

# The Application of the 5E Instructional Model in Chinese Basic Education

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**Abstract:** The 5E instructional framework is a pedagogical approach that consists of five distinct phases, namely engagement, exploration, explanation, elaboration, and evaluation, which together form a comprehensive learning cycle. Each stage denotes a crucial instructional process. The objective of the model is to facilitate the development of a robust knowledge base among students through their active engagement. This paper provides an overview of the historical development of the 5E Model and evaluates its application in the context of Chinese elementary education. The aim is to offer valuable insights into this educational strategy for teachers in the Chinese basic education system.

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**T**HE 5E instructional model, also referred to as the 5E Model, was formulated by the Biological Sciences Curriculum Study (BSCS) in 1987. The 5Es represent a sequential framework for instructional design and learning that encompasses five distinct phases: engagement, exploration, explanation, elaboration, and evaluation. The teaching methodology in question is based on the principles of constructivism, a learning philosophy that highlights the active participation of students in constructing their own knowledge (Wang & Li, 2012). According to Bybee et al. (2006), BSCS conducted an empirical investigation that revealed that the 5E Model surpasses conventional teaching models in terms of stimulating students' curiosity towards learning and enhancing their academic performance. The phenomenon has garnered significant acknowledgement from educational communities worldwide. Currently, with the ongoing curricular reform in China, inquiry-based learning has emerged as a fundamental principle in the new national curriculum program and course standards. The 5E Model, a successful inquiry-based methodology, has been extensively tested in the context of basic education in China. The present study conducted a comprehensive review of the historical development of the 5E Model and provided an overview of its practical and theoretical implications for front-line educational practitioners in Chinese basic education.

## **Background of the 5E Instructional Model**

The 5E instructional model can be traced back to the Atkin-Karplus learning cycle, which was proposed by Myron Atkin and Robert Karplus in the early 1960s, when Karplus presided over the "Science Curriculum Improvement Study" (SCIS) project as part of the second round of primary science education curriculum reform. Atkin and Karplus argued that a successful learning cycle should consist of three stages: exploration, invention, and discovery. Students acquire new knowledge through relatively unstructured exploration experiences. Following the phase of exploration, the phase of invention allows for the interpretation of newly acquired information through the reorganization of prior concepts. In the discovery phase, the new concept is applied to a novel situation. After Lawson et al. modified the terminology in the 1980s, the three terms became exploration, term introduction, and concept application. Despite variations in terminology, the conceptual basis of the learning cycle has remained largely unchanged (Bybee, 2006).

Midway through the 1980s, BSCS developed a new science and health curriculum for primary schools and recognized the value of students' prior knowledge and the evaluation of the concept-construction process. As a result, the engagement and evaluation stages were added to the Atkin-Karplus learning cycle (Bybee, 2006). The engagement stage of the 5E Model learning cycle is when the teacher pre-assesses the students' prior

knowledge, and the evaluation stage is where the students' learning results are examined. Exploration, explanation, and elaboration, the middle three components of the 5E Model, are essentially the same as the three stages of the Atkin-Karplus learning cycle. The 5E Model, which has its roots in constructivist theory and is closely related to the traits of student cognitive development, was a key component of the new curriculum at BSCS. It broadens the use of an effective teaching strategy that can be used in a curriculum, a particular course, or a particular lesson (Wu & Zhang, 2010).

Early in the 21st century, transnational collaboration, the labor market, and living environments became more complex. In response to the challenges of the 21st century, the U.S. academic community advocated the development of "21st century skills" as additional reform requirements. The research of Bybee (2009) suggested that the 5E instructional model could positively influence the development of 21st century skills in students by fostering their competencies in adaptation, communication, problem-solving, and self-regulation, among others.

The National Academies of Sciences, Engineering, and Medicine of the United States issued the Next Generation Science Standards (NGSS) in 2013 to satisfy the demands of economic development and increase the competitiveness of American education. Its introduction marked a turning point in U.S. science education. The Next Generation Science Standards emphasize that learning is a developmental and exploratory process and that instruction should incorporate three dimensions: disciplinary fundamental ideas, science and engineering practices, and crosscutting concepts. NGSS strongly recommends that teachers integrate the 5E Model into classroom instruction by tactfully designing science and engineering practical activities to promote the development of student competence through science education (Liu, 2014). In the years that followed, the 5E Model has been implemented by teachers across the globe in their teaching designs of various disciplines, such as chemistry (Yadigaroglu & Demircioglu, 2012), physics (Ergin, 2012), biology (Sickel & Friedrichsen, 2015), and nursing (Jun et al., 2013), in an effort to promote meaningful learning in students and the attainment of educational objectives.

