Curriculum Design Based on Big Ideas: Connotations and Implementation

Lijie Lv

Abstract Human knowledge continues to increase, but the contents of school curricula are limited. In recent years, the national curriculum standards of the United States, Canada and Australia have connected the knowledge system in their curricula by using big ideas. The study of big ideas can be traced back to Bruner's model of teaching. At present, the big ideas used in curriculum design are differentiated in a broad sense and in a narrow sense with different categories and levels, and are of great significance to the development of students' transferable skills. With the "unit" being an important carrier, important elements of big idea-based teaching include the goal of concept understanding, potential learning materials, situation creation, and independent construction.

Keywords National curriculum standard · Curriculum design · Big ideas · Types of knowledge

For more than half a century, the progression of human technology has grown exponentially. In the face of the social changes driven by science and technology, the total amount of knowledge has surged. Meanwhile, the devaluation of stock knowledge has accelerated, while the linear growth of learning cannot keep up with the growth of knowledge. The growth model of learning first and working later no longer exists. Lifelong learning is not only an idea but also a need for survival. Building the foundation for learners' lifelong learning and learning to learn will inevitably become important educational functions of basic education. Therefore, some countries and international education organizations have proposed a framework of core literacy for talents to guide curriculum reforms in primary and secondary schools. Some countries with decentralized education systems have also begun to develop and introduce national curriculum standards, and these governments have intervened in school education and teaching activities. The curriculum is endowed with multiple meanings: "to achieve social equity, improve the quality of education, satisfy personal development and lifelong learning through the formulation of the curriculum. The

L. Lv (✉)
Northeast Normal University, Changchun, China
e-mail: lvlj@nenu.edu.cn

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curriculum has increasingly become an important means for countries to seek national future competitiveness and to improve the adaptability of human beings to economic, social and scientific progress" (Marope, 2018). At the same time, the existing "universal" school curriculum has been criticized and questioned in many countries. Such courses are overwhelming for teachers and students, and more importantly, they are difficult to grasp the core content, which often results in far less productivity. Therefore, during the process of curriculum reform, many countries begin to connect the knowledge system and organize the curriculum contents by using big ideas.

1 The Origin of Constructing a Knowledge System with Big Ideas in the Curriculum

The study of Big Ideas can be traced back to Bruner's discussion of the educational process. He pointed out that no matter what kind of subject the teacher teaches, he or she must make students understand the basic structure of the subject, which will help students solve various problems encountered in and out of the classroom. To grasp the basic structure of something is to understand it in a way that allows many other things to be meaningfully related to it; and to learn this basic structure is to learn how things are related to each other (Bruner, 1960). To put it simply, the curriculum thought of the big ideas is closely related to the formation of people's knowledge.

1.1 Knowledge Is Derived from Human Experience and Is a Tool for Describing and Understanding the World

As a representative of cognitive psychology, Bruner's views are deeply influenced by structuralism philosophy. From his explanation of the source of knowledge, his understanding of the nature of knowledge emerges. He believes that knowledge is a mode constructed by us that makes the regularity in experience embodies meaning and structure; and any idea of organizing a knowledge system is invented by mankind to make the experience more economical and more coherent. For example, the invention of the concept of "force" in physics, the concept of "motivation" in psychology, and the concept of "style" in the literature are all meant to help us to understand. That is, knowledge is not the reflection or simulation of external objective facts, but is created based on the materials from experience. "It is organized as a tool, not as a form of things, not as a true picture of the static world, but as a means of acquiring more knowledge within our existing knowledge to serve us" (Westbury & Wilkof, 2008). Bruner's viewpoint continues the rationalist philosophical tradition of Kant, that completing the transition between the external world and human cognition, and establishing the structure of the seemingly "objective" knowledge. Knowledge is a systematic expression formed by humans who extract laws and meanings from the experience of understanding the world. After Knowledge is a systematic expression formed, it becomes a tool for people to further understand the world. The system of knowledge is the system of human civilization, which can be constructed and developed.

