Research on Interdisciplinary Thematic Learning—A Perspective Based on Cultural-Historical Activity Theory

Wei Zheng*, Hanyu Wang

Faculty of Education, Beijing Normal University, Beijing, China
*Corresponding author

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Abstract: The introduction of the new version of China's Compulsory Education Curriculum 2022 (hereinafter referred to as the "Curriculum Programme") and the Curriculum Standards for each subject has brought the concept of "interdisciplinary thematic learning" back into the public eye and triggered heated discussions in the education community. The new version of the Curriculum Programme clearly states that it is necessary to "strengthen the connection between curriculum content and students' experience and social life, enhance the integration of knowledge within disciplines, and design integrated courses and interdisciplinary thematic learning in a coordinated manner", and that in principle, "no less than 10% of the lesson time of each course should be devoted to the design of interdisciplinary thematic learning. ". Interdisciplinary thematic learning has become a mandatory option in current curriculum teaching, and how to carry out effective interdisciplinary thematic learning design and implementation has attracted the attention of teachers and scholars. This paper attempts to propose a structural framework and teaching strategies for interdisciplinary theme learning from the perspective of Cultural-Historical Activity Theory on the basis of analysing the problems and confusions in the implementation of interdisciplinary theme learning, so as to provide theoretical guidance for frontline teachers' teaching design and implementation.

1. Introduction

Single-subject education has always dominated the educational structure, whether it is the Six Arts of the Gentleman in ancient times, the Seven Arts in church schools, or the natural and social sciences in the modern education system, which has always emphasized a subject-based approach. This structure of teaching and learning has facilitated the development of the school education system, the unified management of the various elements of teaching and learning, and the construction of standardized tests and evaluations, but it has prevented students from building a comprehensive and holistic understanding of the world. As early as the beginning of the 20th century, the American educational psychologist Dewey directly pointed out the shortcomings of discipline-based teaching, arguing that discipline-based learning often blurs students' understanding of the relationship between disciplines, while integrated learning is more natural[1] . As a result, people began to focus on the reflection of the real world in the content of teaching and learning, and tried to bridge the gap between academic learning and social experience in schools.

Interdisciplinary teaching centered on the integration of disciplines gradually came into the public eye, and the concept of "interdisciplinarity" was born.

The concept of interdisciplinarity was first introduced by Woodworth R.S in 1926[2]. At this stage, interdisciplinarity directly refers to the integrated study of two or more different disciplines, emphasizes the integration of disciplines, and views interdisciplinarity as a method of problem solving. In the 1930s and 1940s, the Unity of Science Movement further promoted the development of interdisciplinarity. Along with the rise of the new social science movement in the 1960s, the United States began to vigorously promote the construction of an integrated curriculum, the birth of the STS (Science, Technology and Society) curriculum marks the interdisciplinary education has become an important part of secondary education[3] . At the same time, educational reforms in universities also called for the cancellation of disciplinary structures in universities and their replacement with holistic concepts closer to real life. People's attention to interdisciplinarity also gradually shifted from research methods to the integration of disciplinary content, and the concept of interdisciplinarity was further developed. Later, in the 1970s and 1980s, Interdisciplinarity published by Organization for Economic Co-operation and Development (OECD), and STEM education proposed by the National Science Council of the United States have pushed the study of "interdisciplinarity" to a new climax. However, the development of interdisciplinary education and teaching in the 20th century failed to bring about a change in the education system, and knowledge remained confined within the framework of disciplines. OECD reviewed interdisciplinarity more than ten years after the publication of Interdisciplinarity and pointed out that interdisciplinarity had lost its impetus, and that school faculties were not only returning, but also being further developed[4] .

