realities (Gao et al., 2018; Gao et al., 2020). Embedding these collaborative frameworks will cultivate a self-sustaining ecosystem where

international expertise accelerates local innovation, ultimately positioning its neuro-oncology community as a global contributor in precision neuro-oncology care.

4.4. Strengthening Clinical Trials

Advancing high-quality clinical trials is essential to address gaps in evidence-based neuro-oncology care and therapeutic innovation (Xu et al., 2016). Despite a rising burden of brain tumors, participation in practice-changing trials remains limited due to fragmented infrastructure and insufficient researcher training. To address these gaps, neuro-oncology training programs should strengthen competency in clinical trial methodology, including protocol development, biostatistics, and ethical governance (Jensen et al., 2006). Trainees should engage in designing and executing investigator-initiated trials tailored to regional priorities (Yu et al., 2025). Central to this effort is establishing a national network of accredited trial hubs to standardize protocols, streamline ethics approvals, and enable multicenter collaborations. Additionally, integrating translational endpoints into trials will bridge preclinical and clinical research, and robust quality control through multiple mechanisms will enhance trial credibility (Zhao et al., 2021; Louis et al., 2021).

5. Conclusion

Neuro-oncology stands at the intersection of rapidly advancing molecular science and highly specialized techniques, making it a pivotal focus area in modern healthcare. In China, the growing incidence of neuro-oncological diseases highlights the urgency of developing robust, standardized training pathways that span neurosurgery, neurology, and oncology. Despite existing challenges, such as resource disparities, limited multidisciplinary exposure, and evolving therapeutic approaches, there are clear opportunities for progress. Strengthening national standards, leveraging platforms and international collaborations, and enhancing research participation can all contribute to bridging current gaps. By embracing these strategies, China has the potential to not only improve patient outcomes but also shape the global landscape of neuro-oncology through innovative research and clinical excellence.

6. Limitations and Future Directions

This study is primarily a qualitative review of existing frameworks. A key limitation is the lack of quantitative data regarding the current competency levels of early-career neurosurgeons across different Chinese provinces. Future research should employ nationwide surveys or longitudinal studies to evaluate the effectiveness of pilot fellowship programs and the impact of online learning on closing the urban-rural gap in neuro-oncological care.

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Multi-directional and In-depth: A Practical Research on Optimizing Homework Design Through School-Based Professional Development

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Abstract

In July 2021, the General Office of the CPC Central Committee and the General Office of the State Council issued the Opinions on Further Reducing the Homework Burden and After-school Training Burden of Students in Compulsory Education. Reducing students' excessive homework burden and improving homework design quality are among the main tasks of this policy. To implement the "Double Reduction" policy, Haining Yangshan Primary School determined to focus on optimizing homework design as the starting point for homework reform. Based on homework design for core competencies, we proposed principles and strategies for optimizing homework design, effectively improving teachers' homework design quality and cultivating students' core competencies. This study explores a school-based teacher training model that includes multi-directional and in-depth dimensions, refined tiered homework, integrated large-unit homework, and collaborative research and sharing mechanisms. Through three years of practice, significant results have been achieved in reducing students' homework burden while improving learning quality.

Keywords: Double Reduction Policy; School-Based Teacher Training; Homework Design; Core Competencies; Primary Education

1. Introduction

In July 2021, the General Office of the CPC Central Committee and the General Office of the State Council issued the "Opinions on Further Reducing the Burden of Homework and Extracurricular Training for Students in Compulsory Education" (hereinafter referred to as the "Double Reduction" policy) (Ministry of Education of the People's Republic of China, 2021).

This landmark policy document explicitly identifies reducing students' excessive homework and improving its design; this policy marks a significant shift in China's basic education reform.

As a vital link between classroom instruction and after-school reinforcement, the quality of homework assignments directly impacts the achievement of instructional objectives and the effectiveness of student learning, serving as a core mechanism and practical cornerstone for implementing the "Double Reduction" policy. Cao (2023) highlights the need to examine the "Double Reduction" issue from multiple dimensions-both through specific governance approaches and broader perspectives of sustainable human and social development. This dual approach clarifies the means-ends relationship. Education, though rooted in the private sphere of children and their families, is defined by its public nature, which is fundamental to public education. The optimization of homework design embodies the integration of education's public nature with the needs of individual development.

Since the implementation of the "Double Reduction" policy, reducing the volume and enhancing the quality of primary and secondary school homework has become a hot topic in educational theory and practice research. In the quest to improve the quality of homework, the academic community has conducted extensive research on the theoretical foundations and practical strategies of homework design. Qian and Shi (2024) point out that well-designed homework is a crucial link in ensuring classroom teaching quality. Cognitive diagnostic theory can not only effectively address the issue of improving quality and efficiency but also help resolve the practical contradiction between personalization and scalability. In their 2024 study, Wang et al. (2024) further emphasize, from a systems perspective, that primary and secondary schools must effectively reduce students' excessive homework burden. They argue that homework design is the fundamental approach to alleviating this burden, and that it is necessary to conduct an in-depth exploration of the standards that homework design should adhere to from a systems theory perspective.

However, empirical investigations also reveal that despite diversified homework optimization reforms in basic education, certain issues inevitably persist across primary and secondary schools nationwide. Wu and Li (2024) note that current homework reduction policies in primary and secondary schools have not been fully implemented in practice. To varying degrees, regions face issues such as homework content failing to effectively align with educational development and student needs, as well as lax homework management processes. Research by Luo et al. (2025) further indicates that schools serve as the primary battleground for implementing the "Double Reduction" policy, with teachers bearing responsibility for its advancement. Teachers' policy execution capacity directly impacts the effectiveness of implementation.

Against this backdrop, optimizing homework design is not only a practical requirement for implementing the "Double Reduction" policy, but also an inevitable choice for overcoming the current challenges in homework reform and returning to the essence of education. As a grassroots educational institution, Yangshan Primary School in Haining City actively responded to national policy directives by initiating homework reform centered on optimizing assignment design. The school established principles and strategies for enhancing homework design, effectively improving the quality of teachers' assignments, and cultivating students' core competencies. This

study aims to share the school's practical experience in optimizing homework design through school-based professional development, providing a reference for other schools implementing the "Double Reduction" policy.

2. Literature Review

2.1. Policy Orientation for Homework Design Under the "Double Reduction" Policy

The core essence of the "Double Reduction" policy is not merely to reduce the quantity of homework, but to achieve a virtuous cycle of reducing students' academic burden and enhancing learning efficiency by improving the quality of homework (Wu and Wang, 2025). The policy explicitly requires that homework design be integrated into the curriculum and teaching research system, embodying characteristics of differentiation, flexibility, and personalization, while eliminating mechanical repetition and punitive assignments (Ministry of Education of the People's Republic of China, 2021). Subsequent supporting policies have further refined these requirements: the 2022 "Five-Pronged Management" initiative emphasized that homework design must align with students' age characteristics and learning patterns, while the 2024 "Work Plan for the 'Education Consortium' on Home-School-Community Collaborative Education" proposed optimizing the supply of homework resources through home-school-community collaboration (Li and Li, 2025).

From the perspective of policy implementation logic, the core orientation of homework design reform is reflected in three dimensions: the value orientation has shifted from knowledge consolidation to competency development, requiring homework to fulfill the function of fostering virtue and integrating core competency development goals (He and Wang, 2025); the implementation approach has shifted from piecemeal design to systematic construction, emphasizing the consistency of homework with curriculum, instruction, and assessment (Wu and Wang, 2025); the shift in primary responsibility from teachers designing assignments independently to collaborative development among multiple stakeholders, highlighting the school's central role and the supportive function of teaching and research (Luo et al., 2025).

2.2. Theoretical Foundations of Assignment Design

The optimization of assignment design must be grounded in diverse educational theories. Cognitive diagnostic theory provides a core technical pathway for precision assignment design, enabling accurate assessment of students' mastery of knowledge and thereby resolving the tension between personalization and scalability (Qian and Shi, 2024). Systems theory, from a holistic perspective, proposes that homework design should establish a cyclical model of "analysis-conceptualization-design-feedback," emphasizing the synergistic interaction among school management, teacher competence, homework content, and evaluation feedback (Wang et al., 2024). Furthermore, the principle of teaching according to individual aptitude requires that homework difficulty be aligned with students' ability levels, providing a direct basis for tiered homework design (Xi , 2024).

2.3. Limitations of Existing Research and Research Gaps

Although existing research has made some progress, there remains a disconnect between theory and practice. Most studies focus on a single theory or a narrow approach, lacking a comprehensive exploration of the full implementation process in grassroots schools. Due to high technical barriers, precision design techniques such as cognitive diagnosis rely on specialized tools and data support, making them difficult to implement in ordinary primary and secondary schools. Additionally, evaluation systems remain inadequate; existing research often emphasizes innovation in homework design formats while neglecting quantitative assessments of implementation outcomes and long-term tracking.

Current research has not fully addressed three key questions: How can a low-threshold, high-effectiveness professional development system for homework design be established that is suitable for grassroots schools? How can a balance be struck between the differentiation and personalization of homework and its large-scale implementation? How can a closed-loop mechanism for optimizing homework design be established? These research gaps provide the core entry points for this study.

2.4. Innovative Value of This Study

The innovation of this study is primarily reflected in three aspects: First, innovation in the practical approach, which involves constructing a “multi-directional and in-depth” school-based professional development model that deeply integrates homework design with teacher professional development, thereby forming a replicable operational framework for grassroots schools; Second, innovation in technical translation: transforming complex theories such as cognitive diagnosis into tiered design methods that are easy for teachers to implement, thereby lowering the barrier to entry for precise homework design; Third, innovation in the evaluation system: establishing a dual assessment mechanism combining “process+outcome” and “quantitative+qualitative” approaches to provide empirical evidence of the effectiveness of homework design.

3. Research Design and Methods

3.1. Research Subject

This study focuses on Yangshan Primary School in Haining City. The school is a public compulsory education primary school with a current staff of 149 members. Its curriculum covers all compulsory education subjects, including Chinese, mathematics, English, science, art, and physical education. The school currently has 56 classes and 2488 students.

3.2. Research Process

This study was conducted in three phases. During the initiation phase (September 2021-December 2021), a school-based professional development plan was formulated based on policy study and current status research, establishing a “multi-directional-in-depth” professional development framework. Implementation Phase (January 2022-December 2024): We fully

implemented refined, tiered homework assignments and integrated large-unit homework designs. Concurrently, we conducted collaborative professional development activities under the "Master Teacher Mentorship+Young Teacher Growth Camp" model, established a three-tier review mechanism for homework design, and conducted periodic effectiveness evaluations and strategy adjustments each semester. Optimization Phase (January 2025-May 2025): Refine the principles and strategies for homework design, establish a school-based homework resource repository, and conduct a summary of outcomes along with an effectiveness evaluation.

3.3. Research Methods

This study employs a comprehensive approach utilizing multiple research methods. Through literature review, we analyzed the "Double Reduction" policy documents, theoretical literature on homework design, and domestic and international case studies to construct the theoretical framework and practical references for the research. Data was collected through questionnaires (a student homework burden and learning interest survey once per semester, and a parent satisfaction survey once per year) and interviews (teacher interviews twice per year). A total of 4860 questionnaires were distributed, with 4628 valid responses received; interviews were conducted with 156 teachers, 320 students, and 280 parents. Using the case study method, representative subjects such as Chinese, mathematics, and science were selected to track and document the entire process of homework design optimization, resulting in 12 typical cases for in-depth analysis; data analysis software was utilized to conduct pre- and post-comparative analyses of quantitative indicators such as student homework time, academic performance, and classroom participation, and to complete statistical data processing.

4. Principles of Homework Design

Against the backdrop of the "Double Reduction" policy, reducing workload while enhancing effectiveness serves as the overarching principle for modern educators in optimizing subject-based homework design. Based on practical circumstances, the school has established four core principles for refining homework assignments. These principles are interconnected and mutually reinforcing, collectively forming the theoretical framework for optimizing homework design within the school.

4.1. Target Principle: Emphasizing Core Competencies

Against the backdrop of the "Double Reduction" policy, enhancing teachers' ability to design goal-oriented assignments is crucial. Optimizing homework design based on the new curriculum standards and targeting core competencies is key to implementing policy requirements. Xi (2024) proposes that the tiered design of elementary mathematics homework under the "Double Reduction" policy should focus on cultivating students' core competencies rather than merely engaging in repetitive, mechanical drills of knowledge points.

Schools should adopt structured design approaches aligned with large-unit homework models, emphasizing holistic frameworks and enhanced interconnectivity to elevate students' cognitive levels. The principle of purposefulness requires teachers to first identify specific core

competencies to be developed when designing assignments. Tasks should then be crafted around these objectives to authentically assess students' developmental progress, transforming homework into an effective tool for promoting well-rounded growth. For instance, in mathematics instruction, if the core competency goal for a lesson is to develop logical reasoning skills, homework should emphasize proof-based reasoning rather than repetitive computational drills. Through this approach, homework ceases to be an appendage of classroom teaching and instead becomes a vital pathway for cultivating students' core competencies.

4.2. Comprehensive Principle: Emphasizing Comprehensive Application

When designing assignments, teachers should focus not only on knowledge content but also on fostering students' comprehensive competencies. By drawing from their own perspectives, educators can explore assignment design that stimulates motivation for learning and achievement. This approach enhances the interactivity between subject knowledge while incorporating students' relevant life experiences and social knowledge. Integrating subject-specific knowledge with interdisciplinary concepts optimizes classroom instruction. Jiang (2024) emphasizes that under the "Double Reduction" policy, the essence of enriching science education should return to the classroom, with assignment design reflecting practicality and comprehensiveness.

