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The Design and Application of Specialized Creative Integration Curriculum for Promoting the Development of Creative Thinking of Teacher Trainees under the Concept of Open Education

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Abstract: Based on the concept of open education, this study designs a specialized and creative integration course to enhance the development of teacher trainees' creative thinking, and presents a curriculum model based on the theory of expansive learning, non-disposable assignments, and the framework of "pre-course knowledge comprehension and assimilation, in-course thematic cooperation and discussion, and post-course thinking training." Through the implementation of the specialized and creative integration course practice with the example of "building an online training platform for teacher qualification," it has been verified that the course design is effective in stimulating the creative thinking of teacher trainees. In addition, the study also analyzes the developmental trajectories of teacher trainees with different levels of creativity and systematically reveals the intrinsic mechanism of the course in enhancing the creativity of teacher trainees and optimizing their thinking paths.

Keywords: Specialized integration; Creative thinking; Open education; Non-disposable assignments; Higher-order thinking

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1. Introduction

With the renewal of knowledge and technology and the strengthening of diversification trends, the education field is stepping into a challenging VUCA (volatility, uncertainty, complexity, and ambiguity) era. Under the intensification of volatility, uncertainty, complexity, and ambiguity, individuals are facing unprecedented development pressure, and the cultivation of multi-skilled and complex talents has become the core driving force to promote the high-quality development of higher education. In this context, national standards for higher education have clearly set out the requirements for the cultivation of 21st-century skills, including critical thinking, creative thinking, and problem-solving skills, which are regarded as transferable skills [1], and are

indispensable literacies for talents in the new era. In 2019, the Organization for World Economic Cooperation and Development released the study "Cultivating Students' Creativity and Critical Thinking," which further emphasized the significant potential value of creative thinking in the context of the new era [2].

Numerous countries have gained a deep insight into the importance of the development of creative thinking in teacher trainees and have made it the focus of research in the field of education, actively engaging in the construction of the relevant curriculum system and the innovation of teaching practice. Scholars have suggested that adopting innovative and creative teaching strategies is a key way to improve the quality of education [3,4]. In this context, the Chinese government attaches great importance to the quality improvement of teacher education and explicitly regards the cultivation of innovative and qualified teachers as a core strategy to improve the higher education system, which in turn promotes multidisciplinary cross-fertilization as a new benchmark for curriculum design [5]. This model not only emphasizes the need for teacher trainees to have a solid grasp of professional knowledge, but also aims to stimulate and cultivate their creative thinking and entrepreneurial potential. Through the deep integration of specialized knowledge and innovative practices, teacher educators are empowered to explore innovative opportunities in diverse educational contexts and enhance their sensitivity and flexibility in responding to educational challenges. This process not only promotes the overall development of higher-order thinking skills, but also enables teacher trainees to quickly adapt and flexibly adjust their strategies in complex and changing educational environments, laying a solid foundation for sustainable personal and professional development.

The specialized integrated education model has successfully overcome professional boundaries and accurately captured the new needs of contemporary society for talent training. With the goal of cultivating social elites with innovative thinking, professionalism, and entrepreneurial spirit, it is committed to building a three-dimensional talent cultivation system, which has become a key path to improving the quality and efficiency of higher education. However, in the face of the constant emergence of new technologies, economy, ideas, and modes in the context of the new era, a future-oriented education revolution is quietly underway. How to transform and upgrade the integration of specialization and creativity in order to better cultivate high-quality applied talents has become a new topic that every educational researcher and practitioner must face.

Open pedagogy is a teaching mode that is flexible, highly participatory, and value-oriented. Under this innovative teaching framework, students are not only recipients of knowledge, but also co-creators and builders of knowledge [6,7], which can significantly stimulate their creativity, and at the same time greatly enhance students' learning interest and motivation [7-10], which provides a strong support for the cultivation of innovative and entrepreneurial talents. Therefore, this study focuses on the innovation of specialized and creative integration curriculum under the concept of open education and explores the effective path to promote the development of students' creative thinking through curriculum reform, which not only responds to the urgent need for educational change in the context of the new era, but also provides new ideas and practical references for cultivating high-quality applied talents in the field of higher education.