As the years go by, the dynamic development of the Internet, blockchain and other modern technological means in the twenty-first century has given rise to the information technology revolution and promoted the process of knowledge globalization. The rapid updating of knowledge and the rapid dissemination of resources have facilitated the construction of distributed information networks, strengthened the links between knowledge and formed a tight knowledge map. Various problems in the real society are becoming more and more systematic and complex, and the single-type talents cultivated by traditional education can no longer adapt to the pace of social development, and countries are beginning to call for the cultivation of all-round development of composite talents. Interdisciplinary theme learning as an important way to develop the overall quality and comprehensive ability of students, once again entered the vision of the government and experts in education. The "Integrated Learning" advocated by Japan in the 1980s, "Phenomenon based Teaching and Learning" promoted by the Finnish National Board of Education in 2004, as well as "STEAM Education" carried out by the United States in 2006, are the thinking and attempts of various countries on interdisciplinary learning. The proposition of "interdisciplinary thematic learning" responds to the needs of the times and the needs of society, and is an important measure to deepen curriculum reform and implement the fundamental task of establishing morality and educating people. However, when scholars look back at past studies, they find that the lack of clarity in the definition of concepts has led frontline teachers to have a biased and narrowed understanding of interdisciplinary thematic learning, and they have encountered a wide variety of difficulties in the design and implementation of interdisciplinary thematic learning, which are mainly focused on the following aspects: (1) being unable to identify the boundaries of disciplines; (2) not being clear about when it is necessary to cross the boundaries of disciplines; (3) not knowing how to cross disciplines and which disciplines to cross; and (4) difficulty in identifying indicators for evaluating interdisciplinary theme-based learning. These key issues, which have remained unimproved for a long time, have constrained the development of interdisciplinary thematic learning, causing frontline teachers to have a simple platter of multidisciplinary content and a

mishmash of teaching forms in the process of designing and implementing interdisciplinary thematic learning[5] . Clearly defining the connotation of interdisciplinary thematic learning and solving the key problems are necessary steps to promote the implementation of curriculum reform.

2. Interdisciplinary thematic learning from a cultural-historical activity theory perspective

As a learning activity, interdisciplinary thematic learning requires a systematic design that takes into account the elements of students, teachers, teaching tools and so on. However, when analyzing the new version of the compulsory education curriculum standards and programmes, it is found that they do not focus on systematic thinking when guiding teachers to implement interdisciplinary thematic learning, and do not adequately consider and unify the contents of and the relationship between the elements in the activity system. Defining the meaning of interdisciplinary thematic learning from a systemic perspective and building a structural framework are key ways to facilitate the implementation of interdisciplinary thematic learning.

2.1. Interdisciplinary theoretical framework in the perspective of cultural-historical activity theory

By analysing the 2022 edition of the curriculum standards for each discipline, we found that only two disciplines, geography and history, currently explicitly provide the meaning of interdisciplinary thematic learning. Synthesizing the ideas of Vygotsky and scholars of Cultural-Historical Activity Theory (hereafter referred to as Activity Theory), we believe that learning is a symbolic process or mediated activity, i.e., activities are mediated by We believe that learning is a symbolic or mediated process, activity is mediated by artefacts (technical tools) and symbols (psychological tools) in the social environment, and that the subject can only construct meaning when interacting with artefacts in the environment and with social others, and that individual human beings do not respond directly to the environment. Activity theory states that learning involves six elements such as tools, community, rules, and division of labor, (see Figure 1 for details). The subject can be either an individual or a group; the object is directly directed to the purpose of the activity; the tools are the intermediaries used by the subject to achieve the object, and include both physical and psychological tools; the community consists of individuals and groups that share the same object and goal; the rules regulate the activity and the members of the community, and the division of labour reflects the responsibilities within the community.
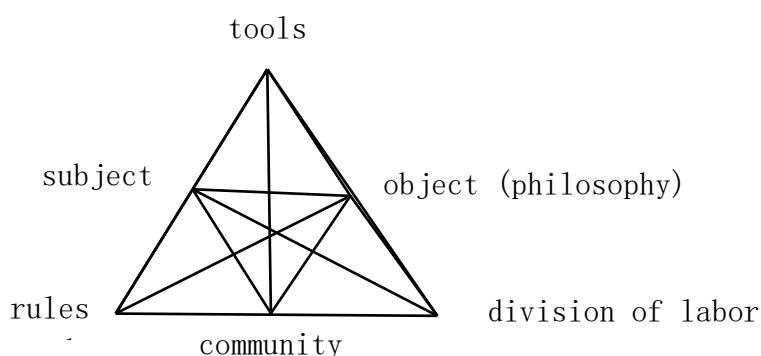

Figure 1: Components of Cultural-Historical Activity Theory.

Activity theory provides us with a clear and operational modelling framework that allows us to examine and analyse the human learning process from a holistic and systematic perspective. This allows us to identify problems in traditional learning models more comprehensively and extensively

and to propose constructive countermeasures. Therefore, when we use Activity Theory to examine the definition of the connotation of interdisciplinary thematic learning in the curriculum, it is easy to directly identify the problem of missing systemic elements in it. Since the definition of interdisciplinary thematic learning is explicitly stated in the standards of only two disciplines, geography and history, we will focus on these two disciplines and analyse them systematically with the framework of activity theory (see Table 1 for details).