The principle of comprehensiveness recognizes that real-world problems rarely align neatly with single-subject boundaries. By designing homework that requires students to apply multidisciplinary knowledge and skills, teachers equip students with the ability to tackle complex challenges in future academic and professional life. Schools encourage teachers to design interdisciplinary project-based assignments, enabling students to synthesize their learning through research, data analysis, product creation, and presentation of findings. Interdisciplinarity does not mean erasing disciplinary boundaries; rather, it involves identifying organic connections between disciplines while preserving the core knowledge systems of each. In their teaching practice, educators should strike a balance regarding "disciplinary boundaries," centering on the core competency goals of the primary subject and using knowledge and skills from other disciplines as support and extensions. This approach helps avoid both the formalism of integration for integration's sake and the tendency to cover everything superficially without delving deeply into any single topic.

4.3. Appropriateness Principle: Focusing on Layered Effects

Teachers can assign homework tailored to individual students. Given that each student's knowledge mastery, homework completion, and overall abilities vary, assignments must accommodate different learners to achieve differentiated instruction. Wang (2025) proposes that effective, appropriate, and high-quality flexible homework design serves as a practical vehicle for precision teaching, emphasizing the creation of tiered, optional, and open-ended assignments based on students' individual differences and learning needs.

The principle of appropriateness requires teachers to develop multiple versions of assignments that vary in complexity and challenge level. For each lesson, teachers should design foundational-level assignments ensuring all students grasp core concepts, intermediate-level assignments challenging students to apply knowledge in new contexts, and advanced-level assignments

providing enrichment opportunities for high-achieving students. Students can autonomously choose which level to attempt, fostering their self-directed learning and self-regulation skills.

Implementing tiered assignments requires teachers to possess a deep understanding of their students. Schools mandate that teachers comprehensively assess each student's learning status and ability level through daily observations, homework analysis, test scores, and other methods to inform tiered assignment design. Simultaneously, schools emphasize that tiering is not static but should be dynamically adjusted based on students' learning progress, ensuring every student develops at their appropriate level. In his 2024 review of Diverse Designs for Innovative Primary Chinese Language Assignments, Li noted that assignment design must balance knowledge reinforcement with interest stimulation, fostering students' autonomous learning abilities and innovative spirit. This perspective aligns with the school's principle of appropriateness, both emphasizing that assignment design should address individual differences and developmental needs.

4.4. Evaluative Principle: Focusing on Comprehensive Development

The purpose of homework evaluation is to assess students' mastery of knowledge and the effectiveness of their assignments. Through communication, work displays, and other methods, a dynamic evaluation is conducted by multiple stakeholders-including self-assessment, peer assessment, teacher assessment, and parent assessment-across dimensions such as knowledge, skills, competencies, and attitudes. This approach motivates students to complete assignments more effectively and comprehensively enhances homework efficacy.

The school has developed a comprehensive evaluation framework that transcends traditional pass/fail grading. As the primary evaluators, teachers focus on the accuracy of students' knowledge acquisition, the proficiency of their skill application, and the development of their subject-specific literacy. Through self-assessment, students reflect on their level of effort, the extent of their progress, and any knowledge gaps in their learning process, thereby cultivating a multifaceted understanding of themselves. Peers evaluate each other's contributions and teamwork skills during collaborative activities. Parents assess their children's attitude toward learning and the development of homework habits, and gain insight into their children's overall development through communication between home and school. This multidimensional evaluation system helps teachers identify students who may require additional support or enrichment, avoids the limitations of a single evaluation perspective, and provides a reference for improving instructional strategies.

4.5. Theoretical Basis for the Formulation of Principles

4.5.1. Understanding by Design

The Compulsory Education Curriculum Guidelines (2022Edition) explicitly require that education and teaching focus on cultivating core competencies. As an extension of instruction, assignments must align with this core objective. Understanding by Design (Grant Wiggins and Jay McTighe) complements core competency theory; its "backward design" logic requires teachers to first clarify the learning objectives for core competencies and students' expected understanding, and then design assignment tasks in reverse. The Principle of Goal-Orientation is

grounded in this theoretical framework, transforming abstract competency requirements into assessable and actionable specific assignment tasks. It ensures that assignment design consistently revolves around the questions: "What competencies should be cultivated? How should these competencies be assessed? How should tasks be designed to achieve these competencies?" This approach prevents assignment design from becoming disconnected from the goals of competency development.

4.5.2. TPACK: The Technology Pedagogical Content Knowledge Model

Systems theory emphasizes the dialectical relationship between the whole and its parts. As a subsystem of the educational system, assignment design must interact synergistically with elements such as curriculum, instruction, and assessment (Wang et al., 2024). The TPACK (Technology Pedagogical Content Knowledge) model (Punya Mishra and Matthew Koehler) emphasizes that assignment design must integrate three core elements: content knowledge (CK), pedagogical knowledge (PK), and technological knowledge (TK). It also requires consideration of interdisciplinary knowledge connections, the alignment of teaching methods with assignment formats, and the integration of modern educational technology with assignment implementation. The principle of comprehensiveness embodies the holistic requirements of this theoretical framework, breaking through the limitations of assignment design confined to a single discipline, a single format, or a single pathway, and enabling assignments to serve as a vehicle connecting disciplinary knowledge, teaching practice, and students' lives.

4.5.3. SOI-SIOP

The concept of differentiated instruction emphasizes that education must adapt to individual student differences (Xi, 2024). SOI-SIOP (Structure of Intellect-Student-Oriented Instructional Planning) provides a scientific and practical framework for differentiated instruction. This model comprehensively assesses students across three dimension-learning styles (visual, auditory, kinesthetic), cognitive abilities (memory, reasoning, problem-solving), and foundational knowledge-to precisely identify their learning needs and ability levels. The principle of appropriateness, grounded in this theoretical framework, elevates tiered assignment design from simple difficulty-based stratification to a multidimensional approach that integrates "difficulty+learning style+ability requirements." This ensures that every student can achieve growth within their own capabilities and in alignment with their learning style.

4.5.4. KANO User Needs Analysis Model

The KANO User Needs Analysis Model provides professional support for precise and diversified assignment feedback. In the context of this study, it categorizes students' needs regarding assignments into three levels: basic needs (feedback on knowledge mastery), expected needs (feedback on skill development), and excitement needs (personalized evaluation and growth incentives). This approach requires that feedback not only meet students' basic learning needs but also exceed expectations by providing guidance on skill development, while simultaneously stimulating learning interest through personalized incentives. Based on this theory, the evaluative principle establishes a multi-stakeholder feedback system, transforming assignment evaluation from a mere judgment of right or wrong into a vital tool for motivating student

learning and helping teachers optimize their instructional design, thereby maximizing the value of assignments.

5. School-based Teacher Training Approach to Homework Design

To ensure the effective implementation of the "Double Reduction" policy, schools-as the primary venues for teaching-should continuously refine their school-based professional development systems. They should prioritize improving homework quality as a breakthrough point for enhancing teachers' professional competence, making homework design a focal point of school teaching research. Regular school-based training should be conducted, and homework design capability should be incorporated as one of the criteria for evaluating teachers' educational and teaching competencies. Research by Luo et al. (2025) indicates that teachers' implementation of the "Double Reduction" policy is influenced by factors such as subjective norms, perceived behavioral control, and behavioral attitudes. Therefore, establishing a supportive institutional environment is crucial for teachers' professional development.

5.1. Exploring New Training Ideas

Under the "Double Reduction" policy, homework design holds significant practical importance. By optimizing homework assignments, teachers enhance teaching practices, stimulate students' interest in learning, and build their confidence. This lays a foundation for students to complete assignments more effectively and improve their core subject competencies in the future. In summary, enhancing all teachers' ability to optimize homework design is particularly crucial.

Based on this, the school implements a school-based professional development program centered on homework design through two dimensions: First, grounded in classroom practice and problem-focused, it conducts multi-directional professional development activities. Through individual study, mentorship by distinguished teachers, grade-level integration, and departmental workshops, it strives to create efficient classrooms and enhance research capabilities (as shown in Figure 1).

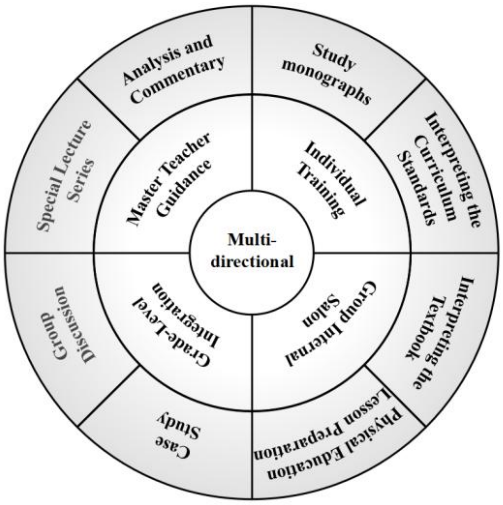

Figure 1. Schematic Diagram of the Connotations of the "Multi-directional" Dimension

Second, centered around the theme, we conducted in-depth training activities through layered refinement. By integrating theoretical guidance, practical design, reflective optimization, and compilation into a handbook, we significantly reduced students' homework burden and stimulated their interest in learning (as shown in Figure 2).

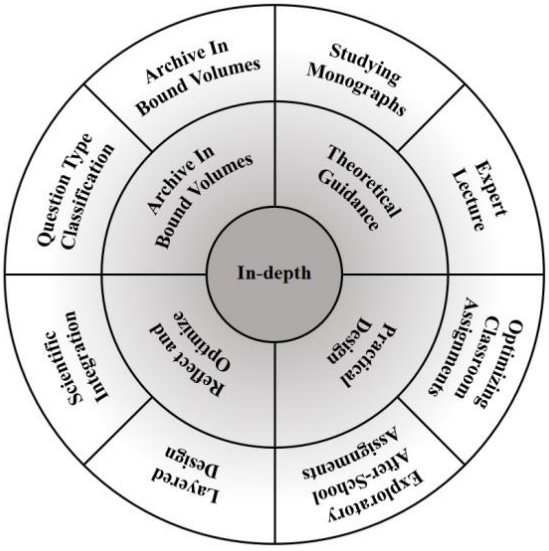

Figure 2. Schematic Diagram of the "In-depth" Dimension's Implications

5.2. Enhancing New Training Patterns

Based on the above considerations, the school has established a school-based professional development program focused on optimizing homework design. This initiative aims to enhance the quality of teachers' homework assignments and cultivate students' core competencies (as shown in Figure 3).

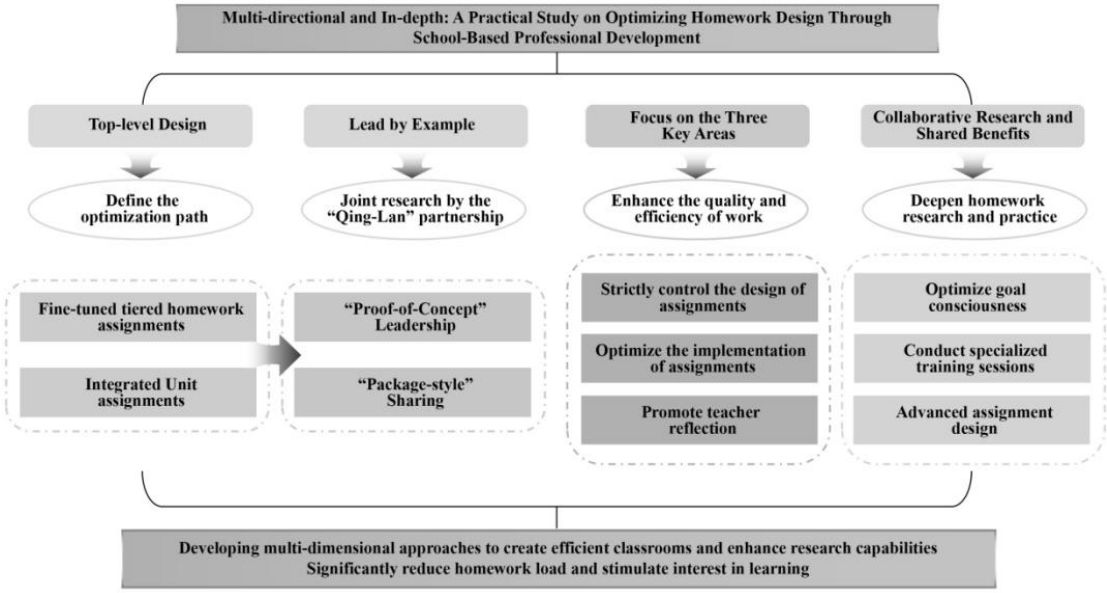

Figure 3. Multi-directional and In-depth: Operational Diagram of Practical Research on Optimizing Homework Design Through School-Based Professional Development

5.2.1. Top-level Design: Clarifying Optimization Paths

Implementing the spirit of reducing academic burdens, specialized training sessions on homework design have been conducted at all levels and for various types of assignments. This initiative strengthens theoretical learning in homework design, laying a solid foundation for scientific and standardized assignment creation. Centering on school-based professional development projects, the school has proposed the following pathways for optimizing homework design.