Since the introduction of the 5E Model to China at the beginning of the 21st century, Chinese educational researchers have endeavored not only to disseminate the theory and methodology of this instructional model but also to implement it in teaching practices. Research on the application of the 5E Model was conducted at all levels of education in China, from primary to higher education. The preponderance of existing research has focused on its application to basic education classroom instruction.

Ma's (2002) article entitled "*The 5E Instructional Model in American BSCS Textbooks*" represents the inaugural theoretical investigation of the 5E Model in China. The article offers an interpretation of the theoretical under-

pinnings and implementation procedures of this pedagogical approach. Yuan (2004) provided a comprehensive account of the functions of the five stages in the 5E Model and demonstrated the application of this model to classroom instruction through the analysis of the section “Decomposition and Utilization of Organic Substances: Respiration.” Dai and Yao (2008) provided an in-depth analysis of the Atkin-Karplus learning cycle’s three stages. They utilized the teaching of “photosynthesis” in junior secondary biology as a case study and put forth practical recommendations for the implementation of the learning cycle model. In their study, Wu and Zhang (2010) expounded on the fundamental constituents and utilization of the 5E Model in the context of instructing “Functions of Respiration” in secondary-level biology. They also provided a summary of the model’s crucial attributes. The connotations of the 5E Model were analyzed by Wang and Li (2012), who emphasized its implications for science education in China. They recommended utilizing the model to its fullest potential in prior knowledge assessment, exploratory ability cultivation, and science concept construction.

The rapid curriculum reform over the past few years has made the 5E Model research in China more discipline-focused, highlighting its importance in lesson planning. Deng and Liu (2011) integrated teaching strategies such as situation creation, role-playing, and group discussion or cooperation with the 5E Model in the biology classrooms to teach students how to reject underage drinking. Their hands-on investigation demonstrated that 5E education was successful in attaining its teaching goals. In their respective lessons on “Cell Differentiation,” “Observational Experiment of Stomata,” and “DNA Replication,” Fu and Yang (2014), Luo (2015), and Tao (2017) used the 5E Model to identify students’ prior knowledge, design inquiry activities to promote the transformation of preconceptions, and help students comprehend and construct new concepts. In order to encourage student science thinking in geography education, Wang et al. (2019) used the methods of the 5E instruction to design the simulative experiment of river topography. This gave students the chance to investigate the effects of river erosion and river-related accumulation on topographic development.

## **Basic Components of the 5E Model and Their Application in Chinese Basic Education**

### ***Engagement***

In the 5E learning cycle, the engagement stage’s goal is to establish contexts for students to become personally invested in the lesson while simultaneously pre-evaluating their knowledge of the topic at hand. As opposed to scientific notions, prior concepts are also referred to as premature concepts.

Due to the limitations of the students' prior knowledge, these conceptions are generally based on the students' past experiences rather than the facts of the matter. Learning activities at this stage should aim to clarify students' misunderstandings, arouse their curiosity and cognitive conflicts, and establish links between prior and current learning experiences.

Chinese teachers in basic education demonstrate a notable understanding of generating stimulating contexts to elicit students' interest in learning during the engagement phase when implementing the 5E instructional framework. Kong (2012) conducted a study on the implementation of the 5E learning cycle in senior secondary chemistry education. During the engagement stage, students were presented with a current event of significant interest and were prompted to identify chemistry-related topics and generate inquiries. In the engagement stage of a junior secondary mathematics lesson, Yuan (2022) utilized a scenario from the classical novel *The Journey to the West* as a context for exploration. The author posed pertinent questions to guide students in identifying the variables in the subject and to stimulate their curiosity regarding the relationships between the variables. This approach effectively increased the students' engagement in the lesson. The utilization of contextualization in the implementation of the 5E Model during classroom instruction can effectively stimulate students' engagement in the subject matter, as observed in Chinese teaching practices. Nonetheless, their failure to demonstrate an awareness of the potential for revealing students' preconceived notions and inciting cognitive dissonance among them was evident. It is noteworthy that the identification of students' pre-existing misconceptions and the subsequent creation of cognitive disequilibrium are fundamental components of the learning process. This approach serves as an effective strategy to facilitate proactive learning and promote a comprehensive understanding of scientific concepts among students.