Table 1: Systematic analysis of the connotations of interdisciplinary thematic learning in history and geography in the new version of compulsory education.

	2022 edition of the compulsory history curriculum standards	2022 edition of the compulsory geography curriculum standards
Subject	Students, history teachers, teachers of other subjects	Students, geography teachers, teachers of other subjects
Object	1. Developing core literacy of students; 2. Promote a change in the way students learn history; 3. Strengthening students' ability to apply multi-disciplinary knowledge and skills for integrated enquiry	1. Cultivation of students' inquiry ability, creative consciousness, practical ability and sense of social responsibility; 2. Promote the all-round development of students and the common development of teachers and students; 3. Materialized learning products (e.g. various texts, models, design drawings, etc.)
Tools	1. A particular research theme; 2. Integrate knowledge, skills, and methods from the history courses they have taken with those from other courses, as well as research on topics; 3. Carry out comprehensive practical activities for in-depth enquiry and problem solving	1. A particular research theme; 2. Use the content of the geography curriculum as the backbone and apply and integrate relevant knowledge and methods from other subjects; 3. Developing integrated learning
Community	--	--
Rules	1. Theme selection: Comprehensive, practical, diverse, exploratory and actionable; 2. Evaluation: Evaluation of interdisciplinary thematic learning requires history teachers to collaborate with teachers of related courses to evaluate student learning; 3. Preparation of teaching materials:(1) Promoting the development of interdisciplinary learning skills,(2) the content of teaching materials should reflect organic links with language, ethics and the rule of law, geography, art, etc., and select inspiring interdisciplinary issues to design various types of inquiry activities; 4. Pedagogical research and teacher training: Thematic training on core literacy, academic quality, cross-curricular theme-based learning, teaching of big concepts and other key difficulties in curriculum reform.	1. Theme selection: Theme learning requires to be close to the reality of students' lives, in line with the age characteristics of students, focusing on the discovery and solution of real problems, and reflecting the characteristics of vivid practice; 2. Teaching suggestions: Geography teachers can work together with other curriculum teachers to develop practical activities for interdisciplinary thematic learning, providing students with opportunities to solve problems through the integrated use of multi-disciplinary knowledge; 3. Preparation of teaching materials: focusing on the implementation of the requirements for interdisciplinary thematic learning, arranging field trips as appropriate, and creating opportunities for students to learn independently, co-operatively and through enquiry; 4. Teacher training and pedagogical research: The new requirements for strengthening geography practice and interdisciplinary thematic learning are the mainstay of training. Geography teachers are encouraged to take an active part in interdisciplinary teaching and research activities in other curricula, to draw on each other's experience and to explore new paradigms for reform and development of interdisciplinary and comprehensive education and teaching in the geography curriculum.
Division of Labor	--	--

2.1.1. Subject

Through analysing the standards of the two disciplines, we find that both involve students, teachers of the discipline and teachers of other disciplines. The design of interdisciplinary thematic learning requires comprehensive coordination and involves the concerted efforts and division of

labour of a number of people involved in the construction and implementation of the curriculum, such as school leaders, students' parents, social groups providing resources, etc. It is difficult to make long-term effective interdisciplinary thematic learning possible by relying on the efforts of teachers and students of various disciplines alone. Therefore, the subjects in interdisciplinary thematic learning are pluralistic and open, and all those involved in that learning should be taken into account.

2.1.2. Object

In terms of objects, interdisciplinary thematic learning in the standards often aims at the development of students' disciplinary core literacy, the transformation of learning styles and the common development of teachers and students, and encourages students to generate concrete products in interdisciplinary thematic learning. In learning activities involving multiple disciplines, learners are confronted with a complex, authentic social situation, attempting to break down the original boundaries of their disciplines, establish a comprehensive understanding of the problem through the integrated use of knowledge and skills from multiple disciplines, and propose creative solutions in their continuous attempts. In this process, students not only develop their core literacy, but also improve their teamwork skills, creativity and other qualities. The goal of interdisciplinary thematic learning is not only to focus on disciplinary core literacy, but also to analyse in depth the multifaceted competencies demonstrated by students in the process, and to identify the unique core competencies that interdisciplinary learning develops, which are known as interdisciplinary learning literacy.

2.1.3. Tools

Both the history and geography standards explore three aspects: (1)the themes of research; (2)the integration of knowledge, skills and methods across different curricula; and (3)integrated practice and learning activities.