The first point is refined, tiered operations. Refined Tiered Assignments. Tiered assignment design involves creating targeted homework based on students' individual characteristics, existing knowledge levels, and learning ability differences. However, its implementation in actual teaching has been less than satisfactory, failing to leverage learning objectives as a guiding principle for assignment design. To address this, the school proposes refined tiered assignments emphasizing "three refinements." First is the precise stratification. This entails two dimensions: stratification must be grounded in learning objectives and student diversity, while assignment difficulty and quantity must be meticulously tiered-for instance, distinguishing between foundational and extension assignments, or written tasks and hands-on practice. Second is refined selection, concerning the content choices for assignments. This requires alignment with learning objectives, emphasizing representativeness and goal attainment, while also ensuring both foundational knowledge and individual development are enhanced. Finally, refined compilation stresses that assignment design should focus on consistency between learning objectives, knowledge content, and real-life contexts. Attention must be paid to the practicality, contextual relevance, and real-world applicability of assignments to stimulate student interest and cultivate key competencies and subject-specific literacy (as shown in Figure 4).

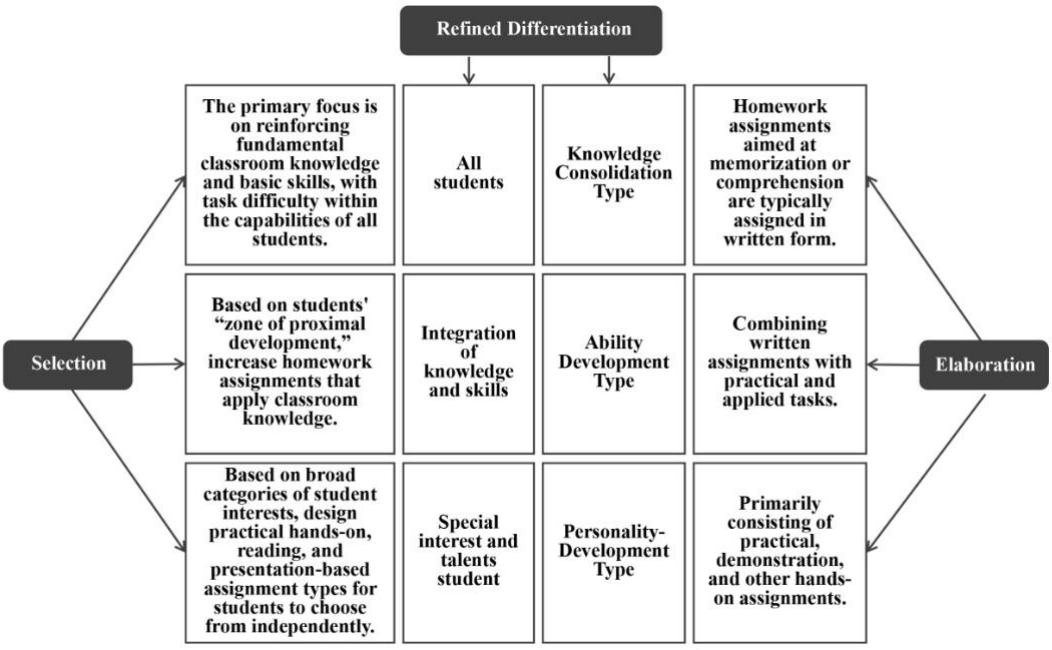

Figure 4. Schematic Diagram of the "Three-Step" Operation

It should be noted that the “fine-grained differentiation” discussed in this paper encompasses two dimensions: first, the differentiation of assignment content, which involves categorizing assignments into different levels-such as foundational, advanced, and extension-based on difficulty and task type; second, the grouping of students, which involves comprehensively assessing students’ mastery of knowledge, learning abilities, and interests to divide them into different learning groups. The grading of homework content and the grouping of students are two interrelated yet fundamentally distinct concepts: the former pertains to the design of the homework tasks themselves, while the latter refers to the organizational structure of the learning group.

The second is integrated, large-unit assignments.Integrated large-unit assignments. These assignments should not only encompass content from each lesson but also span two or more units in their design, potentially crossing disciplines, units, and grade levels. Their integration manifests primarily in three aspects. First is content integration. Assignments target the cultivation of core subject competencies, synthesizing knowledge points across units to identify connections and structure them systematically. Second is design integration, where assignments are conceived from a holistic perspective to reflect the structural and relational connections between unit knowledge points, helping students form sound cognitive frameworks. Finally, form integration involves diversifying assignment formats. Assignments can be designed based on specific learning objectives within the content, or they can integrate students’ existing unit knowledge to combine multiple assignment formats. Xu (2024) emphasizes that to meet the requirements of the new curriculum standards and enhance teachers’ homework design capabilities, conducting school-based professional development focused on homework design within a large-unit framework is essential (as shown in Figure 5).

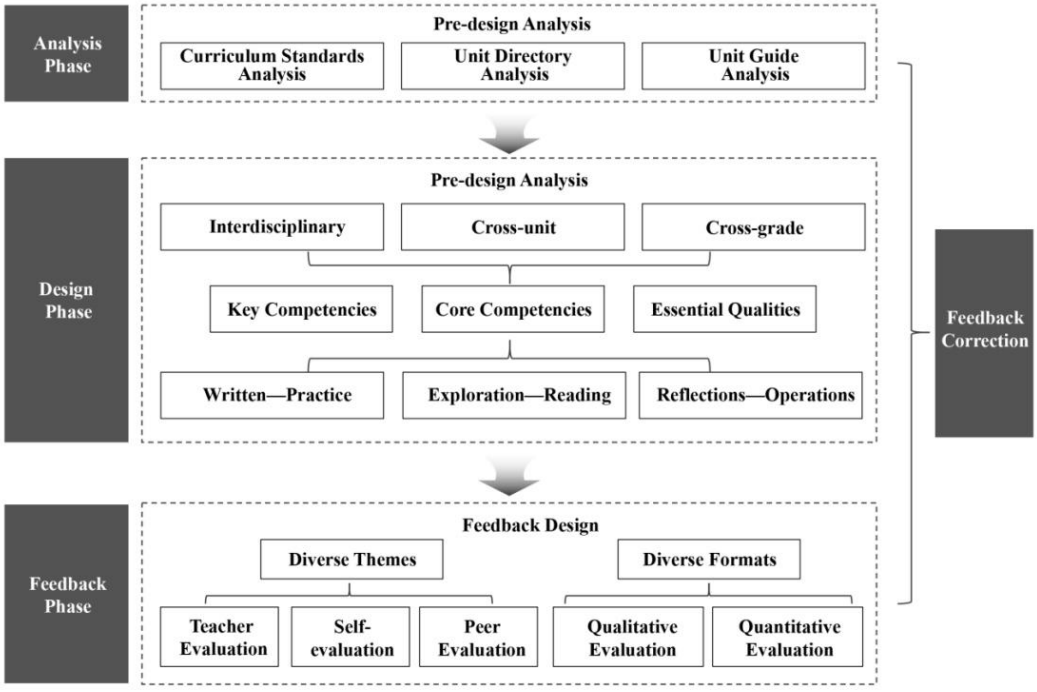

Figure 5. Large-Unit Project Design Blueprint

5.2.2. Demonstration and Leadership: Blue-Green Partnership for Collaborative Research

Led by the school's distinguished teachers and supported by outstanding young faculty members, the Blue-Green Partnership (also known as the Young Teachers' Growth Camp) was established. Its purpose is to guide educators in conducting specialized research on homework design, fostering a school-based homework system that progressively evolves from design and implementation to feedback-spanning daily assignments, periodic exercises, and reflective improvements-ultimately forming an interactive framework of mutual reinforcement and correction.

"Design-Driven" Leadership. The camp prioritizes homework optimization as a core professional development initiative. Addressing issues in current assignment design-such as goal alignment, content relevance, and structural coherence-it adopts a unit-based approach. This involves analyzing unit curriculum materials, designing unit assignments, gathering implementation feedback, and refining assignments through a research-driven cycle. Grade-level workshops focus on developing comprehensive unit-based homework designs. During the implementation phase, participants engage in iterative discussions and refinements of assignment designs. This process identifies challenges while accumulating best practices, with insights disseminated across subject teams to enhance assignment effectiveness.

"Bundled" Sharing. Grounded in curriculum standards and grade-level requirements, the Growth Camp facilitates school-based, phased assignment optimization tailored to student needs and textbook specifications. Members designed segmented assessment assignments for grades 1-6 based on the phased teaching content of each grade's instructional tasks and the key competency training focuses for that stage. Following implementation, teachers conducted quality analysis and reflection on their class situations. Based on the implementation feedback, they: 1.Revised and adjusted relevant designs to prepare thoroughly for subsequent implementation; 2.Provided targeted improvement suggestions for each class's next-phase teaching implementation to enhance effectiveness.

5.2.3. Grasping Three Gates to Improve Homework Quality and Effectiveness

Given the current weakness in teachers' homework design and implementation, homework management is delegated to teaching research groups. The focus is on strengthening three key areas: rigorously controlling homework design, optimizing homework implementation, and promoting teacher reflection. This approach uses management to drive standardization, standardization to drive quality, and continuously enhances the quality and effectiveness of homework.

Ensuring Rigorous Homework Design. Each teaching research group prioritizes monthly specialized training sessions on homework design during collective lesson preparation activities. Standardized procedures are implemented: the lead preparer completes unit homework design one week in advance, and group members independently review and provide feedback. During the preparatory group meeting, the lead designer and members discuss the unit assignment; finally, the lead designer incorporates feedback, revises the assignment, and submits it to the preparatory group leader for review and release (as shown in Figure 6).

Figure 6. Assignment Specialized Training Model

Optimizing Homework Implementation. At the beginning of the semester, the Academic Affairs Office revised the homework routine checklist and organized teachers to study requirements regarding homework objectives, wording, structure, timing, grading, feedback, reflection, and tutoring. During implementation, beyond basic standards like homework frequency and teacher grading, particular emphasis was placed on analyzing homework design quality-specifically considering aspects such as goal alignment, scientific design, diverse types, appropriate difficulty, reasonable time allocation, logical structure, and differentiation. Building on this foundation, subject teams conduct regular peer reviews of homework practices. This allows teachers to identify strengths in others' approaches, reflect on their own shortcomings, and make improvements.

Promoting Teacher Reflection. On one hand, subject teams require teachers to utilize subject-specific homework portfolios effectively. These portfolios document common student errors and individual student mistakes in real time, providing solid evidence for class-wide homework feedback sessions. Teachers are also required to engage in teaching reflections to refine and enhance future instruction. On the other hand, for frequently occurring problems in student assignments, the teaching group collaboratively analyzes the root causes of these errors. Together, they design supplementary exercises to reinforce learning, iteratively optimizing the design and implementation of tiered homework assignments.

5.2.4. Collaborative Research and Sharing: Deeply Cultivating Homework Training

Adhere to a diverse school-based professional development strategy, fostering collaborative research and knowledge sharing through activities. Grounded in competency-based education, problem-oriented approaches, and iterative refinement, we will deepen research on optimized homework design to tangibly enhance teachers' homework planning capabilities.

Competency-based and goal-oriented. Conduct specialized training on effective homework design through both external learning (attending expert lectures and master teacher seminars) and internal training (inviting subject specialists and experts to train teachers). This transforms homework design from arbitrary to standardized, and from experience-based to scientific, providing theoretical support and innovative approaches for in-depth research. The school organizes teacher forums, homework design competitions, and case study writing contests to explore effective strategies and best practices. These insights are shared during teacher forums to find the intersection between reducing workload and enhancing effectiveness.

Problem-Oriented Approach: Conducting Thematic Training. Each teaching research group identifies current homework issues through routine inspections and classroom observations, establishes research themes, and conducts training activities. Leveraging the exemplary role of distinguished and outstanding teachers, we address key challenges in homework design. Through

discussion and practice, teachers gain a deeper understanding of design principles and methodologies, thereby enhancing their homework design capabilities.

Starting with iteration, we advance homework design. Each subject focuses on multiple aspects, including objectives, content, delivery methods, and assessment. Beyond designing targeted consolidation assignments, we also provide ability-development-oriented tasks for high-achieving students, catering to diverse learning needs. To diversify homework formats, we design more creative content and flexible types-such as extension, research-based, and hands-on assignments-emphasizing cognitive development, imaginative thinking, and practical skills. This transforms homework experiences into a holistic, expressive learning journey, pioneering new approaches and embodying innovative principles in assignment design.

6. Recommendations for Optimizing Homework Design through School-based Teacher Training

6.1. Implementing Refined Management

The school has introduced the "Haining Yangshan Primary School Student Homework Management System" and the "Haining Yangshan Primary School Implementation Rules for Strengthening Homework Management," emphasizing aspects such as homework assignment, grading, and evaluation. A management mechanism has been established involving the principal's office, the teaching affairs office, subject departments, and all teachers. Teachers in each subject carefully manage homework in accordance with the system, ensuring comprehensive, meticulous, and practical implementation. Teachers meticulously design assignments, carefully grade work, provide substantive feedback, prioritize process-based evaluation, and emphasize developmental assessment. This maximizes the functionality and impact of homework, effectively reducing students' excessive academic burden and promoting their healthy development. Li and Li (2025) emphasize that optimizing the educational ecosystem is an inherent necessity for advancing the implementation of the "Double Reduction" policy. Evaluating the effectiveness of this policy should focus on the restoration and improvement of the educational ecosystem.

6.2. Grounding in Classroom Teaching

School-based professional development must be grounded in the classroom. Teachers should anchor their efforts in the primary arena of classroom instruction. Building upon a thorough study of curriculum standards and teaching materials, they should meticulously design lesson plans, carefully select exemplary problems and exercises, and continuously reinforce key concepts, promptly address ambiguities, and effectively resolve difficulties during classroom teaching. Before assigning homework, teachers should complete the tasks themselves. Homework should be categorized into required and optional assignments, carefully selected based on student learning needs to ensure foundational coverage and timeliness. Assignments should take diverse forms; beyond written work, oral assignments, research-based learning tasks, and practical projects are encouraged.