## ***Exploration***

Inquiry-based activities are created to give students the chance to take part in studies or experiments during the exploration period. They give students plenty of time for contemplation and imagination with the inclusion of both individual and group exploratory activities. In the exploration phase, the teacher's function is that of a coach or facilitator. It is imperative to conduct experiments using real-world materials and situations. Students begin the basic process of creating scientifically accurate notions by establishing relationships, observing patterns, and questioning events because of their mental and physical involvement in the activity.

In the majority of case studies of 5E instruction conducted by Chinese researchers, the exploration stage is used to formally introduce the concepts, processes, and skills and to guide students in conducting exploratory

experiments. During the exploration stage of the “Combustion and Fire Extinguishing” case study, for instance, the teacher provided a definition of combustion prior to the students’ experimentation and then instructed them to conduct experiments according to the textbook’s design and his additional explanations (Wu & Liu, 2012). In Yan’s (2022) investigation of a physics lesson, the teacher posed a series of questions as the framework for cooperative student experiments, thereby guiding the students’ exploration. Therefore, during the exploration phase of the 5E model, Chinese students must follow their teachers’ instructions on how to conduct their research, and there is no opportunity for students to conduct independent experiments. Or classroom inquiry devolves into the routine execution of experiments outlined in textbooks. These are not genuinely autonomous exploration activities in which students have no idea of the purpose of their experiments and no expectation of making new discoveries. The essence of the exploration stage is to encourage students to actively pursue solutions to the cognitive conflicts that arose during the engagement stage. The purpose of the current stage’s inquiry activities is to cultivate students’ interests in scientific explorations and help them comprehend the exploratory process from query to evidence to conclusion.

## ***Explanation***

The explanation stage serves the purpose of affording students a platform to articulate their comprehension of the subject matter hitherto assimilated and to decipher its significance. Initially, students are prompted to engage in discourse and provide their own interpretations. Subsequently, the teacher presents scientific justifications in a clear and structured manner. The explanations provided by both students and teachers serve as a mechanism for organizing the exploratory experiences. The primary objective of this phase is to effectively communicate concepts, processes, or skills in a concise and straightforward manner and subsequently proceed to the subsequent stage.

The explanation stage is most frequently used by teachers in Chinese 5E instruction scenarios to help students identify incorrect conceptions or immature perceptual knowledge and to establish scientific notions. To show the generality of new concepts, teachers explain specific situations using new notions. Based on the students’ experiences in the exploration stage, the teacher described pertinent phenomena and concepts in the lesson study “Combustion and Fire Extinguishing” and summarized the conditions for combustion (Wu & Liu, 2012). In the example study of a physics lecture by Xiong (2012), the teacher provided more precise explanations of events and improved definitions based on close readings of ideas from the explanation stage. But as the 5E Model is used more frequently, it becomes clear that, in order to get an appropriate answer, teachers’ explanations have received far

too much attention while students' opinions have gone unnoticed. Many teachers made an effort to enhance the explanation stage so that student communication would take center stage. In more recent trials, the teacher gave students more chances to demonstrate their own understandings and even encouraged them to repeat experiments to ensure the accuracy of their understandings (Guan, 2021; Yan, 2022). Teachers should probe further, revise students' explanations, and assist learners in making sense of unfamiliar ideas.

## ***Elaboration***

In the elaboration stage, students develop previously taught ideas, link them to other ideas that are similar, and use their newly acquired knowledge in novel ways. During this stage, teachers might give students the chance to participate in additional activities that elaborate or extend the concepts, procedures, or abilities and make it easier for them to apply those ideas in new contexts.

During the elaboration stage, Chinese teachers primarily emphasize providing students with opportunities to apply their acquired knowledge and facilitating the cultivation of a more profound comprehension. Frequently, teachers provide students with supplementary extension activities or present a set of novel inquiries to solidify their comprehension prior to assessment. During the elaboration phase of his physics course, Guan (2021) instructed his students to apply their recently acquired knowledge to analyze topics such as “forces acting on railway tracks” and “vehicles traversing an arched or concave bridge.” Fu and Chen (2022) instructed their chemistry students to utilize their understanding of the “surface tension of liquids” to elucidate the fundamental principles that govern the construction of bottle openings for essential balm. By means of these instructional practices, teachers directed their students to apply novel concepts or competencies to tackle problems or elucidate phenomena in novel scenarios, thereby enabling them to acknowledge the anticipatory and explanatory potential of fresh concepts in diverse contexts.

