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A Literature Review on Learning Progression

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Abstract: ***This article discusses the significance and value of learning progression in contemporary education by explaining its origins and development process. First, it analyzes the definition of learning progression to lay the foundation for the overall construction of learning progression theory. Next, it explores theoretical research on learning progression, followed by an analysis of research on learning progression in the fields of science education and mathematics education. In conclusion, it derives the significance of researching learning progression.***

Keywords: Learning Progression, Literature Review, Mathematics Education.

1. Introduction

Since the 1980s, with the increasing demands on the quality of science education, science education reform has become a hot topic in the field of education in many countries. How to effectively organize science education content, describe the thinking paths of different students, and establish consistency between education, curriculum, and evaluation has become the focus of educators. As science education reform has gradually progressed, the concept of learning progression has begun to take shape, but at this stage, a formal definition of learning progression has not yet been proposed. In 2004, Smith [1] formally defined the concept of learning progression as “a description of the gradually deepening ways of thinking that learners develop through learning centered on specific themes.” This definition immediately garnered significant attention within the education community. However, even before this, educational reforms in various countries had already begun to incorporate the educational philosophy of learning progression. The concept of learning progression had already begun to emerge in the cognitive development theory of Piaget and Vygotsky’s “zone of proximal development” theory, and Bruner’s spiral teaching method [2]. Brown and Campione’s “developmental corridor” and Carpenter and Lehrer’s “cognitively guided instruction” also incorporate the educational philosophy of learning progression [3]. Driver’s “conceptual progression” and “conceptual trajectory” proposed in *Students’ Conceptions and the Learning of Science* also contain the rudiments of learning progression development [4]. The National Research Council (NRC,) further officially defined the concept of learning progression as “the gradual deepening and refined thinking over a period of time.” In 2007, the NRC explicitly highlighted the critical role of learning progression in developing coherent subject-specific curricula in *Taking Science to School: Learning and Teaching science in Grades K-8* [5].

2. The Conception of Learning Progression

Learning progression, as a descriptive approach to mapping students’ learning trajectories, has been studied by different scholars from various perspectives and using diverse methods. This has led to a proliferation of conceptual definitions of learning progression since its inception.

The National Research Council (NRC) defines learning progression as a continuous and hierarchical description of the development of students’ thinking as they progress from lower-order to higher-order thinking when learning a particular subject within a certain period of time [5]. Duncan [6] proposes that learning progression provides support for achieving consistency among curriculum, instruction, and assessment in the field of science education. Learning progression is a hypothesis, a learning conjecture model that requires continuous revision based on experience. The model development process and validation process are intertwined, emphasizing the integration of scientific concepts and practice. Learning progression focuses on foundational and generative disciplinary ideas and learning practices, with the “high anchor” representing the desired learning outcome and the “low anchor” representing the student’s current achievement level. Learning progression divides the space between the “low anchor” and the “high anchor” into several progression levels, providing theoretical support for targeted instruction.

Roseman [7] proposed that learning progression is a logical sequence of concepts that aligns with students’ developmental patterns. Salinas [8] defined learning progression as “a description of the process by which learners’ thinking patterns and understanding of knowledge gradually evolve from simple to complex, gradually forming higher-order thinking.” Songer [9] argues that learning progression is a process aimed at promoting the development of more complex thinking patterns and enhancing investigative reasoning abilities among learners, encompassing multiple course units and spanning a longer timeframe focused on a specific theme. Corcoran [10] proposes that learning progression is a testable hypothesis based on empirical research. These hypotheses explore how students’ understanding and application of core concepts, as well as the scientific practices associated with them, evolve and become more complex over time, and describe the pathways students may follow in mastering core concepts. Alonzo [11] notes that learning progression is categorized based on the nature of students’ thinking rather than a logical analysis of content, describing the differences in students’ thinking patterns regarding a particular topic, and learning progression does not follow specific progression patterns. Alonzo and Zhai Xiaoming [12] pointed out that learning progression focuses on how students think, using quantitative methods to describe students’ thinking patterns, and that there are multiple possible progression paths.

3. Approaches and Research Methods of Learning Progression

Salinas [8] categorized learning progression into two research approaches based on differences in the construction of learning progression and the presentation of its characteristics: the Escalated Approach and the Landscape Approach. The Escalated Approach is grounded in cognitive science and pedagogy, centering on the understanding of core concepts. It describes the linear developmental process by which students progress from lower-order to higher-order thinking over an extended timeframe. It divides learning progression into several intermediate levels based on expected student performance, establishes assessment tools, and facilitates teaching and learning evaluation. The Landscape Approach is rooted in curriculum theory and pedagogy, ensuring the coherent development of core concepts through conceptual statements. It describes, observing related phenomena, and mastering related methods and knowledge, it forms a networked structural system of interconnected relationships across different domains. The endpoint of the networked system structure points to the advanced endpoint, aiding in curriculum design [13].