6.3. Implementing Burden Reduction and Efficiency Improvement

The school advocates reducing students' excessive and unnecessary academic burdens by implementing appropriate, targeted practice requirements. The Academic Affairs Office centrally manages homework assignments, ensuring overall compliance with curriculum standards, textbook requirements, and students' actual capabilities. This approach aims to reinforce knowledge understanding, hone skills and techniques, cultivate interests and abilities, and serve as a feedback mechanism for adjusting teaching methods. Homework types, content, and quantity must be standardized, with difficulty levels carefully controlled. Regular monitoring and spot checks of homework assignments across all grades are conducted through surveys, student interviews, and parent questionnaires. Grade-level teams carefully select assignments, maintain an overview of class-wide homework distribution, and coordinate effectively with subject teachers.

6.4 Enhancing Feedback on Assignments and Instructional Improvement

The school conducts monthly inspections of homework assignments by teachers, involving the Curriculum and Teaching Research Office, grade-level teams, and subject-specific teaching groups. Inspection results are documented in teachers' professional records. The school incorporates metrics such as homework duration, assignment formats, and evaluation methods into its teacher performance evaluations, thereby encouraging educators to enhance homework design quality and reduce students' academic burden.

Homework feedback not only serves as a basis for evaluating student learning outcomes but also constitutes a vital resource for teachers to conduct pedagogical research and refine teaching methods. The school has established a closed-loop mechanism of "identifying problems-analyzing causes-improving instruction-tracking and verifying results": when homework feedback indicates a high error rate on a specific concept, the teaching research group promptly organizes discussions to analyze the root causes of these errors, adjusts teaching strategies accordingly, and designs targeted remedial exercises; At the same time, the school encourages teachers to transform issues identified in homework feedback into small-scale research projects, such as "A Study on Improving Primary School Mathematics Concept Teaching Based on Homework Error Analysis," thereby continuously enhancing teaching capabilities through action research. This evidence-based model of instructional improvement fully embodies the core function of school-based professional development in fostering teacher growth, rather than merely treating homework feedback results as quantitative metrics for performance evaluations.

7. Discussion

Through over three years of practice, the school has achieved remarkable results in optimizing homework design through school-based professional development. Students' learning interest and academic performance have both improved, with students showing significantly increased classroom participation and enhanced learning initiative. Teachers' homework design capabilities have markedly advanced, fostering a cohort of professionally competent core educators who have consistently excelled in teaching competitions at various levels. Their homework design case studies have been promoted regionally (Table 1 and Table 2).

Table 1. Changes in Students' Homework Load and Academic Performance (2022-2024)

Indicators	2022	2023	2024
Average daily homework time (minutes)	78.5	62.3	55.8
Satisfaction with completed assignments (%)	68.2	75.6	82.4
Percentage of students achieving excellence in academic quality monitoring(%)	24.5	28.3	31.7
Class participation rate (%)	56.3	64.7	71.5

Table 2. Development of Teachers' Assignment Design Skills (2022-2024)

Indicators	2022	2024
Number of teachers awarded for assignment design	2	15
Teacher satisfaction with assignment design training (%)	-	91.5
Parent satisfaction with homework assignments (%)	72.4	89.6

However, challenges have emerged during implementation. First, teachers exhibit varying degrees of acceptance toward new pedagogical concepts, with some still relying on traditional homework design methods. This disparity in mindset leads to inconsistent homework quality, necessitating ongoing school-wide training and guidance. Second, developing large-unit assignments demands substantial additional time and effort, creating a practical dilemma for teachers in balancing daily instruction with homework research. Many teachers report that designing high-quality large-unit assignments often requires several times the effort of conventional assignments, placing greater demands on already busy teaching schedules.

8. Limitations and Future Directions

Since the study was conducted at only one elementary school, the representativeness of the sample is limited, and the applicability of the findings to different types of schools (such as middle schools and schools in urban-rural fringe areas) requires further verification; The three-year implementation period reflects only short-term changes in academic performance; the long-term effects on students' learning interest, study habits, and innovative thinking require longer-

term observation and analysis; the study relies primarily on data collected independently by the school and lacks third-party assessment data, which may introduce some subjective bias; regarding the design of interdisciplinary assignments, challenges in achieving deep integration persist due to disciplinary barriers and limitations in teachers' professional backgrounds, and some interdisciplinary assignments exhibit a tendency toward formalism.

Future research could strengthen long-term tracking of assignment design effects to explore how optimized assignments impact students' sustainable development; Conduct comparative studies across multiple schools to validate the scalability of the school-based professional development model; further explore how to effectively utilize information technology to design targeted assignments, thereby enabling intelligent management of differentiated assignments. Regarding educational resources, establishing regional homework design resource-sharing platforms could facilitate the exchange of exemplary homework design cases among schools. Resource sharing would reduce redundant work for teachers, elevate the overall quality of homework design, and achieve equitable distribution of high-quality educational resources.

9. Conclusions

Optimizing homework design through school-based professional development ensures educational effectiveness by providing tiered, targeted exercises that cater to diverse student needs. This approach also unlocks teachers' potential and fosters their professional growth. Extending from classroom efficiency, optimized homework design must enhance quality while reducing quantity-requiring precise, thoughtful, and meticulous planning. Only through this interplay of "one plus one minus" can we truly align with the original intent of the "Double Reduction" reform.

Author Contributions:

Conceptualization, methodology,formal analysis, resources, data curation: Qunfei Jiang; writing—original draft preparation, writing—review and editing, supervision, project administration, Conceptualization, investigation, data curation: Yingnuo Qi and Qunfei Jiang. All authors have read and agreed to the published version of the manuscript.

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The study did not involve humans.

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Not applicable.

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Conflict of Interest:

The authors declare no conflict of interest.

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Transformation of Shadow Education and Restructuring of Educational Ecology under the "Double Reduction" Policy: A Systematic Literature Review of Multi-Stakeholder Impacts

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Abstract

Since the implementation of the "Double Reduction" Policy, its impacts on the basic education ecology have sparked extensive academic discussions. However, existing studies have mostly focused on the perspective of a single stakeholder and failed to form a systematic integration. To sort out the evolution of the policy's impacts and clarify the multi-stakeholder mechanism of action, this study adopted the method of systematic literature review, followed the PRISMA 2020 framework, screened relevant peer-reviewed literatures published from July 2021 to January 2026, and conducted a qualitative comprehensive analysis. The study found that the "Double Reduction" Policy has driven the redistribution of educational responsibilities and ecological adjustment through the regulation of shadow education. The policy has compressed the explicit space of shadow education, yet the logic of academic competition for further education remains unchanged. Parental anxiety over their children's academic performance has intensified, and parents have shifted to various forms of implicit compensatory educational investment. This not only weakens the effect of burden reduction at the family level but also transmits pressure to teachers, who are confronted with increased workload and occupational burnout. Although students' physical and mental health has improved due to the reduction in homework burden, they face the challenges of intensified parent-child conflicts and the differentiation of academic gaps under the influences of strengthened family supervision and implicit shadow education. Based on these findings, this study puts forward optimization suggestions, including defining teachers' rights and responsibilities and establishing a compensation mechanism for their remuneration, constructing a home-school collaborative guidance system for family education, and strengthening the supervision of off-campus training while guiding the characteristic development of non-academic training institutions. From the multi-stakeholder perspective, this study systematically integrates the logic of the policy's impacts, and provides theoretical reference and practical support for further deepening the effect evaluation and long-term implementation of the "Double Reduction" Policy.

Keywords: Double Reduction Policy; Shadow Education; Educational Ecology; Multi-Stakeholder Impacts; Educational Equity

1. Introduction

In recent years, China's education system has been confronted with the problems of excessive academic pressure on students and heavy burdens from off-campus training. This is particularly evident among primary and secondary school students, for whom the continuous increase in after-school tutoring and homework load has become a prevalent phenomenon (Zeng, 2025). Such paid off-campus tutoring activities, which center on supporting in-school learning and aim to improve academic performance and enhance competitiveness for further education, have developed in attachment to the mainstream school education system, forming a typical form of "shadow education" (Xie, 2025). The scale and intensity of shadow education usually expand with changes in the examination system and academic pressure for further education (Wu & Wu, 2023), which not only exacerbates students' physical and mental stress but also imposes an ever-increasing burden of educational investment on families. In response to the above problems, China officially introduced the "Double Reduction" Policy in 2021, which focuses on alleviating students' excessive homework burden and off-campus training burden. By comprehensively regulating and strictly governing academic off-campus training institutions in the compulsory education stage, the policy has drastically reduced their quantity and scale and strictly prohibited capitalized operation (State Council of China, 2021). The introduction of the "Double Reduction" Policy has directly regulated the institutional expansion of shadow education, strengthened the dominant role of school education, and aimed to build a healthier, fairer and sustainable basic education ecology (Jin & Zhang, 2022; Song, 2022).

The introduction of the "Double Reduction" Policy is a concentrated response to the structural contradictions in China's education sector, against a backdrop intertwined with multiple factors such as the intensified involution in education, the expansion of shadow education, and the accumulation of economic and emotional pressure from family education (Wang, 2022; Zhao et al., 2024). The educational pain points sorted out multi-dimensionally by Li et al. (2022) have fully confirmed the urgency of introducing this policy. Data from the Programme for International Student Assessment (PISA) shows that the weekly study hours of Chinese students far exceed the average level of the Organisation for Economic Co-operation and Development (OECD). This inefficient learning mode of "trading time for scores" not only seriously squeezes students' rest time and affects their physical and mental health, but also forces parents to bear the pressure of accompanying their children in study and bearing the high expenditure on shadow education. Moreover, the disorderly expansion and frequent irregularities of shadow education driven by capital have further deviated from the public welfare nature of education and disrupted the normal educational order (Li et al., 2022). To this end, the "Double Reduction" Policy focuses on breaking the unbalanced situation of burden reduction at school but burden increase outside school, curbs the excessive expansion of shadow education through institutional intervention, promotes the return of education to the main position of schools, and advances the realization of educational equity and the essence of education for fostering people (Zhou & Qi, 2022). The

promulgation of the "Double Reduction" Policy has quickly attracted extensive attention from the academic community. In the initial stage of its implementation, relevant studies mostly focused on the policy's background and the evaluation of its preliminary implementation effects. With the in-depth advancement of the policy, the research focus has gradually shifted to its multi-level impacts on students, families, society and other stakeholders (Zhang, 2025). Existing studies have not only examined the changes in students' academic burden and physical health, but also discussed the adjustment of family education expenditure structure and the transformation of family education responsibilities at the family level, analyzed the changes in teachers' workload and occupational satisfaction at the teacher level. Meanwhile, they have investigated the closure and transformation of academic training institutions at the off-campus training industry level, as well as the governance challenges posed by the hidden mutation of shadow education under policy regulation.

Although abundant research results have been accumulated, existing findings are mostly scattered across different stakeholder dimensions. Studies involving society, families, students and other aspects are mostly carried out independently, and a systematic analytical framework that can integrate multi-level impacts has not yet been formed. Furthermore, few studies have examined the overall effects of the "Double Reduction" Policy in a coherent manner from the perspective of shadow education transformation. Based on the above analysis, the core of this review is to systematically integrate these scattered research conclusions, sort out the influence logic and correlation mechanism of the "Double Reduction" Policy among multiple stakeholders, and provide a more holistic theoretical reference for policy optimization and subsequent research.

2. Research Methods

To systematically sort out and evaluate the multi-dimensional impacts of the "Double Reduction" Policy, this study adopted the systematic literature review method. This method conducts literature identification, screening and comprehensive analysis through explicit, transparent and reproducible procedures. It can systematically integrate research findings scattered across different stakeholder dimensions, and identify the core themes, theoretical gaps and future directions of current research, which aligns with the core requirement of this study to construct a multi-stakeholder impact analysis framework. The entire review process was implemented in accordance with the PRISMA 2020 framework.

2.1. Search Strategy and Literature Sources

To ensure the reliability and quality of the literature while achieving a reasonable coverage, this study selected several mainstream Chinese and English databases covering social science and education research, including China National Knowledge Infrastructure (CNKI), Web of Science and Google Scholar. Searches were conducted on the advanced search interface of each database, with the search fields uniformly limited to title, keywords and abstract. A one-to-one matching search strategy was adopted, with the "Double Reduction" Policy as the core search term, which was combined with research theme terms such as "shadow education", "teacher burden", "family education", "students' mental health" and "off-campus training institutions" for combined retrieval.

Specifically, the search was carried out using search formulas including "Double Reduction Policy AND shadow education", "Double Reduction Policy AND teacher burden" and "Double Reduction Policy AND family education". Through this strategy, the initial literature collection for the literature identification stage in the PRISMA process was completed.

2.2. Inclusion and Exclusion Criteria

To ensure the scientificity of literature screening and the validity of research conclusions, this study formulated explicit inclusion and exclusion criteria in advance before literature screening, as shown in Table 1. These criteria ran through all stages of literature screening and served as the core basis for judgment.