1.2 Education Is the Process of the Individual Transformation of Human Knowledge System

From the perspective of the history of the formation of human knowledge, knowledge comes from experience. For individuals, how does knowledge form, and how does learning generate? In this regard, Ausubel believes that there are two ways of meaningful learning. One is the formation of ideas in childhood, which is acquired by people's direct experience, and a knowledge symbol corresponds to a kind of thing with the same nature. The other is the assimilation of ideas, which is the main way to learn new concepts as we grow. A learner assimilates new information in a situation and explains a new concept with the original cognitive structure. The acquired new concept and new knowledge build a new cognitive structure of the learner, which determines his or her learning of newer knowledge and information. Therefore, "understanding and solving meaningful problems mainly depend on the availability of superordinate ideas and subordinate ideas in learners' cognitive structure" because "people interpret perceptual experience without any processing through some special ideas in their own cognitive structure" (Ausubel, 2018). Ideas in human mind are conditions for the solution of problems and for the understanding of new propositions. School education is a process of individual socialization. Educated people are those who can view the world with human knowledge, and those who can understand and explain phenomena and solve problems with the knowledge already formed by human beings. Learning in school is a process of constructing the knowledge structure and concept system for learners. Therefore, an obvious problem is that in the process of learning, it is very important for teachers to establish connections between new teaching contents and students' existing cognitive structures. In addition, there is an implicit problem of inference, that is, what kind of cognitive structure we intend to establish in students' mind determines what information we should provide and what knowledge we should select for learners.

1.3 Individuals with a High-Quality Knowledge Structure Can Think Like an Expert

What kind of knowledge structure do individuals need to have to better understand the world and solve problems? For this question, much research has been conducted on the cognitive structure of experts. What kind of person is an expert?

It is a person with professional qualities who can deeply and accurately explain different phenomena in nature and human society, and can solve problems based on the human civilization system. Why can experts explain and solve problems? To be sure, experts do not have any special skills. In other words, there is no particular skill that makes experts different from others. What matters is experts' accumulated knowledge and their unique form of knowledge storage. Learning theory holds that the knowledge in experts' minds is clear, relevant and structured. First, experts' knowledge is abundant. It is not isolated or cluttered but is understood, accepted and "put" by experts in an orderly structural framework. This structural framework is independently constructed by experts during the process of learning through understanding new professional knowledge rather than coping from the outside world. Because this structure is clear and orderly, it is easier for experts to select valuable and relevant parts from new information, then incorporate them into their existing cognitive structures, and memorize them long-termly. Second, experts' knowledge structures are highly correlated. In other words, experts are different from novices because not only they accumulate more knowledge but also they can master the relationship between knowledge and knowledge, as well as the relationship amongst knowledge, phenomena, and situations. As a result of mastering these associations, experts have a deeper understanding of the meaning of knowledge. Then, they can understand the situations in which knowledge can be used. When faced with new problems, experts can expertly extract the knowledge related to the specific tasks, that is, the knowledge of experts can be easily acquired, combined and applied. Third, the structured knowledge of experts is "connected and organized around important ideas" (Bransford et al., 2013). In contrast with the novice, this key concept is a more superordinate one. It can incorporate more subordinate ideas to explain more phenomena. With more superordinate ideas, experts can see "patterns, relationships, or differences that are not obvious to novices, and extract the meaning of information which is not obvious" (Bransford et al., 2013). Experts have excellent insight into problems, and thorough understanding of their own field, they can express simply and concisely. When confronting a new problem, experts will think with core ideas or important ideas; that is, they will reorganize knowledge with the core ideas rather than following the original organization of knowledge or applying ready-made formulas or answers.

1.4 The School Curriculum is to Help Students to Build a High-Quality Knowledge Structure

Is it impossible for any course to give students all the knowledge and the important knowledge? What knowledge is important? How do we know what knowledge students will use in their future work and life? Learning theory tells us that the curriculum in education should provide a knowledge framework, which should be a structured and correlated knowledge system, and be organized by important ideas.