(1) Research themes

Themes in interdisciplinary thematic learning are the pillars that support the smooth implementation of the entire learning process, and can play a role in running through the learning activities, creating authentic learning situations and promoting student learning. However, at present, the generation and selection of themes have become the first difficulty faced by teachers. Through analysing the curriculum standards of various subjects, we find that the current themes are often extensions of a single subject, emphasizing the extension of the content of a particular subject and the active integration of two or more subjects, so as to identify leading learning themes and launch teaching activities. This kind of generative theme is prone to the problem of "hegemonic" in the real implementation of teaching and learning, in which teachers pay too much attention to the subject they teach and weaken or neglect the teaching of other interdisciplinary subjects in their teaching. In addition, there are two other ways of generating themes, one of which focuses on discipline integration, selecting two or more disciplines and, based on the qualities of the disciplines, tapping into the interdisciplinary themes shared by the disciplines and advancing the teaching activities based on them, such as the STEAM programme proposed by the United States. Although this kind of generative approach alleviates the problem of "hegemony" in teaching, it often leads to a lack of logical connection in the teaching structure, and teachers randomly choose teaching contents according to the theme. The third type of theme generation starts from the theme itself, using real-life events as a starting point, and members of the learning community choose a theme from a social context that is suitable for joint investigation, analyze the subject matter involved in the theme, and then carry out the corresponding teaching activities. In Finland, the

"Phenomenal Teaching" introduced in the 2014 National Core Curriculum Standards for Basic Education encourages students to interpret a theme based on a "phenomenon" and to develop an integrated approach to subject learning. The third approach is more in line with the way in which problems are generated in real social situations, and is the natural state of affairs for interdisciplinary thematic learning.

(2) Integration of knowledge, skills and methods from different disciplines

Interdisciplinary theme-based learning involves teaching the knowledge and skills of several disciplines in one lesson, so that students can be fully and comprehensively improved. Therefore, the integration of knowledge, skills and teaching methods of disciplines is extremely necessary for students, but the difficulties in generating and selecting themes directly affect the integration of teaching knowledge and skills. How to naturally integrate knowledge, skills and pedagogical approaches between different disciplines has become another major challenge in the design and implementation of interdisciplinary thematic learning.

(3) Integrated Practical Learning and Activities

Interdisciplinary thematic learning emphasizes the creation of authentic problem-solving situations for learners and the practice of complex problem-solving skills. Integrated practical learning and activities fulfil this requirement of interdisciplinary thematic learning, highlighting the importance of learners integrating knowledge from various disciplines and putting it into practice.

The above three tools all belong to the category of psychological tools, and with the development of information technology, the influence of technology in education and teaching has become increasingly far-reaching, which can effectively assist the subject in achieving learning goals. In interdisciplinary thematic learning, it is necessary to comprehensively consider the role of psychological technology and technological tools in learning, in order to reasonably use technological tools to support the subject to achieve the learning objectives.

2.1.4. Community and division of labour

The absence of any reference to community and division of labour in the new standards directly affects the design and implementation of interdisciplinary thematic learning in which subjects collaborate to promote interdisciplinary thematic learning. Although members of the community share the same goal of contributing to the realization of the object, the focus of each subject's work differs due to the different division of their labour. Teachers of the subject, students and teachers of other subjects, school leaders, students' parents, social organizations and other stakeholders of interdisciplinary thematic learning need to coordinate and collaborate according to a certain division of labour to promote the realization of the object.

2.1.5. Rules

Based on Taylor's model of course objectives, the smooth implementation of the course contains four crucial stages: determining course objectives, selecting course contents, organizing course contents and evaluating course effects. Therefore, in the rules section, it is necessary to conduct in-depth thinking on teaching content, teaching methods and evaluation methods, and to improve the selection of themes, the preparation of teaching materials, teaching suggestions, teaching evaluation and other related contents. Considering that interdisciplinary theme-based learning appears in the curriculum for the first time, teachers have many doubts about it, so teacher training and teaching research also need to be included.