Table 1. Inclusion and Exclusion Criteria for Literature

Inclusion Criteria	Exclusion Criteria
1. Literature type: Peer-reviewed academic journal articles or core research reports with clear research design	1. Literature type: News reports policy promotional materials conference briefings and non-academic review articles
2. Research subject: Compulsory education stage in Chinese mainland	2. Research subject: Literature not related to the compulsory education stage in Chinese mainland
3. Research content: Direct analysis or evaluation of the impacts of the "Double Reduction" Policy on students families teachers off-campus training institutions or relevant social levels	3. Research content: Literature that only conducts textual interpretation or normative discussion of the "Double Reduction" Policy without involving its implementation effects or impacts or literature with no direct relevance to the impacts of the "Double Reduction" Policy
4. Publication time: From July 2021 to December 2025	4. Research quality: Literature lacking basic research data or with unclear research methods
5. Language: Chinese or English	-

2.3. Literature Screening Process

The literature screening process followed the standard procedures for systematic literature reviews and was conducted in phases in accordance with the PRISMA 2020 reporting guidelines. The number of literatures at each phase was clearly traceable to ensure the standardization and reproducibility of the research process. A total of 304 initial literatures were retrieved at the literature identification stage using the above-mentioned database search strategy. All search results were uniformly imported into Zotero, a literature management software, and 52 duplicate literatures were removed through a combination of automatic deduplication and manual verification. Ultimately, 252 deduplicated literatures were selected for the preliminary screening phase. At the preliminary screening phase, the 252 literatures were screened by examining their

titles and abstracts, with a focus on excluding those that had no direct relevance to the "Double Reduction" Policy, whose research objects did not involve the basic education stage, or that obviously failed to meet the inclusion criteria. A total of 181 literatures were excluded in this phase, and 71 were retained for the full-text evaluation phase. At the full-text screening phase, an in-depth systematic review was conducted on the 71 literatures, with key verification on whether the research content directly focused on the impacts of the "Double Reduction" Policy, and whether the research methods were clearly specified and the analysis was based on empirical data. In accordance with the inclusion and exclusion criteria, 46 literatures were excluded for reasons including inconsistent research types, insufficient relevance of research content, and inadequate description of data and methods, leaving a final set of 25 literatures. At the final inclusion phase, eligibility recheck was performed on the 25 literatures to confirm that all met the pre-set inclusion criteria of the study, which were then finalized as the research sample for the qualitative comprehensive analysis of this study. The complete process of the above literature screening is presented in the form of a PRISMA 2020 flow diagram, as shown in Figure 1.

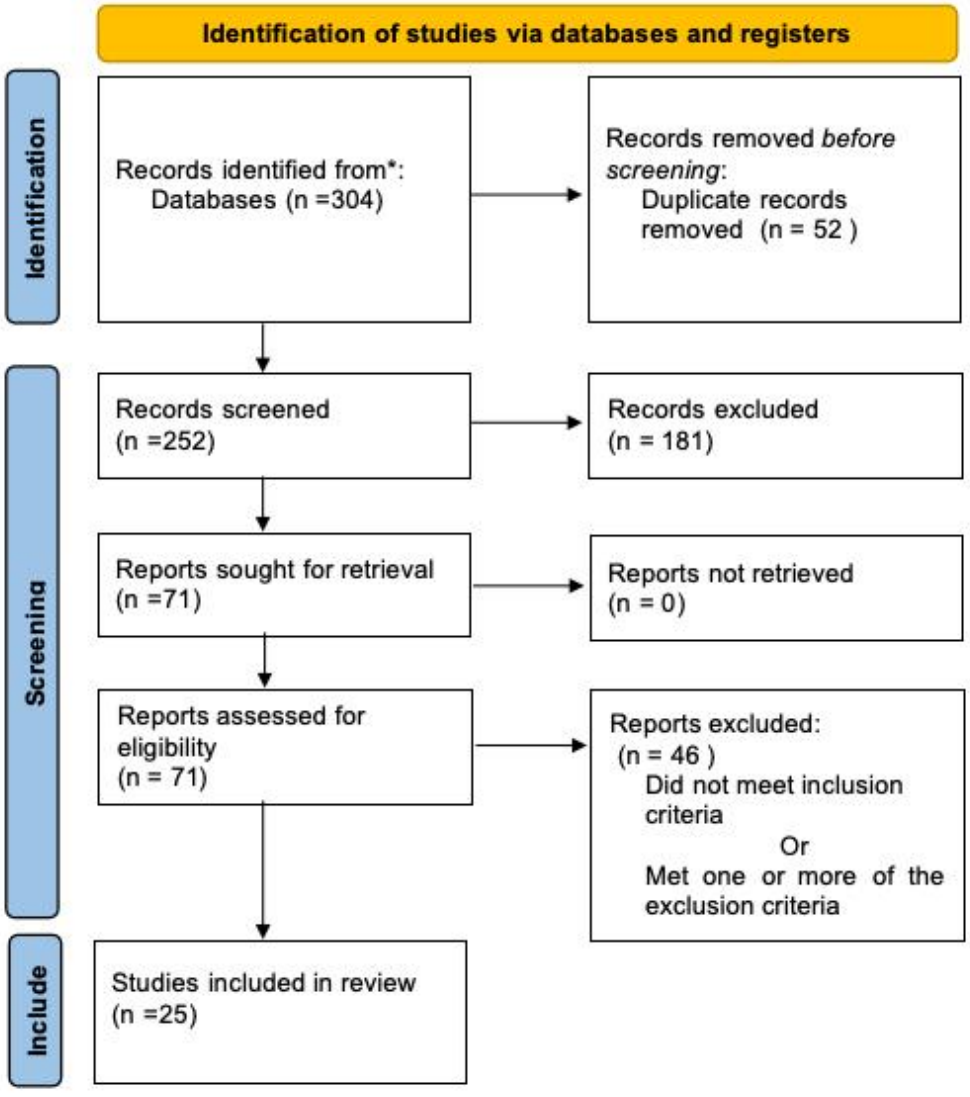

Figure 1. PRISMA Flow Diagram

3. Classified Review of the Impacts of the "Double Reduction" Policy

3.1. Review of Research on Impacts at the Social Level

As a systematic education reform the "Double Reduction" Policy has gradually adjusted the social ecology of basic education in China. Existing studies have focused on the market-oriented supplementary forces and core subjects of educational services. They pay attention to the transformation paths of off-campus training institutions and changes in the work status of teachers. These studies reflect the corresponding adjustments in the educational service system driven by the policy.

The impact of the "Double Reduction" Policy on off-campus training institutions has not only triggered a short-term shock to the industry. It has also promoted its long-term structural adjustment (Wu, 2021). Chen's (2024) study pointed out that the policy has imposed strict restrictions on the operating hours and capitalized operation of academic training. This has led to a decline in the valuation of China's academic training market. A large number of small and medium-sized institutions have withdrawn from the market. Leading institutions have also been forced to close campuses and cut staff and expenses. Surviving institutions on the other hand have launched business model transformations. They have expanded into diversified fields such as quality-oriented education vocational education and study tour camps. They explore integrated online-offline teaching models. They also seek external cooperation and return to the essence of education. Chen's (2022) case study on New Oriental showed that the policy's ban on profit-making academic training in the compulsory education stage led to the suspension of the company's junior high school business. This business accounted for approximately half of its revenue. The suspension resulted in a sharp drop in stock price and market value. The business suspension triggered a chain reaction. Teachers' teaching hours and incomes decreased significantly. A large number of personnel resigned voluntarily. The company also launched large-scale layoffs. To cope with the crisis New Oriental achieved transformation through strategies such as expanding high school and college student training consolidating its advantages in overseas study training and undertaking after-school services of public schools. It provided a reference for the industry. Qi's (2023) study on county-level off-campus training institutions found that after the policy's implementation the number of academic institutions at the county level decreased. Most shifted to non-academic fields such as art or sports to develop innovative courses. However, few academic institutions successfully registered as non-profit entities. Non-academic institutions on the other hand ushered in development opportunities. Their quantity continued to increase. They added characteristic courses such as robot programming and manual creation. They gradually moved towards diversification and differentiation. In addition, there is a mismatch between supply and demand in the transformation of county-level institutions. Some institutions carry out academic training in the name of non-academic training to meet parents' implicit needs. Most emerging non-academic institutions fail to accurately grasp the interests and growth needs of county-level students. They face problems such as insufficient professionalization of teachers and homogeneous courses. Some characteristic courses do not match the actual needs of the local market and lack core competitiveness. They require policy guidance and self-innovation to achieve characteristic and standardized development (Qi, 2023).

The contraction and transformation of the off-campus training industry have promoted the return of education's main position to schools. The core status of schools has been strengthened. As key players in the policy's implementation teachers have thus become important participants in education reform (Zhou et al., 2024). Through two initiatives improving quality and efficiency in schools and full coverage of after-school services the policy has put forward new requirements for teachers' work content and professional capabilities. Existing studies generally agree that teachers' workload has generally increased. Their professional roles have become more complex. They are facing new challenges in professional development.

Multiple studies have shown that the "Double Reduction" Policy has increased teachers' workload and working hours. The implementation of after-school services is the main reason for the increased workload. Zhao and Hu's (2023) survey of a large number of primary and secondary school teachers found that the daily working hours of the vast majority of primary and secondary school teachers exceed the legal standard. Nearly half of junior high school teachers work more than 10 hours a day. About one-fifth of primary and secondary school teachers are dissatisfied with the current work intensity. The quality improvement requirements brought about by the policy continue to emerge. Teachers not only generally work beyond the standard hours. They also face problems such as heavy non-teaching tasks. Head teachers and main subject teachers are the main groups under pressure. Some responsibilities originally borne by off-campus institutions have been transferred to teachers after the policy's implementation. Ji et al.'s (2024) qualitative study further revealed the contradictions behind the burden. Their semi-structured interviews with teachers from a public school in Zhejiang Province found that after-school services have extended teachers' working hours. But the mismatch between economic returns and additional efforts has led teachers to feel that their labor value is underestimated. Their work enthusiasm has been significantly dampened. At the same time teachers' professional roles have changed under the policy's promotion. They show the characteristics of multiple role overlaps. Yue et al.'s (2023) interviews with 45 primary and secondary school teachers using grounded theory showed that teachers' sense of helplessness and anxiety stem from the coordination conflicts of multiple roles. With the reduction of off-campus tutoring channels students' access to knowledge has narrowed. Pressure has concentrated on in-school teachers. In addition to teaching they also need to take on the roles of safety officers and counselors. Some even manage students' accommodation and meals. A large amount of their energy has been dispersed. Furthermore the lack of cooperation or excessive dependence of some parents in home-school communication has further increased teachers' pressure. It directly affects their professional identity physical and mental health. Ding et al.'s (2025) questionnaire survey of primary and secondary school teachers in Jiangsu Province guided by the Stress Process Model showed that the work pressure brought by the "Double Reduction" has reduced teachers' professional satisfaction. The greater the pressure the lower the satisfaction. Social support and teachers' self-efficacy can play a buffering role. They effectively weaken this negative impact. Zhong et al.'s (2025) survey of primary school teachers covering multiple cities further showed that more than half of the teachers meet the criteria for occupational burnout. The emotional exhaustion and cynicism dimensions are strongly positively correlated with depressive symptoms. Teachers' professional pressure has become a problem requiring attention.

Studies at the social level have shown that the "Double Reduction" Policy has not eliminated the educational burden. It has triggered a structural transfer. Under the policy's influence off-campus academic training has contracted and passively transformed. Although it has expanded into diversified fields such as quality-oriented education problems exist. These problems include the mismatch between supply and demand in the county-level market insufficient professionalization of teachers in the industry and serious course homogenization. All these reflect a disconnect between the transformation direction and the real market demand. At the same time the educational pressure originally shared by the market has concentrated on schools. In the process of the return of education's main position to campuses this part of the pressure has been directly converted into teachers' workload. It exposes teachers to challenges such as increased tasks and complex professional roles. The problem of occupational burnout has also worsened accordingly. The transformation dilemmas of the off-campus training industry and the continuous increase in teachers' burden have further transmitted educational pressure to families. It prompts adjustments in family education responsibilities and parents' anxiety levels.

3.2. Review of Research on Impacts at the Family Level

Existing studies generally agree that by reducing off-campus academic training the core form of shadow education the "Double Reduction" Policy has transferred some educational functions originally undertaken by the market to families. It has thereby triggered adjustments in family education responsibilities educational behaviors and internal family relationships (Chen & Zhou, 2024). Relevant research mainly focuses on three aspects. These aspects are changes in family education responsibilities compensatory educational behaviors and adjustments in parent-child relationships. They present the policy's impacts on families.

With the restricted supply of shadow education the role of families in supporting students' learning and guiding their growth has been further amplified. Parents have gradually shifted from relying on external auxiliary participation through shadow education to directly intervening in students' learning processes and development paths. This shift has led to increased participation and responsibility intensity in family education. Luo and Liu's (2022) study is based on Giddens' theory of modernity and the perspective of institutional sociology. It found that the "Double Reduction" Policy has had heterogeneous effects on alleviating family education anxiety. It shows a characteristic of partial relief but widespread persistence. Implicit anxiety has not been fully eliminated. The study further pointed out that the persistence of anxiety is closely related to changes in family education responsibilities. The limited function of shadow education has directly increased families' educational responsibilities. However, parents generally lack corresponding family education capabilities. Even though the policy has alleviated the economic burden of education to a certain extent they are still inadequate in key links such as academic guidance and parenting decisions. This increase in responsibility has not only raised parents' educational participation. It has also made the pressure of parenting responsibilities a new source of anxiety. It has triggered a new type of educational anxiety. Subsequent empirical research has further revealed the inherent connection. Zhang et al.'s (2025) study took parents of students in Hangzhou as samples. They used questionnaire surveys and mediation and moderation effect tests. They found that parents' perception of the "Double Reduction" Policy is positively correlated with

educational anxiety. The stronger the policy perception the higher the anxiety level. Parent educational participation plays a fully mediating role between the two. Parents with stronger policy perception are more inclined to intervene in their children's learning by increasing learning guidance and formulating personalized learning plans. They do so to make up for the competitive pressure caused by the reduction of shadow education. However, this increase in participation has instead aggravated the emotional burden.