Duschl [14] proposed two paradigms for learning progression research: validation learning progressions and evolutionary learning progressions. Validation LPs are a top-down research model that starts from standards and uses assessment results to validate and revise the progression framework; evolutionary LPs are a bottom-up research model that centers on scientific activities, identifies key variables in teaching, and then forms scientific concepts. Based on the above classification of learning progression research, most current research on learning progression falls under the comprehensive research paradigm, which incorporates characteristics of both research models [15].

Yao Jianxin [15] proposed that learning progression research follows an evidence-driven paradigm, where progression research may undergo several cycles: starting from the identification of key competencies of core concepts, formulating progression hypotheses, selecting measurement models, developing research tools, and revising progression hypotheses. If progression cycles are to be undergone, the endpoint of the first progression stage becomes the starting point of the next progression stage.

4. Applied Research on Learning Progression

Since the concept of learning progression was first introduced, it has sparked significant research interest among scholars worldwide. Initially, research on learning progression was primarily focused on science education, but it has since expanded to encompass various fields. Scholars abroad have conducted research on learning progression across multiple disciplines, including physics, chemistry, and biology, with studies in mathematics education also gaining widespread attention.

4.1 Theoretical Research on Learning Progression

Some scholars have conducted research and discussions on the characteristics of learning progression itself, as well as its theoretical and practical significance. Jin [16] analyzed literature on learning progression and concluded that learning progression serves as a bridge between curriculum, assessment, and instruction, focusing on three dimensions of continuity: the developmental continuity of students transitioning from concrete to abstract thinking; the horizontal continuity between curriculum, teaching, and assessment; and the longitudinal continuity between classroom and large-scale assessment. They have proposed reasonable suggestions for the application of learning progression in subsequent research on cross-thematic and cross-disciplinary learning, how teachers can intervene in teaching and professional development, and the connection between classroom assessment and large-scale assessment. Shepard [17] discussed the value of learning progression in teaching and learning, providing a theoretical foundation for teaching and learning assessment. Gotwals [18] explored the relationship between learning progression and formative assessment, highlighting that learning progression offers teachers a supportive tool to understand students' thoughts, extracting key information from students' current learning status for application in subsequent teaching. This helps teachers shift from "diagnostic correction" to "cognitive intervention" reflected in learning pathways, thereby more effectively promoting the rigor and flexibility of teaching. Scott [19] explains the meaning of learning progression and how to apply research findings on learning progression to guide teaching practice. Using the carbon cycle as an example, he illustrates how learning progression describes the maturation process of students' thinking during learning on a specific topic and provides instructional guidance for subsequent teaching.

Since its introduction into China's educational field, the concept of learning progression has garnered significant attention from Chinese scholars. Domestic researchers have conducted localized interpretations of the concept, engaging in rational analysis and discussion regarding its characteristics, applications, and educational value. Zhai Xiaoming [20] pointed out that learning progression focuses on how students think, using quantitative methods to describe students' thinking patterns, with multiple possible progression paths. Yao Jianxin [15] explained the relationship between learning progression and curriculum development, emphasizing that teaching based on learning progression aligns with students' cognitive development pathways, with teaching playing a crucial role in the construction of learning progression. Guo Yuying [21] proposed the concepts of integration and development, arguing that science education should not impart fragmented knowledge to students. Learning progression provides theoretical guidance for learning around core concepts, and science teaching design based on learning progression helps promote the coherent development of students' scientific core literacy. Wei Silin and Jia Yu'e [3] explored learning progression role in science education from two aspects: establishing consistency between curriculum, teaching, and evaluation, and integrating theoretical research with practical implementation. Zhou Gaixiao [22] systematically explains learning progression and its implications for China's education from three aspects: the origin of learning progression, the construction and validation of learning progression, and the application of learning progression. Huangfu Qian [23] analyzed the definition of learning progression, arguing that it is based on disciplinary integration, centered on core concepts, grounded in empirical research, and emphasizes diversity of pathways. Using the "carbon cycle" as an example, she elaborated on the core elements of learning progression and analyzed its research framework. Xiao Dan [24] explores teacher learning progression from the perspective of teachers, focusing on enhancing teaching quality. She proposes that teacher growth is a systematic process of continuous development of high-level practical competencies. Teacher learning progression advocates the philosophy of "learning for teaching," encouraging teachers to become learners themselves, and outlines pathways to enhance and improve teacher professional development.

4.2 Empirical Research on Learning Progression

4.2.1 Research on Learning Progression in Science Education

Numerous scholars in the field of science education have conducted empirical research. Alonzo and Steedle [11] investigated the construction of a learning progression model for "force and motion" in physics education, developing an assessment tool for the "force and motion" theme by comparing the differences between multiple-choice questions (MCQs) and open-ended questions (OEs). Lee and Liu [25] analyzed the learning progression levels of middle school students in physics, biology, geography, and discussed the prototype of learning progression research based on the analysis of empirical research results. Todd, Romine and Cook [26] studied the application of learning progression in high school biology, established a learning progression model in the context of the "genetics" theme, and validated and applied the model. Duncan [27] took students in grades 5-10 as the research subjects, examining learning progression in modern genetics from three aspects: core concepts of modern genetics; students' learning progression levels across different grades; and measurement tools for students' learning progression levels. Wyner [28] created a three-dimensional plant evolution course to measure students' understanding before, during, and after using the course over two implementation cycles. Pierson [29] conducted a semester-long design study targeting eighth-grade students to address the challenge of coordinating the overall course path with each student's learning path in modeling learning progression. The study explored conceptual and representational contexts aimed at supporting complex modeling practices and ideas, revising the modeling learning progression model proposed by Schwartz et al. to enhancing its practicality and general applicability. Gunckel [30] found through empirical research that the use of curriculum materials based on learning progression led to moderate improvements in teachers' subject knowledge, pedagogical knowledge, and understanding of student thinking.