Refining the elements of interdisciplinary thematic learning from a systemic perspective, we believe that interdisciplinary thematic learning is a teaching practice that has arisen as a response to the current problem of talent cultivation triggered by the fragmentation of disciplines - the inability

to comprehensively, scientifically and creatively solve real problems in society. This practice requires teachers of the discipline, students and teachers of other disciplines, school leaders, parents of students, social organizations and other stakeholders of interdisciplinary thematic learning to form a community of co-ordination, in accordance with a certain division of labor and the rules of collaborative promotion, based on a certain discipline, based on the content of the teaching and the actual needs of students' development, and take the initiative to integrate the knowledge, skills, and methodologies of two or more disciplines, featuring disciplinary links, authentic contexts, and integrated practices, with the characteristics of disciplinary links, authentic contexts, and integrated practices. Characterized by disciplinary connections, real-life situations and comprehensive practices, students are encouraged to apply knowledge from multiple disciplines to solve real problems in comprehensive practical activities, so as to achieve the enhancement of students' core qualities and promote teachers' professional development.

2.2. Structural framework for interdisciplinary thematic learning
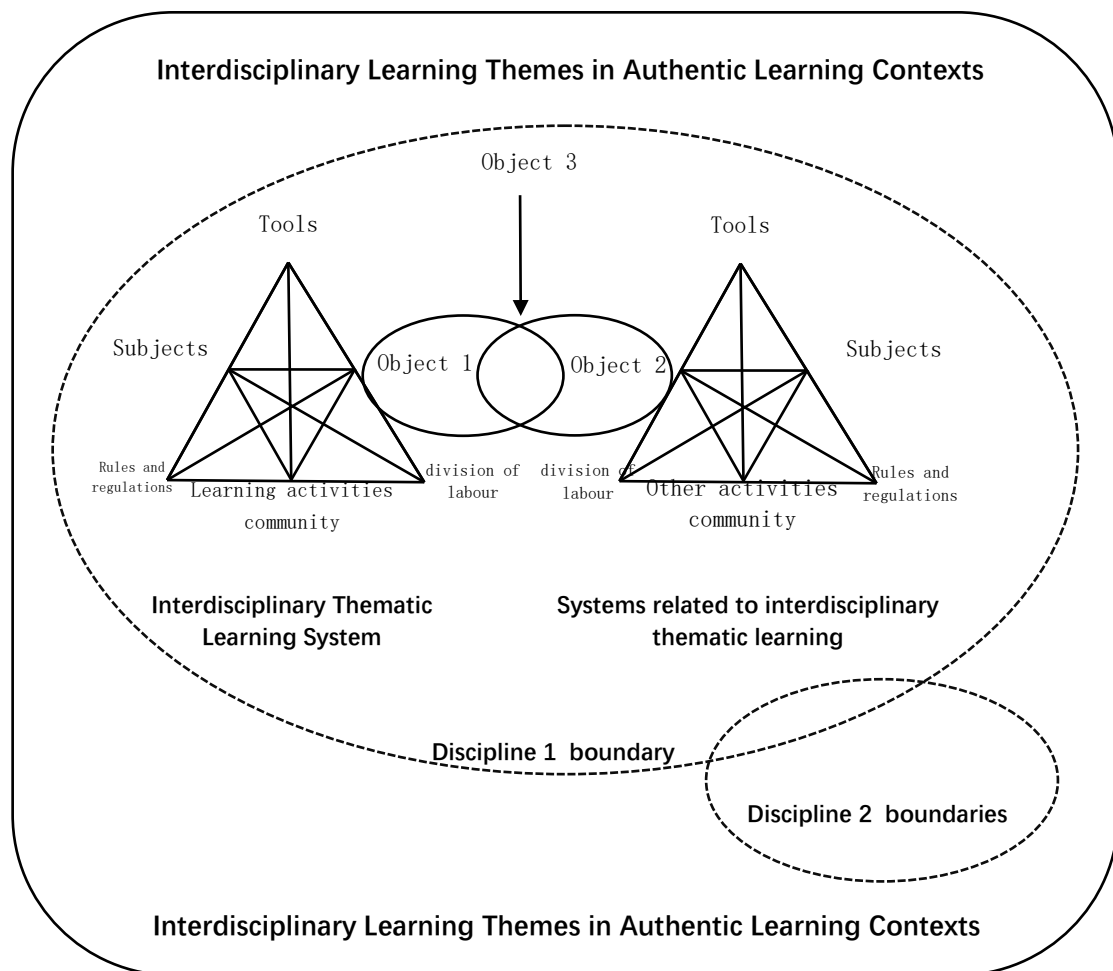

Figure 2: Structural framework for interdisciplinary thematic learning

Interdisciplinary theme-based learning is a learning activity carried out in an authentic context, in which the interdisciplinary theme-based learning system with teachers and students as the main body and other related systems (e.g. systems formed by parents or social organizations) collaborate with each other under the leadership of a certain learning theme, cross the boundaries of disciplines,

and comprehensively apply the knowledge, skills and methods of multiple disciplines to solve problems together (see Fig. 2 for details).