## ***Evaluation***

The evaluation stage serves the purpose of enabling students to engage in self-evaluation of the extent to which learning and comprehension have been achieved. The process is continuous and diagnostic in nature, enabling the teacher to assess whether the students have met their learning goals. According to the 5E Model, the process of evaluation and assessment can take place at any stage of the learning process and can be integrated throughout all four preceding stages. Teachers could assess students' comprehension and im-

plementation of novel ideas, as well as shifts in their affective dispositions, through both formal and informal evaluation techniques. During this interim period, teachers can also avail themselves of opportunities to assess their own pedagogical practices.

Most Chinese teachers can actively participate in evaluating both the learning process and the learning results of their students throughout the evaluation stage. No matter what responses students provide in the initial lesson period, the teacher typically exerts favorable assessments initially to ensure that their motivation to learn is not destroyed and then guides them to modify their responses through other approaches. The teacher evaluated the students' learning process and learning outcomes in the lesson study on "Combustion and Fire Extinguishing" using both qualitative and quantitative methods (Wu & Liu, 2012). In some instances, the teacher includes the students' peer and self-evaluations in addition to their own ratings. For instance, Cao (2022) used appropriate software in her physics class to include information technology into evaluation. She included digital self- and peer-assessment to help students review new material and provided feedback on students' responses via the teacher's online evaluation.

## **Conclusion**

As research into the 5E instructional model becomes more in-depth, voices have been raised about its limitations, and other models, including the 6E, 7E, and 4E x 2 models, have been adapted from it. The 7E instructional model was proposed by adding the elicitation stage before the engagement stage of the 5E model and inserting the extension stage between the elaboration stage and the evaluation stage to emphasize the significance of exposing students to their prior knowledge and transferring new information (Eisenkraft, 2003). Some researchers argued that students are not sufficiently involved in the explanation phase and, as a result, proposed inserting the expression phase between the explanation and elaboration phases so that each student has the opportunity to demonstrate their learning gains and correct any misconceptions formed in the previous phases. Teachers can use formative assessment in the expression stage to determine whether or not students have attained learning objectives and to assess their teaching effectiveness. This is the origin of the 6E model (Duran et al., 2011). In addition, attempts have been made to incorporate formative assessment, inquiry learning, and metacognition theories into the 5E instructional model in order to develop the 4Ex2 Model, in which assessment and reflection are implemented on all phases of engagement, exploration, explanation, and elaboration. The 4Ex2 Model is intended to assist teachers in focusing on formative assessment and designing exploratory activities of a higher order (Marshall, 2009).

A close examination of the 5E model and its variations, however, reveals that it is a framework that is comparatively comprehensive and already includes the components that the 6E, 7E, and 4Ex2 models assert to supplement. A link analogous to the expression stage that the 6E model adds is present in a regular 5E model. It happens at the explanation stage of the 5E model, where both the teacher's explanations and the students' expression of ideas are prioritized. Similar to the elicitation and extension processes proposed by the 7E Model, the 5E Model's engagement stage entails exposing students' preconceptions and existing knowledge structures through concrete situations, and the elaboration stage also includes the extension of new knowledge. The 5E Model's evaluation stage is broken down into the 4Ex2 Model's assessment and reflection phases, which are then incorporated into each of the preceding four processes. In actuality, the evaluation step of the 5E Model gives equal weight to both teaching and learning reflections as well as assessments of the learning process and outcomes.

Despite all efforts to modify it, the 5E instructional model continues to be a classic and essential teaching method with irreplaceable theoretical and practical value in basic education. First, it can arouse students' curiosity for learning and encourage their active participation. Second, through inquiry-based learning, students acquire a deeper understanding of the material, thereby enhancing their learning outcomes. Third, the 5E Model can effectively cultivate innovative thinking and practical skills in students. It is anticipated that the 5E learning cycle will have greater application potential in basic education classroom instruction. In addition, it is important to note that when implementing the model, the actual learning situation and student characteristics must be taken into account, and teachers must possess the necessary teaching skills and experience to maximize the role of this learning cycle in student development.

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