Against the background of increased family education responsibilities families have become important bearers of educational competition pressure. They have not passively accepted the increase in responsibilities. They have responded to policy constraints through a series of compensatory educational behaviors. Existing studies have shown that the decline in expenditure on academic training in shadow education does not mean an overall reduction in family education investment. On the contrary families have adjusted the direction of educational expenditure through other implicit investment methods such as non-academic training or private tutoring. They aim to cope with the unchanged reality of the academic competition pattern. Zhang et al.'s (2023) semi-structured interviews with parents of students in public middle schools found that most families still recognize education as an important path to social mobility. Educational anxiety has not been alleviated. All interviewed parents agree that the current phenomenon of educational involution is still serious. The consensus is that necessary expenses must be incurred. Some families continue to maintain high educational investment by hiring private tutors and striving for key school resources. This indicates that changes in family education expenditure are more about adjustments in investment forms. They are not a weakening of investment willingness. Building on this Zhao's (2023) study selected 9 parents of students in Beijing for interviews. It further revealed the actual implementation paths of such compensatory educational behaviors. Against the background of restricted off-campus academic training and adjusted in-school homework more than half of the parents fell into confusion. They experienced persistent anxiety due to concerns about their children's declining academic competitiveness. To make up for the uncertainty caused by the interruption of original tutoring channels some families turned to implicit methods such as underground training and cross-regional tutoring. They did so to maintain control over their children's academic progress. This reflects the strategic response of families to carry out educational compensation through informal channels under policy constraints. Niu et al.'s (2025) study went a step further. It adopted the perspective of family socioeconomic status. Based on a large-scale questionnaire survey covering 8 provinces it found that family socioeconomic status is a key structural factor affecting parents' educational anxiety and coping capabilities. For each unit increase in family socioeconomic status parents' educational anxiety level decreases by 0.062. The core reason for this difference is that families with high socioeconomic status are more likely to maintain their children's academic competitive advantages through implicit methods such as private tutoring. Families with low socioeconomic status on the other hand face both the dilemma of resource scarcity and guilt in parenting.

Such family anxiety and compensatory investment triggered by increased educational responsibilities have changed family educational behaviors. They have also had an impact on internal family interaction patterns. The implementation of the "Double Reduction" Policy has

freed students from excessive academic burdens and off-campus training. It has increased the time students devote to family life (Zhang et al., 2023). The extension of parent-child coexistence time has had complex impacts on internal family interactions. It has created conditions for enhancing parent-child affection and optimizing family education. It may also expose potential family conflicts and lead to intensified parent-child conflicts. Existing studies not only focus on the current situation and problems of parent-child relationships after the "Double Reduction". They also explore in depth the key factors affecting relationship quality and their improvement paths. Zhou's (2022) practical study based on a school in Zhejiang Province analyzed the roots and specific manifestations of parent-child conflicts after the "Double Reduction". The study found that nearly half of the parents and students reported increased anxiety after the policy implementation. The roots of parent-child conflicts are mostly concentrated in the gap in educational expectations between parents and children. The specific manifestation is that parents find it difficult to accept the gap between their children's academic performance and their own high expectations. They then attempt to reverse the situation through excessive discipline such as strictly controlling their children's entertainment time. This ultimately intensifies parent-child conflicts. The study also confirmed that schools can effectively reduce the frequency of conflicts by building a systematic home-school-community collaborative intervention system. They can turn the challenges brought by the "Double Reduction" into opportunities to improve parent-child relationships. To explore the internal psychological mechanisms of optimizing parent-child relationships Xie et al.'s (2024) study used questionnaire surveys to collect sample data from parents of adolescents. They tested the impact mechanism of parental autonomy support on family adaptation after the "Double Reduction". The study found that in the context of the "Double Reduction" parents who provide more autonomy support to their children can not only directly and positively predict the overall family adaptation level. They can also indirectly promote family harmony by improving the quality of parent-child communication and enhancing parent-child cohesion. This research result not only proves that good parenting styles are the core factor in improving parent-child relationships. It also indicates that the "Double Reduction" Policy not only promotes student burden reduction. It also indirectly promotes the transformation of parents' parenting concepts and the optimization of family functions.

Overall relevant studies at the family level have shown that the "Double Reduction" Policy has not eliminated the pressure of educational competition among families. It has prompted changes in its form of existence. After the space for shadow education was compressed the academic tutoring work originally undertaken by the market has been taken over by families. This has led to parents' new type of educational anxiety. It has prompted parents to turn to implicit compensatory methods such as non-academic training and private tutoring. Differences in such educational investments due to differences in family socioeconomic status have further widened the gap in access to educational resources among different families. At the same time the increase in students' time returning home has created conditions for improving parent-child relationships. It has also amplified potential parent-child conflicts due to differences in educational expectations between parents and children. Parents' compensatory educational behaviors and anxiety not only affect the quality of parent-child interaction. They also have a direct impact on students' academic adaptation and growth status.

3.3. Review of Research on Impacts at the Student Level

Compared with the indirect impacts at the social and family levels changes at the student level are generally regarded as the most direct and critical manifestation of the "Double Reduction" Policy's effectiveness (Zeng, 2025). Existing studies have systematically examined changes in students' learning outcomes and development status after the policy's implementation. They focus on the policy's impacts on students' academic performance physical health and mental health. Relevant studies attempt to reveal the actual effects of the "Double Reduction" in reducing academic burdens and promoting students' all-round development. They do so through comparative analysis of students' performance before and after the policy implementation. They also explore the differentiated manifestations of these effects.

Academic performance as the core indicator of students' learning outcomes is an important entry point for evaluating the "Double Reduction" Policy's effectiveness. Relevant research mainly examines the policy's impacts on students' academic performance and the development of learning abilities. It also explores the differentiated responses of students with different academic levels to the policy adjustments. These are achieved through comparative analysis of students' performance changes before and after the policy implementation.

Sun's (2024) study combined quantitative surveys and qualitative interviews. It involved students, parents, teachers and school administrators from multiple first-tier cities. The study confirmed that the academic performance of urban students declined in the early stage of the policy implementation. It gradually stabilized after one year. A considerable proportion of students showed improvements in classroom participation and critical thinking skills. Further analysis found that students with stronger independent learning abilities adapted faster. Their academic performance recovered significantly. Students highly dependent on shadow education on the other hand faced obvious academic decline in the early stage of the policy. Building on this Shen and Zhang's (2024) research extended the perspective to the detailed dimensions of grades and subjects. Based on the perspective of sociological institutionalism they adopted the Tukey multiple comparison test method. They conducted an empirical analysis of the final exam results of students from different grades in 30 primary schools in Hunan Province. They sorted out the differentiated characteristics of the policy's impacts. The study found that students in grades undergoing transitional learning stages had weaker adaptability. Their scores declined most significantly in memory-based subjects. Students in grades that had formed stable learning strategies showed an upward trend in scores. They performed particularly well in comprehension-based subjects. At the same time there was no significant difference in the score changes between urban and rural students. This result confirms the policy's role in alleviating the imbalance of educational resources between urban and rural areas. Zhou and Fan's (2025) study went further. It adopted an in-depth perspective of policy tool combinations and students' socioeconomic status. It conducted an analysis with upper-grade students from multiple primary schools as samples. The results of two waves of longitudinal tracking data showed that the "Double Reduction" achieved two expected outcomes simultaneously. These are the improvement of students' sense of happiness and the stability of academic performance. Among them the reduction of homework burden and the expansion of after-school services not only improved students' life satisfaction and

reduced their negative emotions. They also had a positive promoting effect on academic performance. Further heterogeneity analysis showed that regulating shadow education weakened the academic performance of students from low socioeconomic status families to a certain extent. Families with high socioeconomic status on the other hand could maintain their children's academic advantages through implicit shadow education forms such as private tutoring and underground training. In contrast students from low socioeconomic status families and those with low academic achievements could better benefit from the academic compensation provided by after-school services. This result also reflects the role of after-school services in alleviating educational inequality and promoting educational equity.

The core goal of the "Double Reduction" Policy is not only to reduce burdens. It is also to promote the physical and mental health development of students. This dimension has thus become an important part of policy effect evaluation. Existing studies focus on how the policy improves students' sleep quality and mental health conditions. This is achieved by reducing academic pressure and increasing rest and exercise time. These studies have confirmed that the policy has achieved positive results in alleviating students' insomnia symptoms depression and anxiety.

In the field of mental health Wang et al.'s (2022) study conducted two rounds of follow-up surveys on students from multiple schools in Guangdong Province. It explored the policy's role in improving students' depressive and anxiety symptoms. The study found that the policy alleviated students' negative emotions by optimizing their lifestyles. Although the improvement in relevant symptoms was limited a positive mental health effect has been shown. The reduction in homework load the increase in parent-child time and the extension of sleep duration are the key factors driving this improvement. As a key measure of the policy after-school services have also been proven to play an important role in promoting students' physical and mental health. Fu and Zhang's (2022) large-scale empirical study involved primary and secondary schools in multiple regions of eastern central and western China. The results showed that high-quality after-school services have a positive impact on both students' physical and mental health. Sports activities can effectively increase students' exercise time and help steadily improve their physical fitness. At the same time rich group activities can promote students' interaction and communication. They enhance interpersonal skills and further help students reduce negative emotions such as loneliness and depression. After-school services are not just an arrangement to take over students' after-school time. They are an important way to achieve burden reduction and efficiency improvement and help students grow healthily in the context of the "Double Reduction".

Overall relevant studies at the student level have shown that the "Double Reduction" Policy has driven tangible changes in students' growth status. The policy's impact on academic performance presents phased characteristics of short-term fluctuations and long-term stability. There are also group differences related to learning abilities grades subjects and family socioeconomic status. Measures such as after-school services have also played a role in alleviating educational inequality. At the same time the reduction of academic pressure has improved students' physical and mental health status. Both the alleviation of depression and anxiety and the improvement of physical fitness confirm the policy's core goal of promoting students' all-round development. The

implementation of high-quality after-school services has become the key link connecting burden reduction and efficiency improvement.

4. Main Findings

This study adopts the Stress Process Model as the core analytical framework. It conducts a systematic analysis of the generation transmission and multi-stakeholder impact logic of stress in the basic education ecology after the "Double Reduction" Policy regulates shadow education. The theory points out (Pearlin et al., 1981; Pearlin et al., 1997) that changes in macro-institutions will alter the environment in which individuals and organizations operate. They affect the way stress is generated and distributed. Stress will also be transmitted amplified or weakened among different stakeholders. It ultimately produces differentiated impact results. In this study the "Double Reduction" Policy is the initial stressor of the entire education ecology. It cuts off the main way parents used to cope with academic competition through off-campus tutoring by governing shadow education. However, because the logic of academic competition for further education remains unchanged the initial stress evolves into new stressors during the policy implementation. It is transmitted and diffused among different stakeholders. Figure 3 presents the transmission path of this stress within the education system. It also shows the chain impacts on different stakeholders.

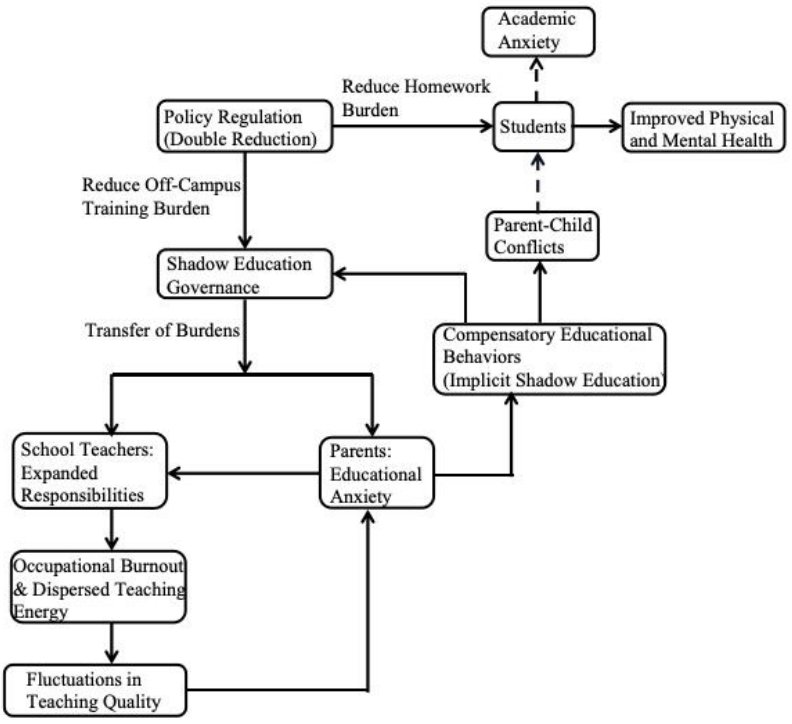

Figure 2. Logic Diagram of Shadow Education-Related Stress Transmission and Multi-Stakeholder Impacts Under the "Double Reduction" Policy

The "Double Reduction" Policy aims to break the vicious cycle of burden reduction at school and burden increase outside school. It curbs the disorderly expansion of shadow education by reducing students' off-campus training burden. It promotes the return of educational leadership to schools. In this process some academic enhancement responsibilities originally borne by off-

campus training institutions have been transferred to school teachers. This constitutes a direct stress transmission to the teacher group. Teachers not only need to improve the quality of classroom teaching to fill the academic tutoring gap caused by the reduction of off-campus training. They also have to take on additional work such as after-school services and student safety supervision. Their professional responsibilities have increased. According to the Stress Process Model the impact of responsibility adjustments brought about by institutional changes depends on whether individuals or organizations have sufficient buffering resources to regulate the role of stress (Pearlin et al., 1981; Pearlin et al., 1997). However existing studies generally show that in the process of promoting the "Double Reduction" Policy the remuneration subsidies and burden reduction measures matching teachers' new responsibilities have not been implemented simultaneously (Zhao & Hu, 2023). This leads to teachers lacking effective institutional support when facing increasingly heavy work tasks. In this case teachers' stress can easily be converted into occupational burnout. Their teaching energy is dispersed. This not only affects teachers' professional satisfaction and physical and mental health. It also indirectly affects students' learning experience due to fluctuations in classroom teaching quality. It further triggers parents' educational anxiety. Thus a vicious cycle of intensified parental anxiety increased teacher pressure and fluctuating teaching quality is formed.