Such knowledge structure will benefit students to learn more new knowledge and be facilitating for the extraction, transfer and application of knowledge. Therefore, the curriculum design should pay attention to the establishment of such knowledge frameworks for students. To this end, first, important and key ideas in curriculum content should be established. This key idea is the pivot of the curriculum. For students, this structural pivot is similar to a fixed point or anchor point, on which new information and knowledge in future studies are tied. The process of tying is the process in which the new information and knowledge are connected with the fixed point. The fixed point provides attributions for the new information and new knowledge. Then, they acquire meaning and are incorporated into the original conceptual framework matrix, so the original conceptual framework enhances. Relatively speaking, "since the material acquired by rote learning is not fixed to the existing conceptual system, it is more susceptible to proactive and retroactive interference and thus more likely to be forgotten, unless over reviewing it or it is particularly vivid" (Ausubel, 2018). Second, these important key ideas are correlated. The ideas subordinate to the key ideas and factual knowledge are not necessarily to be large or complete, but the superordinate and subordinate knowledge need to support and relate each other. Moreover, new knowledge needs to be extracted in the situation and have the opportunity to be comprehensively used to solve the problem. Third, he learning of key ideas is an upward spiral. The more stable this fixed point in students' minds is, the more inclusive, general and abstract it is, and the easier it is to provide a solid foundation for new learning. However, it does not mean that teaching requires students to learn general and abstract concepts first. Students still need to learn the concrete one first. The accumulation of concrete and subordinate ideas can be convenient for extracting, abstracting and understanding abstract superordinate ideas. With the spiraling of curriculum content, the understanding of key ideas is deepening and expanding, which requires curriculum designers to present the course in a way from superordinate ideas to subordinate ideas. This will make students gradually form more general, extensive and attributable ideas.

2 The Meaning, Categories, and Levels of the Big Ideas in Curriculum Design

2.1 The Meaning of Big Ideas

The thought of the curriculum design based on big ideas originated from Bruner's theories of pedagogy and psychology. However, it was not until the end of the twentieth century that it began to be systematically elaborated. *Understanding by Design* by Wiggins and McTighe is an early work. Since then, Erickson, Lanning, Clark, Whiteley and other scholars have systematically discussed it. In 2009, a major report, *Principles and Big Ideas of Science Education*, was produced in Scotland at an international seminar on science education in primary and secondary schools (Harlen, 2010). Harlen and other scientists put forward the big ideas system in science education. They emphasized that science education is not a pile of knowledge fragments but a structured and correlated model. This report has pushed forward the reform of the scientific curriculum structure in primary and secondary schools and brought more attention to curriculum design based on big ideas. In approximately the last decade, curriculum standards at the national or provincial (state) level issued by many countries, such as the United States, Canada and Australia, were widely used big ideas as the basic framework of each subject. Based on the views of experts, scholars and some influential curriculum standards in recent years, the author believes that the meaning of big ideas can be discussed in both broad and narrow senses. Big ideas in the broad sense refer to curriculum design guided by the idea of structuring cognition. It refers to the integration of relevant knowledge, principles, skills, activities and other curriculum content elements with core ideas in the basic structure of the subject or several abstract concepts in the core position of the curriculum to form related curriculum content blocks to avoid scattered and complicated content. Big ideas can be followed by smaller ideas or sub-ideas to form a structural content system. Big ideas in the narrow sense also target the purpose of structuring curricula. They are inferential expressions formed by understanding core ideas at different levels, and emphasize students' understanding of the essence of core ideas. That is, first, the big ideas in the narrow sense must be in the system of the core idea. Second, it is an abstraction and extraction of factual knowledge or skill rather than a specific knowledge or skill. Moreover, it is the general meaning behind specific knowledge and an important understanding that students can retain even after they forget most of the details. In addition, it is presented in the form of the description of abstract meaning. For instance, one of the core ideas in the Ontario science curriculum of Grade 3 is system and interaction in the biosystem. Two concepts are closely related to it. One is that plants are a major source of food for humans, and the other is that humans need to protect plants and their habitats (Ontario Curriculum Standards, 2000). Some Chinese scholars believe that big ideas can be discussed at two levels. One is to discuss curriculum at the middle level, such as reconstructing the content system of science education with a number of scientific big ideas. The other is at the micro-level, that is, to study the design of unit teaching or theme teaching with big ideas on the basis of curriculum standards (Cui, 2015).