2.2.1. Interdisciplinary learning themes in authentic learning situations

In authentic learning contexts, interdisciplinary learning themes are the basis for students' learning activities, influencing the identification of students' learning objectives and the design of learning activities, and are the first step in promoting interdisciplinary thematic learning. Teachers need to fully explore the interdisciplinary learning theme before they can identify the subject content, knowledge and methods that may be involved, formulate learning objectives geared towards the development of students' core literacy, identify driving learning questions and design challenging learning activities. Scientific and reasonable evaluation indicators should be formulated to provide timely feedback and evaluation of students' learning activities while teaching activities are effectively implemented.

In interdisciplinary thematic learning, every subject is a human being with social attributes, whose learning activities cannot be separated from interaction and engagement with social personnel, environment, tools and other elements. As the educational psychologist Grino said, all teaching and learning takes place in a complex social environment [6]. Therefore, interdisciplinary thematic learning must be carried out in authentic social contexts, presenting real problems and assigning real tasks, closely linking students' learning with the realities of life, and guiding students to actively engage in cognitive activities and social interactions. The teacher's task is to guide students to solve authentic practical problems, to engage in meaningful, in-depth and emotional learning, and to transfer and apply what they have learnt.

Based on the different degrees of integration of disciplines, the generation of interdisciplinary theme learning can be divided into three orientations. The first is the extension of a single discipline, which emphasizes the extension on the basis of the content of the discipline, the active integration of two or more disciplines, the identification of leading learning themes and the development of teaching activities. The second is the integration of multiple disciplines, selecting two or more disciplines from a disciplinary perspective, tapping into themes shared among disciplines, and promoting teaching activities based on them. The third is the selection of realistic themes, in which members of the learning community choose a common theme of inquiry from a social context, and analyse the disciplines involved in that theme and carry out the corresponding teaching activities. Both Orientation 1 and Orientation 2 start from the perspective of disciplines, which is the current real state of interdisciplinary theme learning; Orientation 3 starts from the theme and takes real-life events as the starting point, which is more natural and in line with the way of generating problems in the real social context, which is the ideal state of interdisciplinary theme learning.

2.2.2. Learning system

The learning system in interdisciplinary thematic learning is the driving force behind learning activities. In this process, the whole learning system is in an open state with complexity and dynamics. A complete interdisciplinary thematic learning system, in addition to the teacher, students as the main body of its own system, but also covers one or more and interdisciplinary thematic learning system and interdisciplinary thematic learning system to share part of the object of the relevant system, the main body of these systems may include students parents, university experts, social organizations and so on. The systems interact with each other, and members of the community integrate knowledge and ideas from various disciplines, with the help of applicable tools, and work together to advance the learning goals under the rules and division of labour in order to achieve the desired outcomes. Each system has elements such as subject, object, mediating

tools, community, rules, and division of labour. The elements are described here in detail using the example of an interdisciplinary thematic learning system.

(1) Subjects of interdisciplinary thematic learning activities

Learning is a process of continuous construction and improvement, and teachers and students are both producers and consumers in learning activities. Both are jointly involved in designing, implementing and evaluating the educational process, learning the content of teaching and learning, and adjusting and optimizing based on feedback. Teachers, as transmitters of knowledge, leaders and organizers of learning activities, guide and organize diverse, contextualized, project-based and other forms of educational activities; students not only receive knowledge, but also construct knowledge creatively and critically through cooperation.

Each subject is a complete person composed of knowledge, emotion, intention and action, and is an indispensable part of the system, with independent and autonomous cognitive concepts, emotional thinking, volitional ability and behavioural activities. Therefore, the analysis of the learner should start from the learner's cognitive and skill level, learning interest, learning intention and activity experience and other dimensions, connect with the learner's life and learning needs, analyse the influence of other elements of the system on the learner (such as intermediary tools, family situation, social culture, etc.), build a picture of the learner, so as to determine the learner's learning objectives and the content to be mastered in the system.

(2) Object of interdisciplinary thematic learning activities

The object of interdisciplinary thematic learning is directly directed to the solution of problems in real environments, and its essential purpose is to enable students to comprehensively build up their understanding and mastery of the knowledge and skills of their disciplines in the exploration of problems, and to cultivate core literacy and promote their socialization. Learning objectives need to be constructed with the participation of all members of the learning activity community by analysing the interdisciplinary learning themes and the curriculum standards and contents of the disciplines involved in the learning activities. The objectives should be described in a literacy-integrated manner, aiming to reflect the requirements of developing core literacy and focusing on the students' position.