At the same time after shadow education is restricted part of the stress accumulates at the family level. Shadow education has always been an important means for parents to cope with academic competition. Its sudden restriction has forced parents to take on heavier educational responsibilities. On the premise that the rules of academic competition for further education have not changed parents generally worry about their insufficient tutoring capabilities. They are afraid that their children's academic competitiveness will decline. This worry becomes persistent educational anxiety within families. According to the Stress Process Model when individuals or families lack sufficient coping methods stress is more likely to be converted into strong emotional reactions and behavioral changes (Pearlin et al., 1981; Pearlin et al., 1997). To alleviate this stress parents often adopt various compensatory educational methods. They even turn to illegal training that conducts academic training in the name of non-academic training. They do so to ensure control over their children's academic performance. Although this approach alleviates parents' anxiety to a certain extent it weakens the burden reduction effect of the policy at the family level. It also allows shadow education to continue to exist in a more hidden form. It increases the difficulty of governance.

The stress and coping methods at the family level are ultimately transmitted to students. As the ultimate target of the policy the impacts on students present differentiated characteristics of both benefiting and facing challenges. The reduction of shadow education burden and the control of in-school homework volume have alleviated students' academic pressure to a certain extent. They have improved students' physical and mental health. These are the positive effects brought by the "Double Reduction" Policy. However, some parents have strengthened their academic control over their children due to their own anxiety. This is likely to trigger parent-child conflicts. They also pass on emotions to increase students' psychological pressure and academic anxiety. At the same time the existence of implicit shadow education has widened the academic gap between

students from different family backgrounds. Students with strong independent learning abilities or access to implicit tutoring have gradually maintained their advantages. Students who rely on explicit shadow education on the other hand face the dilemma of academic decline in the short term.

Overall the systematic analysis based on the Stress Process Model shows that the "Double Reduction" Policy promotes the redistribution of educational responsibilities by regulating shadow education. However, under the premise that the logic of academic competition for further education remains unchanged the policy mainly reduces the external manifestations of educational stress. The continuous transmission of stress among multiple stakeholders and the existence of implicit shadow education together restrict the effectiveness of the reform. To break this dilemma and avoid the cyclic accumulation of stress within the education system it is necessary to follow the core logic of the Stress Process Model. We should provide sufficient buffering resources and stress relief channels for each stakeholder from the institutional level. We need to clarify the responsibility boundaries of different stakeholders. Only in this way can we avoid the cyclic accumulation of stress within the education system (Pearlin et al., 1981; Pearlin et al., 1997). Specifically, we can clarify teachers' rights and responsibilities and establish a remuneration compensation mechanism. We can construct a home-school collaborative family education guidance system. We can strengthen the supervision of off-campus training and guide the characteristic development of non-academic institutions. These measures can promote all parties to form a synergistic effect. They can help the education ecology develop in a more fair and sustainable direction.

5. Conclusions and Limitations

The "Double Reduction" Policy has promoted the adjustment of the distribution of educational pressure and responsibilities through the regulation and guidance of shadow education. The governance of shadow education by the policy has not only consolidated the dominant position of school education. It has also increased teachers' workload in classroom teaching and after-school services. The extension of teachers' responsibilities lacks adequate institutional guarantees. Phenomena such as occupational burnout and the dispersion of teaching energy have gradually emerged. The teaching effect is affected accordingly. This further intensifies parents' educational anxiety and forms a negative cycle. At the same time the underlying logic of academic competition for further education remains unchanged. Parents' demand for shadow education still exists. They turn to compensatory educational investment or underground training activities instead. This leads to the survival of shadow education in a more hidden form and increases the difficulty of governance. As the ultimate target of the policy students feel the effects of burden reduction. They also face new adaptive pressure at the same time. Therefore, the policy only changes the external manifestations of educational pressure. It does not eliminate the pressure itself. The redistribution and transmission of pressure among multiple stakeholders are the key factors affecting the policy's effectiveness and the restructuring of educational ecology.

Although this paper systematically sorts out the multi-dimensional impacts of the "Double Reduction" Policy it is necessary to explain several existing limitations. This paper mainly conducts analysis based on publicly published Chinese and English peer-reviewed literatures after the policy release. This is helpful to ensure the research quality. It may however omit some unpublished practical reports or long-term follow-up research results. This limits the comprehensiveness of the conclusions to a certain extent. At the same time most existing studies focus on the short-term or medium-term impacts of the policy. Sufficient time accumulation and data collection are still lacking to evaluate its long-term effects. In addition,the samples of existing studies are mostly concentrated in eastern regions and urban schools. There is a relative lack of systematic comparison of educational contexts in rural and county-level areas and differences in policy implementation across different regions. This may underestimate the heterogeneous impacts of the "Double Reduction" Policy in different social environments. Based on the current research limitations and new practical challenges of the "Double Reduction" Policy future research should advance in a more in-depth and operational direction. Long-term tracking can be strengthened to make up for the deficiencies of short-term research. Attention can be paid to the differences in policy implementation in rural and county-level underdeveloped areas. Research can also focus on specific solutions such as alleviating teachers' burden improving family education guidance and supervising illegal behaviors. These efforts can help form a healthy and orderly educational service ecology.

Author Contributions:

Yinfan Zhang: Conceptualization, Methodology, Formal analysis, Investigation, Resources, Data curation, Writing—original draft preparation, Writing—review and editing, Supervision, and Project administration. All authors have read and agreed to the published version of the manuscript.

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Conflict of Interest:

The author declares no conflict of interest.

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Paradigm Reconstruction of University Entrepreneurship Education in the AI Era

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Abstract

This paper proposes a conceptual framework for reconstructing university entrepreneurship education in response to the emergence of Artificial Intelligence Generated Content (AIGC). Drawing on the philosophy of technology and educational sociology, this paper argues that the displacement of routine entrepreneurial functions by AI necessitates a paradigm shift ─ from instrumental rationality to Symbiotic Rationality, and from generic creativity to adaptive, context-specific competencies. The proposed framework operates across three dimensions: cultivating innovation ecosystem participants rather than standalone entrepreneurs; developing situated capabilities, including critical AI literacy, value-rational decision-making, and interpersonal intelligence; and reorienting pedagogy toward real-world intervention through entrepreneurship laboratories. To assess these outcomes, this paper introduces a three-dimensional evaluation framework comprising process indicators, capability measures, and impact assessments, grounded in Whitehead's process philosophy, Dewey's pragmatism, and Value Sensitive Design. The framework centers on Adaptive Innovation Capacity (AIC) as its core construct, offering a theoretically integrated response to the pedagogical challenges of the AI era.

Keywords: Artificial Intelligence; Entrepreneurship Education; Paradigm Reconstruction; Adaptive Innovation Capacity; Symbiotic Rationality

1. Introduction

The emergence of AIGC technology challenges the existing mode of instruction in entrepreneurship education, as many business-related work can be done by current AIGCs, such as writing plans, conducting market analysis or developing innovative ideas. The technology poses challenges to the teaching methods used traditionally. The conventional model of entrepreneurship education is linear. Opportunity identification, then planning, and finally fundraising. But AI systems do the same thing today more efficiently at a lower cost. This raises

questions about why there is a need for an entrepreneur education that focuses on people, rather than other approaches to business innovation.

AI not only helps automate activities but also transforms entrepreneurship by altering the ways in which entrepreneurs work with skills that were perceived to be the cornerstone of conventional courses like S. W. O. T. analysis, financial planning, and strategic decision making. Modern-day AIs are capable of producing technically adequate business plans in a very short period. Universities that keep training students in the standardized ways of entrepreneurship will see what they teach rendered obsolete by increasingly capable AIs. This paradox challenges us to rethink what should be taught. Today's reality involves substantial uncertainty, and collaboration between people and computers. It is, therefore, an urgent task to identify educational elements which are not simply imitable through technology.

This paper proposes to change the focus from teaching students how to do things to be able to create value by quickly building prototypes and gaining experience-based knowledge in complex, changing, uncertain contexts. However, AI is not as flexible compared with the human brain. Firstly, humans are able to handle uncertain scenarios which cannot be modeled with probability distributions. Furthermore, human decisions involve complex ethics depending on the context. In addition, humans can radically change the problem, or redefine it, while AI tends to be limited to specific goals.

Dell'Acqua et al. (2023) document that AI does well with highly structured problems but it fails in tasks that require deeper understanding. The result is a complex set of competencies where entrepreneurs must develop Adaptive Decision-Making Competency, which means knowing when to apply the benefits of artificial intelligence and when not to rely on it. Existing scholarship has begun to address AI's role in entrepreneurship education from several angles. Kuratko (2005) traces the historical development of entrepreneurship education, highlighting its predominantly skills-based orientation. More recently, Chalmers et al. (2021) explore how AI reshapes venture creation in the Fourth Industrial Revolution, while Dell'Acqua et al. (2023) demonstrate empirically that AI augments productivity when used critically but diminishes performance when adopted uncritically. Despite these contributions, existing frameworks largely address AI as a tool to be integrated into existing curricula rather than as a force that demands fundamental pedagogical reconstruction. The specific limitations of prevailing educational theories in responding to AIGC—particularly their inability to cultivate judgment under uncertainty, ethical reasoning in human-AI collaboration, and ecosystem-level thinking—remain insufficiently theorized.

Therefore, how should university entrepreneurship education be reconstructed in response to AIGC? More specifically, what theoretical foundations, educational objectives, curriculum content, teaching methods, and assessment approaches are required? This paper develops a conceptual framework integrating the philosophy of technology and educational sociology to address these questions.

2. Theoretical Framework

2.1. From Instrumental Rationality to Symbiotic Rationality

Conventional entrepreneurship pedagogy relies upon the notion of Instrumental Rationality, which breaks down the process of creating a company into steps that can be taught, replicated, and learned. The limitations of this approach have been brought out by the rise of artificial intelligence. Entrepreneurship depends on tacit knowledge, responds to contextual factors, and includes judgmental elements. To define them as skills which are quantifiable misses the point.

According to Heidegger (1977), technology enframes the understanding of the world, reducing beings to resources available for optimization. Applying this to AI in education, an instrumentalist approach reduces students to skill-processors and entrepreneurship to an executable algorithm. Moving beyond this enframing does not mean rejecting AI. It means cultivating what Heidegger calls *Gelassenheit*—a disposition of openness that preserves human agency and judgment. Pedagogically, this translates into designing learning environments that deliberately create space for reflection, ethical deliberation, and value-driven decision-making—capabilities that resist algorithmic substitution. This kind of theory calls for Dynamical Plasticity. The model goes beyond pure functional logic, and calls for business innovators to retain critical thinking, inspiration, and a sense of responsibility towards the use of artificial intelligence. This new mindset is empirically supported. Dell'Acqua et al. (2023) find that humans boost their productivity by almost 40% if they use artificial intelligence cleverly. On the other hand, students that used AI irresponsibly saw a significant drop in performance. As a result, the teaching goal can be reoriented, where instead of training entrepreneurs who operate AI tools, teaching how to cope in this ever more complicated world is more important. Symbiotic Rationality is introduced here. It views users not as passive consumers but rather as active partners in shaping the ways that technologies are integrated into innovative activities.

2.2. The Turn Toward Innovation as Social Practice

The change in perspective to Symbiotic Rationality affects the relationship toward technologies. However, this point of view should be completed by a sociology approach, because entrepreneurship is socially constructed in organizational contexts. Pierre Bourdieu's theory offers some useful instruments to do so. In the conceptualization of Bourdieu (1990), social systems work in a multitude of semi-autonomous fields. Instead of being individual inventors, entrepreneurs compete inside specific entrepreneurial ecosystems defined by certain rules. They choose strategies that depend on their status, as well as the resources. The advent of AI creates new forms of capital relating to data and algorithms fundamentally altering the logic of competition.

In the social scientific sense, Adaptive Innovation Capacity (AIC) is not simply a personal attribute. It entails knowing how industries evolve over time and deciding what actions to take. AIC consists of three interrelated dimensions. The first dimension is related to the analysis of industrial models. The entrepreneurs must understand how AI changes money flows. The business rules of their industry; opportunities they may pursue along with constraints. The second part is about uniqueness. It refers to identifying a sustainable niche given the resource, rather than

following algorithmic recommendations. Entrepreneurs must leverage distinct human attributes that are not easily imitable by AI. Third, the practice needs to be reoriented. Entrepreneurs create new rules: new relationships, new tools or techniques. They do not follow existing standards, but aim at changing those.