What is the point of designing a curriculum based on big ideas? Some scholars have discussed the essence of big ideas from the perspective of their function; believing that big ideas have the characteristics of centrality, sustainability, network and transferability (Li & Lv, 2018). Other scholars hold those big ideas are an important way to implement the practice of core competences and values (Shao & Cui, 2017). Big ideas contribute to achieving high-road transfer and are a significant way to cultivate creativity (Liu, 2020). From the perspective of curriculum design, the significance of big ideas lies in changing the tradition that curriculum design tries to cover all knowledge. Students learn a course not to gain general knowledge but to create a lens to see the world, especially in the era of information avalanche, where knowledge is abundant and growing rapidly. The school curriculum is becoming increasingly difficult to carry ever-increasing knowledge, so designing curricula by using big ideas appears to be more valuable. Since we cannot teach all the knowledge to students, we can let the students understand how the human sees the world with wisdom, what is the main idea, and what is the main way of thinking. Of course, this idea and way of thinking, no matter how important, cannot be directly "taught" to students. Big ideas need to be broken down into smaller ideas, which should be directly related to facts and specific problems. Students start learning from the small ideas first and then gradually deepen the core ideas and ways of thinking in terms of viewing the world. There is no need to exhaust the facts and specific problems as long as they are enough to prove small ideas. Also, there is no need to exhaust the small ideas as long as they can sufficiently infer the larger ones. Each time students acquire a big idea at a certain level, it is equivalent to establishing a fixed point (anchor point) in their mind, with which students can build a framework to absorb, focus and process information independently. Another important significance of curriculum design based on big ideas is that big ideas and deep understanding are inseparable. A big idea is not a visible and tangible fact but an abstraction and an inference based on facts and situations. The learning of big ideas also starts with factual knowledge, specific problems or specific situations. Moreover, it is necessary to abstract and infer factual knowledge into general knowledge under the guidance of teachers and understand its essence after seeing the phenomena. Therefore, students can understand more clearly when they return and look at specific facts with general knowledge. As the level of ideas increases, the student will stand higher and see farther and will travel between abstract ideas and facts, in which they can explain and prove each other. Then, on the basis of this deep understanding, ideas can be preserved by lasting memory when factual knowledge is forgotten, because what is preserved in the mind is not a particular fact or event but a relatively general understanding. Therefore, there will be a wider range of applications which can be extracted and applied flexibly when faced with new problems and situations.

2.2 The Categories of Big Ideas

Big ideas are the understandings and views of the world that are to be taught to students, and are transferable understandings based on the learning of subject facts and basic skills. However, what views are valuable? What understandings can be applied to solve problems in the future? Due to the different characteristics of disciplines or the different concerns of designers, curriculum designers have different ideas about big ideas in different countries or different courses in the same country. Thus, titles of big ideas are various. The American Science Curriculum Standards have refined 13 discipline core ideas and several crosscutting concepts. The Australian Science Curriculum has put forward a number of key ideas and regards humanities and social curriculum as concepts of disciplinary think, such as meaning, continuity, change, rights and responsibilities. There are also those who call them big ideas directly. For instance, big ideas are expressed with phrases such as "the movement of objects depends on its nature" in the curriculum of language and science in British Columbia, Canada. The Ontario Science Curriculum encompasses not only fundamental concepts, such as matters, energies, systems and interactions, structure and function, but also big ideas, such as "plants are a basic source of food for humans". There is also someone who calls them enduring understandings. As the American Art Curriculum Standard refers to dance as a kind of experience, all personal experience, knowledge and background should be integrated to explain the meaning of dance. Therefore, it is necessary to clarify the new progress of knowledge classification to sort out the categories of big ideas.

2.2.1 Anderson's Classification of Knowledge

The history of studying the types of knowledge in psychology, philosophy and pedagogy is long. There are procedural knowledge, declarative knowledge, contextual knowledge, conditional knowledge, strategic knowledge and tacit knowledge. The value of the classification of knowledge is to analyze the characteristics of learning content in order to grasp the way and path of learners' learning process and clarify the nature of learning. The types of knowledge established by Anderson et al. in the revision of Bloom's Taxonomy of Educational Objectives in 2001 have had a great influence on curriculum research and curriculum reform in recent years. On the basis of the types of knowledge and the levels of cognition, Anderson et al. classified educational objectives in the cognitive domain. In the dimension of the types of knowledge, knowledge was classified into four types: factual knowledge, conceptual knowledge, procedural knowledge, and metacognitive knowledge. At the cognitive level, the cognitive process is divided into six levels from low to high; they are memorizing, understanding, practice, analysis, evaluation and creation. These four types of knowledge and six levels of cognitive process constitute 24 objective units. This work is a supplement and revision to Bloom's Taxonomy. It should be noted that Anderson distinguished between factual knowledge and conceptual knowledge. According to Anderson et al., factual knowledge means discrete, isolated information, while conceptual knowledge refers to more complex, organized knowledge (Anderson, 2008). He also viewed that conceptual knowledge combined with deep understanding can help individuals transfer what they have learned to new situations. That is why Anderson's knowledge classifications are important to curriculum reform. In an era that pays much attention to the development of students' quality, the international community is thinking about how to cultivate innovation ability and transfer ability through education. Anderson undoubtedly answered from the perspective of knowledge formation.