2. Research design

2.1. Instructional design for specialized integration courses

2.1.1. Course structure design

In terms of course structure design, the experiment adopts the three-stage teaching method of pre-course knowledge comprehension and absorption + in-course thematic cooperation and discussion + post-course thinking training. The design of this teaching structure is in line with the dual requirements of specialization and integration of students' solid professional knowledge as well as innovative application of knowledge.

Students' understanding and absorption of knowledge before class can enable students to have a preliminary understanding and mastery of new knowledge, and this kind of independent learning requires students to take the initiative to access information and think about the problem, which helps to cultivate students' independent learning and self-management abilities and lays the foundation of professional knowledge for the thematic cooperation in the class. In the class, through the form of group cooperation and discussion, students are able to look at the problem from a diversified perspective, stimulate inspiration, and deepen their understanding of knowledge. In the process of solving practical problems, students constantly experience the cycle of criticism, reflection, and creation, a process that greatly enhances their problem-solving and higher-order thinking skills. The post-course thinking training session focuses on helping students systematically sort out the knowledge in the learning process, strengthen the combination of theory and practice, and the formation of problem-solving strategies. This process can well enhance students' critical thinking and creative thinking, so that students can be more calm and comfortable in the face of complex and changing problems, and can utilize what they have learned to innovate and solve problems with ease.

2.1.2. Curriculum design theory

A specialized integrated curriculum requires a teaching model that promotes active exploration, practical reflection, and collective collaboration among students, and expansive learning theory is just such a theory. Developed by Finnish scholar Engstrom on the basis of Vygotsky's "cultural-historical" activity theory, the theory emphasizes deepening and expanding learning through collective participation, experience sharing, and deep reflection. It advocates that students start from basic concepts, and through continuous practice and reflection, gradually move towards the goal of complex activities or innovative forms of practice, so that while mastering specialized knowledge, they can innovatively apply this knowledge in practice and develop new insights and solutions. In addition, expansive learning theory also emphasizes the characteristics of contextual, transformative, collective, and cyclical [11], which are highly compatible with the teaching objectives of specialized and creative integration courses, which often involve real or simulated contexts and allow students to learn in the process of solving real problems. At the same time, it emphasizes the power of teamwork and collective intelligence, believing that teamwork and a cyclical learning process are powerful drivers of project progress and innovation. The theory depicts the learning process as a closed-loop cycle of "questioning→analysis→modeling→testing→implement ation→reflection→consolidation" (**Figure 1**), and this model provides solid theoretical support for instructional design. This study is based on the seven key links of this cycle to explore and practice instructional design.

Figure 1. Learning process based on expansive learning theory

2.1.3. Instructional organization strategies

The learning process emphasized by expansive learning theory is reflective and cyclical, which is compatible with the teaching organization of non-disposable assignments, and the thematic discussion under the integration of specialization and creativity is aimed at consolidating students' professional knowledge and improving their various thinking skills in a more open entrepreneurial context, therefore, the non-disposable assignment model with more openness and participation is selected as the teaching organization strategy for the in-class thematic discussion. Non-disposable assignments are constructive and renewable assignments that emphasize the open sharing of learning outcomes and have a gain value beyond knowledge acquisition [12]. Non-disposable assignments are cyclical, requiring students to repeatedly modify and improve the learning outcomes, students can constantly change the pondering and reflection, and co-create valuable outcomes through collaboration, in which students' creative thinking, critical thinking, and metacognitive abilities can be developed and enhanced [13]. The activity flow of non-disposable assignments contains:

(1) Knowledge absorption: Students understand and master the content of the professional curriculum and incorporate and integrate the knowledge content into the process of completing the topic assignment.

(2) Learning search: Students independently collect, analyze, integrate, and use information to form a preliminary design for the assignment under the guidance of the assignment topic.

(3) Peer feedback: Student groups analyze, critique, evaluate, and rewrite each individual student's assignment concept.

(4) Group work: Student groups review, rewrite, and refine assignment work.

(5) Evaluation and reflection: Students evaluate their own performance and project work during the realization of the NDAs project, and reflect on what needs to be improved.

Therefore, with the principle and goal of improving teacher education students, a proprietary integration instructional design model was designed with five non-disposable assignments as the baseline point, three instructional components as the starting point, and seven learning theory process indicators as the entry point (**Figure 2**).