(3) Intermediaries/tools

The tools in the interdisciplinary thematic learning system include hardware equipment (e.g., computers, projectors, etc.), teaching platforms (e.g., Tencent Conferencing, Catechism), teaching resources (e.g., books, instructional videos), teaching strategies (e.g., context creation, cooperative learning, imitation), and pedagogical scaffolds (learning task lists, etc.) that are used by the teachers in the implementation of their teaching. With the development of information science and technology, we also need to pay attention to the role of modern technology, such as the Internet and artificial intelligence, in promoting learning activities. Instructional designers should choose appropriate tools and fully integrate them into learning activities to support students' independent learning and co-operative enquiry, boost the development of learners' subjectivity, and promote problem solving and knowledge transfer.

(4) Rules and division of labour

Rules are norms and practices shared by the interdisciplinary thematic learning community that guide the conduct of learning activities. The division of labor directly affects the roles, tasks and responsibilities of each member of the community. In the process of promoting interdisciplinary thematic learning activities, teachers and students need to abide by the rules, take on their own responsibilities in accordance with the division of labor, complete the required tasks, and promote the completion of learning activities and the achievement of learning goals.

(5) Community:

Community is composed of all the subjects in the system, and the community in the

interdisciplinary thematic learning system includes all the teachers and students involved in the learning activities. In the community, each member enjoys all rights equally, and the teacher-student relationship is reconstructed in the learning activities. Students also need to be involved in all aspects of the design of interdisciplinary thematic learning activities, clarifying learning objectives and negotiating evaluation criteria with teachers. At the same time, the roles of "teacher" and "student" are not fixed, and students can fully express their own ideas and organize teachers and classmates to carry out investigations together.

2.2.3. Disciplines and discipline boundaries

Disciplines and discipline boundaries underpin the development of interdisciplinary theme-based learning. Students' learning should be based on their original subject knowledge and learning experiences, and they should seek solutions to problems by applying their subject knowledge and skills, and by trying and exploring in real situations. When the knowledge and way of thinking of a certain discipline cannot meet the needs of problem solving, members of the community need to make efforts to break through the boundaries of the discipline, take the initiative to learn and incorporate the knowledge systems of other disciplines, and make comprehensive use of the skills of multiple disciplines. Interdisciplinary thematic learning activities can not be separated from the knowledge of the discipline and the initiative to cross the boundaries of the discipline to explore the behaviour of the discipline and the boundaries of the discipline to provide support for the development of learning activities.

3. Interdisciplinary Thematic Learning Design Based on Cultural-Historical Activity Theory

Based on the above discussion, we advocate a comprehensive design of interdisciplinary theme-based learning from a systemic perspective. Therefore, this paper is based on the theory of cultural-historical activities and combines the characteristics of interdisciplinary theme-based learning with a comprehensive design of teaching activities (see Fig. 3 for details).

Figure 3: Interdisciplinary thematic learning design

3.1. Generating creative themes

The creative theme is a distillation of the core knowledge of the subject, encompassing the essence of the subject and the requirements for the development of students' core literacy, and is linked to real life. It leads students to sustained enquiry and learning, mobilizes students' interest in learning, stimulates creative thinking, and explores solutions to problems with new perspectives.

Creative themes are characterized by value, authenticity and integration, and are associated with contexts, tasks and other elements. On the one hand, the generation of themes originates from the curriculum standards and teaching materials, reflecting the core knowledge and core qualities of each discipline; on the other hand, it originates from life and meets the actual needs of students' development, instead of putting the contents of various disciplines into one piece in a rigid manner. Teachers and students, as members of an interdisciplinary thematic learning community, participate in the generation of creative themes, form learning activity design teams, study the curriculum and textbooks, consult teachers of different disciplines for ideas, absorb the opinions of experts in the field, and take into account the interests and developmental needs of different groups of students. The sources of creative themes can be ongoing social events (social hotspots, such as the post epidemic era, global warming, wars, etc.), or they can be classic issues in history, or the characteristic culture of the school in its development over the years.

Creative themes can come from the following sources: social hotspots: e.g. post epidemic era, global warming, local wars, etc.; historical classics: e.g. ancient civilizations, cultural heritage, etc.; school characteristics: e.g. campus environment, school history and motto.