2.2.2 Different Categories of Ideas in Curriculum Design

The *Next Generation Science Standards* (NGSS) issued in 2013 are supposed to be a good way to present different types of knowledge. It describes the curriculum content and proposes the performance requirements with four types of knowledge. They are the discipline core idea, science and engineering practices, crosscutting concepts and knowledge about the nature of science. The Organization for Economic Co-opera (OECD) Learning Framework 2030 designs the curriculum content system, which can support the formation of competences, including knowledge, skills, attitudes and values. Knowledge is also constituted by disciplinary knowledge, crosscutting knowledge, procedural knowledge and epistemic knowledge. The categories of ideas in these two curriculum frameworks are very similar to Anderson's knowledge classification. Thus, we try to classify the big ideas in the various curriculum standards into the following four types.

The first is the discipline core idea. The discipline core idea in NGSS is the main axis of the curriculum content, which is composed of 13 core ideas and 44 sub ideas extracted from the four disciplines of Physical Sciences, Life Sciences, Earth and Space Sciences, and Engineering, Technology and the Applications of Science. The construction of the system of ideas in curriculum is the most common in science and mathematics, which is the key node established in the traditional knowledge system. The system of big ideas in science constructed by Harlan and other scientists has also established core knowledge nodes and put forward the 10 most refined ideas in the way of meaning description, such as all matter in the universe is composed of very small particles (Harlan, 2016). These core ideas can aggregate concrete, basic factual knowledge, information and skills to form an interrelated, hierarchical content system that can be learned.

The second is the crosscutting concept. The crosscutting concept is more of an idea than a concept. It is a more abstract general view of nature and society formed after a certain amount of learning; and it is the synthesis, connection and re-abstraction of discipline core ideas in different disciplines and study sections. The patterns, cause and effect, scale, system and system models, structure and function, stability and change in the NGSS model, and the core ideas, such as pattern, order and organization, form and function, stability and change in Australian Science Curriculum, as well as the fundamental concepts in the Ontario Science Curriculum, such as structure and function, sustainability and management, change and continuity, are all crosscutting concepts. The learning of crosscutting concepts needs to be understood after accumulating the discipline core ideas in different grades and courses. On the other hand, if students can repeatedly use the crosscutting concepts when they understand the discipline core ideas in the exploration and experience of factual knowledge, they will also enhance the deep understanding of these discipline core ideas. Through the learning of crosscutting concepts, students can establish connections amongst disciplines without barriers and understand the complexity and integrity of the world. It helps students apply what they learned in one situation to another. Moreover, crosscutting concepts can also assist teachers in designing a meta-disciplinary learning theme to promote project-based learning.

The third is the concept of thinking and skills. They are ideas about the way of thinking and the exploration of skills with procedural knowledge as the core. In different curriculum standards, the expressions of the concept of thinking and skills are very different. Someone regards them as a core clue of curriculum content. For example, the art curriculum standard in the United States classifies art into nine parts, such as dance, media art and music. Each part is composed of four ideas: connection process, creation process, expression process and reaction process (State Education Agency Directors of Arts Education, 2018). Someone views them as another set of idea systems that students need to learn in parallel with the discipline core ideas. The science and engineering practices in the NGSS of the United States contain two idea systems with different emphases: scientific methods and engineering thinking. There are also some national curriculum standards that take the concept of thinking and skills as competence objectives or quality objectives. For instance, scientific curriculum literacy in British Columbia includes problems and predictions, planning and implementation, process and data analysis, and evaluation, application and innovation.

The fourth is the concept related to the nature of different disciplines. Knowledge about the nature of discipline, also known as epistemic knowledge, is knowledge of the nature and function of the discipline itself. This kind of knowledge is specifically mentioned in the NGSS and OECD curriculum framework. Knowledge about the nature of discipline in NGSS includes knowledge of science, the process of scientific inquiry, and the understanding of science careers, such as scientific knowledge assumes order and coherency in the natural system, and science is a kind of human activity. This kind of knowledge needs to be supported by two dimensions: science and engineering practices, and crosscutting concepts. The OECD refers knowledge about the nature of the discipline to cognitive knowledge, that is, how to think like an expert and act like a practitioner (OECD, 2018). The content includes what I have learned in these disciplines and why, how this knowledge serves my life, how experts think about these professional questions, and what ethical standards scientists, writers, and artists will take. Therefore, knowledge about the nature of discipline helps students to understand the value and purpose of the learning content. It also enables students to use the content with a clear goal, and think about how knowledge can be applied to improve the well-being of human life from ethical and moral perspectives.