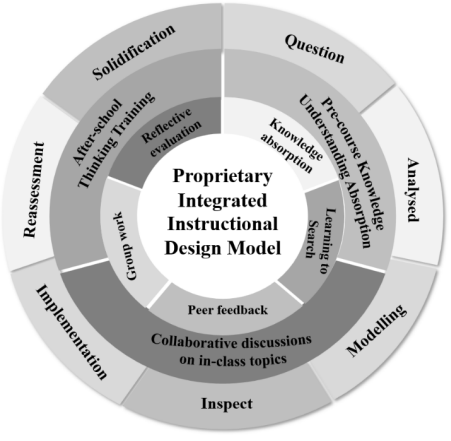

Figure 2. Model of specialized integration curriculum design

2.2. Research development

In this study, the core course "Distance Education Applications" of the Educational Technology program is selected as an example of the design of a specialized and integrated curriculum. As the core course of the program, Distance Education Applications aims to broaden students' educational horizons, cultivate their

ability to use information technology to promote learning, strengthen their competitiveness in the design and development of digital educational resources, and ultimately achieve the goal of enhancing their creative abilities. Based on this course, the experimental design of the "Teacher Qualification Online Training Platform Construction" as the theme of the specialization and integration of projects, aimed at allowing teacher training students to understand the dynamics of the job market in advance, to stimulate and explore their educational innovation ability, the specific thematic task planning is shown in **Table 1**. The course lasts for nine weeks, with a total of 36 hours, for the 2020 class, with 36 undergraduate students in a class of teacher education technology majors. According to the peer feedback literacy pre-test, students were divided into six groups, with two groups of high school and two groups of low-level, each with six students, and were jointly engaged in the learning of the specialized creative integration course. Based on this, the following instructional sessions were planned based on the above model of instructional design for specialized creative integration:

(1) Pre-course pre-study session: Pre-study assignments are released on Thursday, and basic knowledge related to this week's special discussion is provided, including learning materials and teaching videos. The teacher provides a discussion forum platform for students to facilitate answering their doubts; the students' knowledge of the doubt is submitted at the end of the course on Friday afternoon, and the teacher submits feedback on Sunday.

(2) In-class group discussion: The online training program for teacher certification is used as a case study of proprietary integration to develop learning-based search, peer feedback, and group cooperation sessions in non-disposable homework activities. Students combine pre-study content with collaborative innovation on discussion topics and specific topic tasks (**Table 1**).

(3) Post-course thinking training: Thinking Maps are used to reflect on the learning process after pre-study and theme discussion, with the focus falling on the meta-analysis of the thinking process, which students need to sort out combining with the top ten thinking tools applied by Thinking Maps.

Table 1. Thematic tasks of online training programs for teacher certification

Theme	Thematic mandates
Theme 1 Needs analysis of an online training program for teacher qualification and research on the current status of similar programs online	Write a SWOT analysis to identify the strengths, weaknesses, opportunities, and threats of the project and find an entry point for the business plan Contents: analysis of learning targets, analysis of students' needs, comparative analysis of online programs of the same type, strengths and weaknesses of the program, breakthrough strategies for key points and difficulties, and the biggest challenges and coping strategies.
Theme 2 Online learning content module design and knowledge graph design	Construct a knowledge map, online learning content module design proposal related to the content of the teacher certification exams Contents: login and registration module, learning resource library, self-directed learning pathway, teaching and tutoring module, online examination system, web-based lecture theatre, and design of live lecture theatre.
Theme 3 Support and service strategies for motivating students to learn online and stay engaged in learning	Write learning support to the service program, online interactive activity design program Contents: learning environment and technical support, learning resources and services, learning process management, incentives and rewards, online interactive activity design.
Theme 4 Analysis of online platforms and revenue models for project placement	Draw bubble charts representing the characteristics of different online platforms, and analyzing options for the project's revenue model Contents: selection of mainstream information platforms, advantages and disadvantages of platforms, feasibility of placement, advertising revenue sources, e-commerce revenue sources, value-added service revenue contents, and design of membership system revenue.