3.2. Clarifying literacy-orientated goals

"Clarity of purpose" gives direction and meaning to students' learning and avoids fragmented and off-topic learning. According to the requirements of the 2022 version of the compulsory education curriculum and curriculum standards, the design of learning objectives needs to reflect a literacy orientation, and almost all the core literacy frameworks proposed by countries and international organizations are both disciplinary and interdisciplinary[7] . Disciplinary literacy is related to specific disciplines and focuses on deepening the understanding and application of disciplinary knowledge, e.g. "digital learning and innovation" in IT, "mathematical modelling" in mathematics, etc. Interdisciplinary literacy, on the other hand, often encompasses a wide range of disciplines. Interdisciplinary literacy is often multi-faceted, such as 21st century learning skills (critical thinking, creative thinking, communication skills, collaboration skills) and other generic literacy. Interdisciplinary thematic learning emphasizes the collaborative application of knowledge, skills and methods from two or more disciplines to solve authentic problems. In the process, in addition to disciplinary core literacy, students' core 21st century skills are effectively enhanced. Designers of teaching and learning activities need to deeply analyse the creative themes, identify the potential disciplinary core literacy, and at the same time explore the 21st century core literacy, screen the literacy that students will embody in the learning process, and comprehensively promote students' development and enhancement.

3.3. Designing challenging learning activities

Challenging learning activities are closely linked to the creative theme, aiming to implement the literacy-orientated learning objectives, fully mobilize students' interest in learning, help students build up a multi-perspective understanding and awareness of the problem, actively participate in problem-solving practice, and transfer and innovate what they have learnt, so as to promote the development of students' comprehensive competence and core literacy. The first and foremost task

in designing challenging learning activities is to identify the core issues of interdisciplinary thematic learning, then refine the core issues into a hierarchical and logical sequence of problems, and design corresponding challenging activities according to the needs of the problem sequence.

Challenging learning activities are meaningful inquiry based on understanding. In promoting challenging learning tasks, teachers should provide students with appropriate prior knowledge and basic knowledge of the subjects involved, and stimulate students' knowledge and experience to encourage them to carry out independent enquiry and teamwork. Teachers need to pay attention to students' problems and ideas in learning, and provide timely assistance and feedback to promote the development of students' subjectivity. As interdisciplinary thematic learning involves knowledge from two or more disciplines, teachers also need to draw on the strengths of teachers or experts from other disciplines and involve them in the teaching and learning process when guiding students to complete challenging learning tasks. The design and implementation of activities should have the following characteristics: (1) centred on interdisciplinary themes; (2) driven by authentic problems; (3) in line with students' cognitive patterns; and (4) focusing on self-directed enquiry while emphasizing cooperative learning.

3.4. Collaborative development of evaluation indicators

The evaluation of interdisciplinary thematic learning is a rule agreed upon by the members of the Community to analyse and diagnose the performance of students in the learning process and the achievement of learning objectives. Evaluation indicators should correspond to students' learning objectives, run through the whole process of interdisciplinary thematic learning and focus on the development of students' core literacy, which can be divided into three parts of evaluation before, during and after class[8] . Before the lesson, students' prior knowledge, interests and learning characteristics are understood through preview assignments, interviews or questionnaires, which provide a basis for the design of teaching activities; during the lesson, students' behaviour and the effect of knowledge construction are observed, and process evaluation is carried out to provide timely feedback and assistance in adjusting the content and progress of the teaching; after the lesson, evaluation is combined with students' assignments, quizzes and learning summaries, which provide useful information for the design of the next lesson.

3.5. Ongoing evaluation

Providing students with timely and clear feedback on an ongoing basis, based on interdisciplinary thematic learning objectives, is conducive to helping students improve their learning. Evaluation subjects should be diversified, and members of the community, such as students' parents, university experts and social organizations, should be involved. At the same time, the evaluation content should be diversified, using a combination of expressive and summative evaluation. The establishment of evaluation standards generally points to the three dimensions of interdisciplinary learning output: first, "observable manifestation", such as the specific actions of students in the learning process, and second, "concrete learning results", such as problem solving, task completion, experimental reports, presentation of works, creative ideas, and so on. The second is "concrete learning results", such as problem solving, task completion, experimentation, presentation of work, creative design, programme development, etc.; the third is "interaction with others", clear and logical expression of their own views, active questioning, and presentation. The process is more important than the result, don't avoid learning activities that may "fail"[9].

Acknowledgements

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