On the one hand, curriculum design based on big ideas with various types of knowledge breaks out of complicated isolated knowledge, such as facts, information and specific skills. It constructs the overall structure of the curriculum content. On the other hand, it inspires teachers that the discipline core content can be used and extended. Extending does not mean increasing the coverage of the content or increasing the degree of difficulty but adds perspectives of the problems in order to improve the understanding of them. Therefore, through the learning of the discipline core content, students can not only understand the meaning of the discipline knowledge, form a more macro world view, cultivate the way of thinking and train inquiry method, but also develop the ethical attitude of the discipline. The curriculum framework constructed by big ideas with various types of knowledge substantially connects the curriculum content with multi-dimensional objectives.

2.2.3 The Levels of Big Ideas

Erickson et al. classified ideas into five levels. First is the thematic facts. The second is the concept. Compared with facts, concepts are universal. They are abstracted from examples and facts and expressed with one or two words or phrases. The third is generalization, which is the sentence describing the relationship between two or more concepts. The fourth is the principle. Like generalizations, principles are expressions of conceptual relationships but are more stable, such as Newton's laws and mathematical axioms. The fifth is theory. It is an inference, or a set of conceptual ideas that explain phenomena or practices. Erickson believes that there is no need to distinguish between generalizations and principles in curriculum design because they are both expressions of conceptual relations and belong to big ideas (Erickson & Lanning, 2018). In fact, the classification of levels of ideas proposed by Erickson describes what big ideas are. They are not specific facts but the generalization of the fact and the expression of relations and meanings. However, from the perspective of designing a course throughout the curriculum, the levels of big ideas must be related to its level in the framework of the discipline system. This means that different levels in the discipline structure are naturally different levels of the big ideas. In addition, the crosscutting concept in curriculum design is not only a type of big idea but also a level of big ideas. Big ideas at this level are more abstract and more macro and are gradually acquired through the accumulation of learning.

Are the high-level crosscutting big ideas appropriate for organizing curriculum content? Organizing the curriculum content by using high-level crosscutting big ideas can break the original boundaries between disciplines. Also, it takes some macro ideas as the core clue of the curriculum system to contain factual knowledge and other contents. Taking the science curriculum in Singapore as an example, the theme of model includes models such as the cell model and the matter model. The theme of systems includes biological transport systems, human digestive systems, human reproductive systems, and electrical systems. In contrast, fewer science curriculum standards adopt this way of content organization. Most of them construct the framework by using the disciplinary core ideas that are abstracted from disciplinary facts. In curriculum design, should the macro high-level big ideas be presented as a hidden clue of the system of the discipline core ideas, or should they be directly used to organize the curriculum content? "Some curriculum designs use macro ideas to organize the discipline content… While the problem is that almost everything can fit any big ideas" (Erickson & Lanning, 2018). The macro high-level crosscutting big ideas can indeed break the original boundaries between disciplines, but it may also make the newly established concept system separate away from situational facts and common sense. Then do big ideas fit into organizing content? In fact, there is no definite answer to whether or not the curriculum should break the original boundaries between disciplines. Rather, it depends on the requirement of the curriculum on the systematicity of the corresponding discipline, the possibility of the curriculum capacity, and the degree to which the learning of macro ideas depends on the factual knowledge of the discipline.

To be more precise, multidisciplinary ideas and high-level crosscutting big ideas have become a kind of thought, a way of thinking, and a profound expression of human wisdom. Therefore, the macro high-level big ideas are closer to the goal.

For instance, the crosscutting concepts in Australia are known as the key ideas or concepts of disciplinary thinking. It can be seen systematically in many curriculum designs, such as math, science, humanities and social science. It is similar to the subject key competences proposed in the curriculum standards in high schools in China.

3 The Key Points of the Implementation of the Curriculum Design Based on Big Ideas

The curriculum design based on big ideas emphasizes the structure of the curriculum and deep understanding of the problems. How to implement such curriculum design and how to arrange classroom teaching can be considered from the following five key points.