4.2.2 Research on Learning Progression in Mathematics Education

Many scholars have applied learning progression to the field of mathematics education, conducting research on learning progression in mathematics education. Bai [31] used the GDINA model from the cognitive diagnostic model with 1624 Chinese junior high school students as subjects to explore the learning progression of probability in junior high school students. The results showed that the probability thinking level of junior high school students is steadily improving, validating the psychometric reliability of the measurement tools and the feasibility of using the cognitive diagnostic model to explore students' probability learning progression levels. Fonger [32] proposed a learning progression theory focused on students' cognitive development, providing a form of curriculum research that connects students' understanding, instructional structure, and evaluation systems in mathematics education, and based on empirical research, he used the concept of mathematical equivalence as an example to explore the progression of algebraic thinking among students in grades 3–5. Chen [33] used the cognitive diagnostic model and rule space model to explore the progression of number sense learning among elementary school students, with 1207 Chinese elementary school students as the research subjects. He used observational projects to verify the progression levels of number sense learning among students in grades 3, 4, and 5, validating the rationality and feasibility of applying the cognitive diagnostic model to construct a model of progression in number sense learning. Blanton [34] conducted empirical research to explore children's early algebraic thinking progression through their understanding of functional relationships. Barrett [35] studied the development of strategic and conceptual knowledge in linear measurement among second and third-grade students, clarifying the developmental progression patterns of students in linear length measurement and providing guidance for measurement-themed instruction. Clements [36] discussed children's understanding of the composition process of geometric shapes from ages 3 to 7 based on empirical research, developed a learning progression model and assessment tools, and provided theoretical guidance for promoting children's geometric cognitive development.

He Shengqing and Gong Zikun [37] focused their research on children aged 6–14 to promote the development of children's "probability literacy" and mathematical literacy. They used the Rasch model to analyze the progression of probability concept learning. Children's probability concept learning begins with randomness as the starting point, progresses through fuzzy cognition, quantification, and random distribution, and ultimately can be expressed as fractions. The children's learning process was divided into six levels, and based on this, guidance and suggestions were provided for classroom design. Gong Zikun and others [38] focused on elementary school students, using "proportion problems" as an example, one of the main themes in elementary school mathematics. They categorized different progression levels based on "qualitative reasoning" and "quantitative reasoning," identified progression variables, and constructed a progression model for proportion reasoning learning. They adjusted the progression levels based on questionnaire data, refined the model, and provided a good example for constructing progression models. Li Huxia [39] explored a progression model for elementary school students' statistical thinking, understanding the trajectory of students' cognitive development, providing a theoretical basis for the development of statistical thinking, and offering a new perspective on revealing the patterns of students' cognitive development. Liu Bing [40] used "isosceles triangles" as an example to promote deep learning among students, constructing a learning progression model under this theme and analyzing students' levels and performance.

5. Conclusion

Since the concept of learning progression was introduced in the field of science education at the beginning of the 21st century, it has become a hot topic among educational researchers and frontline educators, providing new research approaches and perspectives for educational research. Learning progression focuses on students' cognitive development, describing the cognitive development paths of students when learning specific topics through observable behaviors, and then analyzing students' thinking development paths, progression characteristics, and progression challenges, thereby providing systematic theoretical support for educational practice.

In the field of science education, current research on learning progression primarily focuses on natural sciences such as physics and biology. This research revolves around constructing learning progression models based on core concepts, describing students' thinking trajectories, integrating classroom teaching, and adjusting evaluation methods. Currently, research on learning progression in science education has closely integrated theory and practice. First, theory guides practice, and second, practical experience is fed back into learning progression theory, thereby continuously improving learning progression research. Learning progression research has gradually expanded from the field of science education to other fields. In the field of mathematics education, learning progression research has also developed in depth due to the widespread attention of mathematics educators, and has been widely applied in various branches of mathematics, primarily including the construction of learning progression models around mathematical core concepts, the development and use of measurement tools, and covering areas such as numbers and algebra, geometry and geometry, and statistics and probability. Learning progression serves as an effective means to characterize students' cognitive development pathways and promote their cognitive growth, playing a significant role in optimizing teaching processes and enhancing teaching efficiency. It assists teachers in understanding students' cognitive development characteristics and the challenges of cognitive progression, thereby strengthening the targeting and effectiveness of instruction. Learning progression research still holds substantial research value. Future studies should further expand the scope of learning progression research and deepen its depth, not only broadening the research domains horizontally but also further delving into the research layers vertically.

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