This sociological approach complements the philosophical underpinning described above; together, they provide an overarching narrative. Both individual judgment and situational understanding are cultivated. Building on these philosophical and sociological foundations, AIC operates through three dimensions—field analysis, situated judgment, and iterative learning—that directly structure the educational reconstruction in the following sections.

3. Educational Framework Transformation

The incorporation of artificial intelligence into entrepreneurial settings calls for a paradigm shift. In other words, where past paradigms have focused on training managers in engineering skills, today's paradigm seeks to produce creators who can collaborate effectively with machines. The change is not only conceptual, but also relates to new meanings of entrepreneurship. Coursework built on outdated understandings of the relationship between people and technology may be training students for a world that has already passed us by. In the following, three dimensions will be discussed.

3.1. From Training Entrepreneurs to Cultivating Innovation Ecosystem Participants

Traditional entrepreneurship usually has an end goal in mind—starting new enterprises. However, AI changes what it means to be an entrepreneur. The incremental cost of invention approaches zero, starting a standalone business is only part of a larger set of options available. New forms of collaboration between humans and artificial intelligence create new types of entrepreneurship which are not easily categorized, generating so-called augmented entrepreneurial personhood patterns.

The changing environment demands cultivating so-called ecosystem participants who are able to manage complex innovation ecosystems rather than starting a business themselves. Three key attributes differentiate these ecosystem participants.

Firstly, they are sensors for useful information and possible opportunities. They can identify new demands arising from AI adoption. They see these problems as a way to drive the development of new technologies

Secondly, AI became an important production factor, fundamentally changing what is important for firm success: How one manages, coordinates dispersed resources matters far more than having those resources (Helfat & Peteraf, 2003). It resembles more like a conductor leading the symphony as creating value through coordination of human and AI agents.

Third, throughout the process of innovating, they rely on adaptive methods. The frequency of dynamic innovation practices needs to be observed.

3.2. From Knowledge Transmission to Situated Capability Generation

Driven by the shift towards symbiotic rationality, universities will have to stop teaching how to write a standardized business plan or do competitive market analysis and start teaching, building capabilities to recognize the emergence of new technology/social shifts, orchestrating distributed resources toward specific objectives, and adjusting plans based on real-world results. Traditional entrepreneurship training is based on the assumption of a known business context, teaching students how to write business plans, internal analysis using SWOT matrices, marketing planning. Those analytical skills are structured and can therefore be recorded and duplicated. Today, as these tasks are outsourced to machines, skills training should be focused on skills which are hard to automate or in which human advantages will show through. Teaching students the use of technologies such as ChatGPT is not sufficient for building technology literacy. As shown in Long & Magerko (2020), the general definition of AI covers a range of abilities such as—but not restricted to—the ability to critically analyse the application of AI: work effectively with intelligent systems, and use the technology ethically in different contexts. These ideas must be reflected in the business curriculum. Students must be taught how to evaluate issues like fairness, transparency, and accountability in computing technologies. For example, recommendation engines promote echo chambers because they repeatedly recommend similar content to people. Concrete, real-world examples are employed to enhance learners' understanding of the practical implications associated with diverse systems-level design decisions.

An important perspective here is the Social Shaping of Technology approach: technology does not develop in a neutral, inevitable manner. Instead, social factors such as authority relations, culture, or economics shape not only the technology but also its adoption practices Williams & Edge, (1996). That knowledge allows a CEO or other decision-maker to put ethics ahead of what is technically possible. Acknowledging cognitive bias adds a new layer to technological literacy, as people tend to have preferences for thinking: e.g., confirmation bias, machine learning algorithms may inherit and even amplify biases present in the data they are trained on. It is essential to equip students with how to recognize these biases within themselves as well as the technologies developed, and how to mitigate or avoid biased outcomes of technology.

With the development of intelligent algorithms, the ability to make complex decision-making and ethics will be more important. AI can rapidly generate multiple feasible solutions and predict the probability of each solution's success or failure. At this point, humans' roles change from providing solutions to making decisions. While the central challenge is no longer identifying feasible solutions but selecting the optimal one among them.

In this regard, courses need to highlight the role that values play when making decisions and choices. There are at least two forms of rationality according to Weber (1978): instrumental rationality, which aims for a specific goal with maximal efficiency, and the rationality of values, which means acting morally regardless of consequences. Education today needs to teach both kinds of rationality. In particular, future workers must learn how to weigh ethical considerations and social implications in addition to economic productivity when making decisions. Students should be able to react quickly and decisively in unprepared, emergency circumstances. Young

people need to learn how to use intuition, experience, and values in making timely decisions where deferral is not possible.

Emotional intelligence and relationships with people are two aspects that AI can't currently match. Good leadership and teamwork. Innovative startups gather teams of individuals with different skills: technical specialists, designers, developers, marketing staff, product managers, and executives. Both understanding users' emotion states as well as discovering latent user needs require different skills: while analyzing behavioral data reveals patterns of what is observable, often misses the big motivations and mental processes. Ethnographic methods such as in-depth interviews and the elicitation of unstated needs which may be unknown to the user himself/herself. While AI can easily identify patterns in existing data, it may not account for those subtle feelings and emotions, which can also play a major role in influencing consumers' purchase decisions.

At every stage in the process of innovation, negotiation and conflict mediation skills are essential, as innovation contexts involve complex webs of actors with multiple viewpoints. The future demands consensus in the face of disagreement. Such difficult conversations demand advanced communication skills that acknowledge the tension, personalize the provision of information for particular constituencies, and find creative solutions that meet several goals at once.

These capabilities—particularly ethical decision-making and value-rational judgment—form the core competencies that the assessment framework in the following section is designed to measure.

3.3. From Artificial Exercise to Practice

The focus must shift toward applied learning, defined here as learning based on direct experience with the processes involved in making things and running a business.

Today's project teams are collaborative human-AI working environments. Mollick & Mollick (2023) recommend positioning AI as a teacher's assistant. Students learn how to distribute their cognitive loads effectively. It is capable of quickly coming up with a range of ideas for the solution and also simulates customers that test different aspects of proposed solutions. and additional scanning of the other papers in order to identify relevant concepts and connections. However, students retain the agency to identify problems, weigh ethical considerations, and reach conclusions.

Learning is a cyclical and iterative process that works from an affectation logic. The learning methodology supports a rapid feedback cycle of continuous building and assessment, and learning (Ries, 2011). Users build simple working models as quickly as possible. They learn through direct interaction with their users. They discover truths in the contrast between assumptions about how people will behave and what they actually do, leading to improved later generations. It is a learning loop based on experience and not just data acquisition.

This teaching strategy has its roots in well-established pedagogical theories. This strategy is rooted in experiential education (Dewey, 1997) and social constructivism (Vygotsky, 1978). Within a lab environment for entrepreneurship learning, students interact with AI agents and end-

users, experts, or any number of stakeholders. Each interaction reveals different facets of a problem and different criteria for successful solutions.

For example, in a semester-long entrepreneurship laboratory, student teams might be assigned to address a real urban mobility challenge in three phases. In the first phase, like week 1 to 4, students use AI tools (e.g., ChatGPT, Perplexity) to conduct rapid market scans, while the instructor facilitates critical reflection sessions on AI output reliability. For the next phase, such as in weeks 5 to 12, students conduct ethnographic interviews with target users—a task deliberately withheld from AI—to surface latent needs. While the final phase, from weeks 13 to 16, teams iterate prototypes through build-measure-learn cycles, with AI agents simulating customer responses and faculty assessing the ethical reasoning embedded in design decisions.

4. Enhancing Curriculum Assessment Methodologies

The following approach is measured in terms of (a) ecosystem participation; (b) contextual skills acquisition and real-world applications outside the classroom environment. The proposed evaluation framework moves beyond traditional start-up metrics to assess the three capabilities central to AI-era entrepreneurship: ecosystem participation, situated competencies, and real-world intervention outcomes. Typically, entrepreneurial education has been measured by the traditional metrics of industry and manufacturing: for example, universities track start-up rates. Such quantitative measures offer simple, directly comparable information attractive to program developers. Yet such an assessment is far from complete. Traditional performance indicators capture only the most superficial and short-term learning results, ignoring indirect education effects, crucially, the complexity of human-AI interaction. Current metrics also fail to capture social outcomes and ethical dimensions. A far more fundamental weakness with end-result measurement is that it measures past achievement, i.e., it serves as a lagged indicator of observing the outcome of events without providing timely feedback for adjusting teaching practices. A paradigm shift in evaluation methodology is now warranted. It must capture multiple facets of evaluation, not just reduce achievement to numbers or simple metrics. It has to capture dynamic processes when they happen and not only evaluate the end outcome. It should also embed ethics within its design; not dealt with on the periphery. The most important thing is that such a new paradigm supports the development of what is called Adaptive Innovation Capacity. This paper presents an evaluation framework that is based on the following categories of indicators: process criteria, competence assessment, and impact assessment.

4.1. Developing a Multidimensional Assessment Framework

Traditional assessment instruments are focused on documenting what programs do, not evaluating how they adapt over time. This paper proposes a set of interrelated domains that focus on assessing AIC.

The behavioral axis captures the way in which learners deal with uncertainty and human-AI collaboration. Crucial indicators include the transition from blindly accepting AI outputs to critical interrogation. Similarly important are critical thinking skills wherein students can identify

algorithmic bias, logical fallacies, and moral hazards. Project development documentation and reflection journals indicate if the student questions LLM outputs, or blindly accepts them.

Furthermore, refinement rate evaluation must be based upon learning content instead of the number of repetitions. The changes should reflect genuine evidence-based knowledge and not gut feeling posing as assessment. The focus is on whether human-AI interactions led to substantive improvements in the project's logic and viability

The developmental exam comprises several items to evaluate adaptability. Researchers can use existing instruments like the Cognitive Flexibility Scale (Dennis & Vander Wal, 2010) that tracks students' behaviors in response to uncertainty. Building on the ethical decision-making competencies introduced in Section 3.2, assessment here focuses on how students apply value-rational judgment in practice. Scenario-based tasks reveal whether students systematically deploy VSD methods ─ specifically, whether they can balance instrumental efficiency with ethical accountability when evaluating AI-generated recommendations. The impact dimension deals with broad impacts. Social value creation is not only about economics. Sustainability means whether the stakeholders consider long-term viability rather than ephemeral spectacle. A key metric is whether a project leads to collaboration between different stakeholders or encourages change in another stakeholder's behavior.

4.2. Integrated Utilization of Combined Research Techniques

Measurement is not possible with quantitative evidence alone; therefore, an integrated method that includes various kinds of evidence on both breadth and depth is required. While quantitative data (e.g., LMS activity logs, psychometric scales) provide baseline comparisons, they fail to explain why events happen or describe the nuances of human-AI processes.

The qualitative approach reveals dynamics, context effects etc. , which are not captured by quantitative analysis. Students must keep a log of his/her experience with the Human-AI co-innovation project. They contain information about decisions made at each step, the AI agent's communications issues faced, values, and teamwork behaviors. These stories undergo analysis using grounded theory coding, demonstrating how these adaptive innovative abilities develop in detail. Researchers are also observers who attend multiple semesters. The researcher captures real-time use cases of AI tools, detects changes due to unexpected events, and spots patterns of behaviour. To assess students' portfolios, a set of artifacts documenting students' learning journey is required. The artifacts can include questions showing increasing sophistication, participant discussion transcripts, iterative design changes based on feedback, and individual responsibility lists for ethical issues. These detailed logs create a story line for evaluators to track progress in skills through written evidence. Implementing this mixed-method approach requires faculty training in ethnographic observation and portfolio assessment to effectively measure the nuances of AI-integrated entrepreneurship.

4.3. Process Philosophy, Pragmatism, and an Ethically Aware Evolution

The proposed framework is oriented towards growth. It requires a radically new epistemology grounded in three theoretical pillars.

This model is built on Whitehead's process philosophy (1978). Process philosophy views reality as a network of dynamic events rather than static objects. In such an educational assessment paradigm, learning is a transformative experience per se. Students constantly produce themselves through interaction with AI, social networks. The idea of adaptive innovation capability is not something you can measure at the end of a programme—it's more something which emerges in doing the evaluation itself. It means that evaluation becomes the act of tracing lines of change rather than taking points in time.

Dewey's pragmatic philosophy (Dewey, 1997) emphasizes learning by doing. Assessment must occur as part of real world tasks and be formative. In teaching entrepreneurship in uncertain contexts, such formative evaluation method plays an important role.

Value Sensitive Design (Friedman et al. , 2017) ensures that ethical values form its foundation assessment. Ethical considerations should be incorporated into assessments by design, for example, when defining criteria that are to be assessed and establishing expectations at the beginning of a project or program. This encourages students to weigh ethical impact on society rather than treating ethics as an afterthought.

5. Conclusion

The impact of AI is not only a question of technology substitution, but an inflection point marking the limit of instrumental rationality. The disruptive nature of AI forces us to reevaluate education through the lens of symbiotic rationality. This model is based on three dimensions: Structural analysis situates technical innovation within social rules. Distinctiveness leverages unique human attributes, and practice redefinition fosters ethical intervention. To nurture Adaptive Innovation Capacity, universities must shift from information transmission to process-oriented assessment and real-world intervention.

However, this paper only offers a conceptual framework and does not present empirical validation. The proposed AIC construct and three-dimensional evaluation framework require empirical testing across diverse institutional and cultural contexts. Future research should examine implementation challenges, including teacher preparedness for ethnographic and portfolio-based assessment, institutional constraints on curriculum redesign, and the ethical risks of embedding AI agents within entrepreneurship laboratories. Longitudinal studies tracking the development of AIC across a full program cycle would further strengthen the evidence base for the proposed paradigm.

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