3.1 Carriers of Big Units

Every big idea contains truth, a meaning, or a connection. When teachers guide students to learn big ideas, there must be a premise that big ideas are in the teaching system, or in other words, the teaching system provides a carrier for the learning of big ideas. A unit is the best teaching carrier that responds to the thinking of structured curriculum design. Units that carry the big ideas come in three forms: explicit, semi-implicit, and implicit. Explicit means that the discipline core ideas are clearly extracted from the curriculum standards and placed in the pivot of the curriculum system. Then, the compilation of textbooks will design the units based on this. Teachers relying on the units in the textbooks will naturally lead students to understand the big ideas. Semi-implicit refers to the fact that there is no explicit core idea used to design content blocks in curriculum standards or textbooks, so teachers need to adjust part of the content in textbooks and carry out secondary curriculum development. There must be one or a few big ideas in the big units developed by teachers, and the big ideas can be different types of knowledge. Implicit represents the situation that some big ideas will spiral or splice in different grades, different academic sections or even between different disciplines. Such units also require teachers to develop them into virtual units and then purposefully guide students to gradually understand the big ideas in different time periods or courses.

3.2 The Goal of Deep Understanding

The teaching of concept understanding requires factual knowledge because the understanding of concepts needs to be refined on the basis of factual knowledge. The key is whether or not there is a consciousness of this refinement after mastering the factual knowledge; and whether or not there is an intention to design and teach for understanding when designing the learning method of factual knowledge. Erickson and Lanning proposed three-dimensional teaching objectives, which are to distinguish what students must know at the factual level, what they must understand at the conceptual level, and what they can do through cultivate strategies and skills (Erickson & Lanning, 2018). For teachers, the greatest confusion is what students should know and what they should understand. Therefore, teachers should first examine the factual content by general and deep understanding from a high level of the nature of the discipline. Then, in the teaching process, teachers can lead students to learn from factual knowledge to general understanding.

3.3 Potential Learning Materials

Whether or not the teaching content contributes to achieving the curriculum goal of deep understanding depends on if the learning materials can establish a connection with the specified conceptual framework and the fixed point and if they can provide facts, information, and activity design for the understanding of big ideas. Some researchers regard this performance of curriculum materials as curriculum potential. The reason why it is potentially is that "teachers' daily experience tends to narrow their horizons about the potentials of curriculum materials. Teachers are accustomed to believing in obvious explanations of teaching materials, especially those they are already familiar with" (Ben-Peretz, 1975). Designers of teaching materials or other learning materials should have a clear awareness of the big ideas. Although the material does not cover all the disciplinary content, it is highly closely related to the core pivot of the discipline and the fixed point expected to be established in students' minds, and it is distinctive material that can extract meanings. Such learning materials are conducive to achieving goals, and are with potential. However, meanings cannot be expressed directly in textbooks or other learning materials. Therefore, teachers need to dig it out, that is, to determine the understandable and explainable possibilities contained in the materials and present them in teaching.

3.4 Confrontation Between Situation and Experience

The creation of a teaching situation should imply the basic elements of new knowledge and be related to students' experience. The way to connect learners with knowledge is to directly confront individual ideas with objects, experiences, or other learners' existing ideas (Giordan, 2015). The process of confrontation is the process of deconstruction of the original idea, which is also the process of receiving new knowledge. Situations offer learners the conditions under which knowledge is produced. Different situations or complex situations can provide a deeper understanding of the conditions under which knowledge is produced. However, the situation alone is not enough. Teachers are also supposed to guide learners to abstract the essential features of ideas in the situation, then transfer the trivial and isolated information to general ideas, and store them in the conceptual framework. Such knowledge is more conducive to being extracted and flexibly applied to solve problems.

3.5 Guided Independent Construction

Teaching based on big ideas focuses on students' understanding and acquisition of the core general ideas, and it must be learner-centered teaching. It is essential to help students find the connections between the old and new knowledge, broaden their horizons, discover and understand new knowledge, and be able to transfer and understand across time, culture and situation. Teaching based on big ideas must emphasize the independent construction of students as well as the guidance of teachers. In regard to meaningful learning, Ausubel states that "rote learning doesn't have to be passive, discovery learning can also be mechanical in nature" (Ausubel, 2018). Meaningful learning may occur not only in the discovery method but also in the lecture method. The key is to provide cases and present detailed facts in the process of teaching so that students can clarify the relationship between knowledge and then guide the transition of concepts. Similarly, the discovery method also needs to monitor the process of students' concept transition; otherwise, the inquiry activity may not be a learning process but a lively scene that may not lead to valuable growth.

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