Table 1 (Continued)

Theme	Thematic mandates
Theme 5 Comparative analysis of marketing and promotion models for projects	Write a marketing communications program and promotional model program Contents: audience characteristics, audience usage habits, product life cycle, budget constraints, coverage of promotion channels, interactivity and participation of promotion channels, channel effectiveness evaluation methods and indicators, etc.
Theme 6 Analysis of the safeguard mechanism for the division of labor in the project mission	Develop a tree diagram of the division of labor among team members and write a proposal for a safeguard mechanism for the implementation of the project Contents: division of responsibilities among members, staffing, collaboration mechanism, analysis of policy safeguards, analysis of organizational safeguards, analysis of staff safeguards, analysis of financial safeguards, etc.

2.3. Research tools

2.3.1. Creative tendencies scale

In this study, Williams Creative Tendency Test Scale [14] was used, which consists of 50 questions divided into four dimensions and scored on a Likert three-point scale. Positive questions were scored as 1 point being a total discrepancy, 2 points being a partial conformity; and negative questions were scored as a total discrepancy of 3 points, a partial conformity of 2 points, and a total conformity of 1 point.

2.3.2. Coding framework for creative thinking

This study adopted the coding framework for learners' new viewpoint formation in peer feedback (**Table 2**) proposed by Zhang *et al.* [15] based on the sequence of learners' behaviors in social interactions in peer feedback for the path analysis of learners' viewpoint formation, integration, and creation in peer feedback activities.

Table 2. Table of coding frameworks for the generation of innovative ideas

Level 1 code	Level 2 code	Explanation
Cognitive-divergent thinking (A)	Associate (A1)	Linking concepts, objects, or situations
	Decomposition (A2)	Breaking down concepts, objects, or situations into rich detail
	Integration of adjustments (A3)	Combining or adapting concepts, objects, or situations
Cognitive-opinion generation (B)	New point of view (B1)	Generating a point of view from a new angle not previously mentioned
	Constructing perspectives (B2)	Modifying, refining, or expanding on previous ideas to develop a new one
Metacognition (C)	Reflection, management (C1)	Managing and reflecting on cognitive processes
Social exchange (D)	Refinement, elaboration (D1)	Explaining a point with examples, analogies, reasoning, or providing details
	Questions (D2)	Questioning for information or further elaboration
	Direct answers (D3)	Directing answers to questions without elaboration
	Agree (D4)	Positive evaluation of a point of view. E.g. agree, support, accept
	Disagree (D5)	Negative comments on a point of view. E.g. disagreement, scepticism, rejection
	Contend (D6)	Arguing for the appropriateness or value of an idea with clear reasoning
Emotion (E)	Positive (E1)	Positive emotion words or expressions
	negative (E2)	Negative emotion words or expressions
The rest (N)	Unrelated topics (N1)	Dialogue not related to the given mandate

3. Results and discussion

3.1. Analysis of the enhancement of creative tendencies

In this study, a pre-test and post-test comparison was conducted to examine the effect of the curriculum on the development of creative tendencies in students who participated in the curriculum (**Table 3**). The data were analyzed using paired samples *t*-test and the results showed that the students' creativity tendency scores after the curriculum intervention (M = 114.61, SD = 6.366) were significantly higher than those before the intervention (M = 105.08, SD = 6.451), and the difference was statistically significant (t = -11.621, $P < 0.01$). Further analysis of the four sub-indicators of creativity found that all of them were significantly higher ($P < 0.01$), indicating that the course was able to stimulate students' multidimensional thinking assessment and problem-solving skills through the design and execution of diverse tasks, thus enhancing their overall creativity tendencies.

Table 3. Paired samples *t*-test for creative tendencies

Name	Type	*n*	Mean	SD	*t*	*P*
Creative thinking tendency	Creative thinking pre-test	36	105.08	6.451	-11.621	< 0.01
	Creative thinking post-test		114.61	6.366		
	Adventurous pre-test		22.22	2.192	-10.646	< 0.01
	Adventurous post-test		25.81	2.471		
	Curiosity pre-test		29.39	2.476	-8.214	< 0.01
	Curiosity post-test		31.61	1.871		
	Imagination pre-test		26.78	1.869	-5.502	< 0.01
	Imagination post-test		28.83	2.569		
	Challenging pre-test		26.69	2.291	-6.786	< 0.01
	Challenging post-test		28.36	1.973		

3.2. Creative thinking path analysis

In order to reveal the dynamic development of students' creative thinking, this study coded the texts of six online discussions and used GSEQ software to conduct lag sequence analysis to construct a path model of students' creative thinking (**Figure 3**). The results showed that students with different creative tendencies showed the core characteristics of creative thinking, but the specific path development was unique.

The low-level group demonstrated a cognitive path of more active social cooperation to promote the generation of new ideas (D1→B1, D2→B1) in a harmonious and pleasant communication atmosphere (E1). The generation of innovative ideas resulted from questioning and elaboration of ideas (D2→D1, D2→D3) and was accompanied by positive emotions, indicating a more congenial classroom atmosphere in this course. However, the depth of new cognition still did not fully reach the level of theoretical construction, and it was more of a preliminary exploration and formation of new viewpoints, while lacking in-depth systematic analysis.

The cognitive process of new viewpoint generation in the intermediate-level group gradually tended to be complicated, containing the innovative viewpoint paths of viewpoint refinement (A2→B2), argumentation (D5→D6), revision (D6→B1), reflection (C1→B2) and integration (D6). Conflicting perspectives stimulate critical thinking, reflection, and revision. Through in-depth interactions, students were able to analyze and validate existing viewpoints in detail, which led to consensus and the generation of new viewpoints.

The high-level group's viewpoint innovation activities reached a highly integrated level with complex

and multiple pathways. Students not only absorbed external knowledge and exchanged viewpoints, but also strengthened cognitive monitoring and regulation mechanisms, forming multiple links of high-quality question and answer (D2→B2), thought activation (A1→B1), cognitive management (C1→A1), and emotional feedback (B2→E1, D1→E1). Metacognition plays a central role in this stage, guaranteeing the organization and efficiency of viewpoint innovation. The emergence of abstract and holistic thinking reveals the flexibility and adaptability of cognition and broadens the breadth and depth of viewpoint innovation.

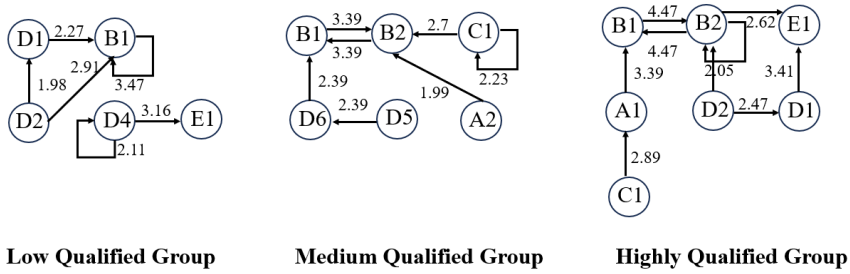

Figure 3. Pathway map of collective wisdom generation across peer feedback literacy groups in a proprietary integration course

4. Conclusion

Based on the concept of open education, this study designed a specialized creativity integration course based on expansive learning theory and framed by non-disposable assignments. The course was practically investigated with 36 teacher-training students as research subjects, which verified the significant promotion effect of the course on the development of creative thinking and revealed the characteristics of the hierarchical paths of the development of creative thinking of teacher-training students with different levels of creativity through dynamic path analysis. The thinking paths of low-level students are mainly characterized by "social interaction-driven," with viewpoint generation and simple feedback as the main features, and lack of in-depth argumentation and innovative construction; intermediate-level students show "cognitive conflict-promoting" paths, which gradually promote the deepening of their thinking through viewpoint debates and contradiction analysis; while high-level students show a "multidimensional integration and enhancement" path, which can comprehensively use metacognitive strategies to realize the deepening of thinking from theoretical construction to innovative application. These findings enrich the theoretical model of creative thinking development and provide a scientific basis for the design of teaching and learning for students with different levels of creativity.

In addition, this study found that a positive emotional climate plays an important moderating role in the development of creative thinking. The process evaluation data showed that emotional support not only significantly enhanced students' motivation and the quality of interaction, but also optimized the cognitive process through group collaboration and open discussion. Emotional support further played a facilitating role in the process of deepening the thinking of students with high creative tendencies, significantly increasing the complexity and innovation of their thinking. This result suggests that emotional support is an important facilitator of creativity development and has a non-negligible role in a specialized and creative integration course.

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