Advances, Insights, and Future Trends of Research on Learning progression in mathematics: A Perspective

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Abstract: The paper provides a comprehensive and in-depth analysis of the study of learning progression in the field of mathematics. Through combing and analyzing the relevant literature at home and abroad, the paper summarizes the importance and current situation of learning progression in the field of mathematics education. Learning progression refers to the process of deepening and expanding students' understanding and mastery of knowledge in the learning process. Research on learning progression in mathematics focuses on conceptual understanding and skill mastery, providing guidance for instruction by analyzing elements such as learners' thinking patterns, problem-solving abilities, and conceptual understanding. Meanwhile, learning progression also provides an effective tool for assessing students' learning progress and understanding. Based on the literature review, the dissertation also explores the implications of current research on learning progression for mathematics education and future research questions. In conclusion, the dissertation provides a systematic review of learning progression in mathematics, which provides important references and insights for further in-depth research.

Keywords: Learning progression; Mathematics.

1. Introduction

The study of the progression of learning has its roots in U.S. education reform. In 2006, the National Research Council[1] published Bringing Science to School: Learning and Teaching in Kindergarten through Grade 8, which pointed out that the U.S. elementary and middle school science curricula lacked a comprehensive curriculum. School: Learning and Teaching in Kindergarten through Grade 8, which pointed out that the U.S. elementary and middle school science curricula lacked depth and called for educators to propose a framework for the progression of learning that would be more effective and more efficient.

The following will summarize and analyze the progress, educational revelation, and future trend of learning progression research in mathematics from The following will summarize and analyze the progress, educational revelation, and future trend of learning progression research in mathematics from the definition of learning progression.

2. Theoretical framework for progression of learning in the field of mathematicson

Smith[2] considers a progression of learning (where students think about a concept in a series of successive, more integrated ways) to be better connected to concepts that students will encounter in future learning. In fact, there is a concept in the field of mathematics education that is similar to the concept of "learning progression", i.e., "Learning Trajectories" (LTs). "(LTs). Simon[3] first used Hypothetical Learning Trajectory to refer to a teacher's prediction of the possible paths of student learning, and to describe the "paths of learning" that students take as they move from a starting point to a desired learning goal. "the path by which learning might occur." The path of the trip is your "hypothetical trajectory", which is a characteristic of anticipatory tendency. The path you travel is your "trajectory", and the path you expect to take at any given point in time is your "hypothetical trajectory".

According to Confrey et al.[4] , a learning trajectory is "a researcher-suggested, empirically based description of the ordered network that students experience through instruction (i.e., activities, tasks, tools, forms of interaction, and methods of assessment, etc.) in order to make a gradual transition from informal ideas, through a continuum of expression and reflection, to more and more complex concepts. " Maloney & Confrey (2001)[5] suggest that LTs represent a progression of cognitive power that, while not necessarily linear, is not random. The trajectories depict ordered expected trends that have been developed through empirical research designed to identify the highly probable steps that students follow in developing initial mathematical ideas into formal concepts, recognizing that each student's path is unique.

3. Key Findings and Conclusions of the Learning Progression in the Area of Mathematics

Reviewing from an international perspective, it can be assumed that research on learning progression in mathematics education is in its initial stage. Generally speaking, there are two main types of research on learning progression in mathematics education: first, basic research on learning progression, which mainly refers to the use of empirical methods to establish a learning progression that describes the in-depth development of students' cognition on a certain mathematics learning topic; and second, applied research on learning progression in the fields of mathematics curricula, teaching, and assessment.

Lam Chit-Min has studied the learning progression of factors and multiples in elementary school math clocks[6], he systematically sorted out the relevant contents about factors and multiples in the mathematics curriculum outline and textbooks, clarified the main learning objectives of the content, and then decomposed the learning progression of factors and multiples into 3 dimensions, namely, division, factors, and multiples, and identified 3 developmental variables on the basis of this.

In recent years, scholars have carried out a lot of useful research on the concepts related to "function". Xu Na[7] takes "primary function" as the core concept, establishes a learning progression model based on the theory of APOS, the teaching requirements of functions in the compulsory education curriculum standard and the contents of three versions of textbooks, and on the basis of which the hypothetical model of the learning progression of primary function is verified and revised through test questions. The specific performance of students' learning progression in learning the primary function

Meanwhile, the research results on learning progression in "fraction" and "probability" are also fruitful. Chen Xiaoyan took "probability" as the core concept, and constructed a learning progression model from four dimensions, such as understanding the problem and the object, the arrangement of probability content text， and the students' cognitive knowledge in the compulsory and elective phases, and then tested, examined and corrected the model by using the Rasch assessment tool, and finally put forward teaching strategies in the aspects of curriculum arrangement and teachers' teaching. Finally, teaching strategies are proposed in terms of curriculum organization and teachers' teaching.

Song Yuyang[8] takes "Graphics and Geometry" as an example, establishes the criteria for determining whether a concept is a core concept through the difference between concepts of different levels, identifies 12 core concepts and 5 hierarchical structures between concepts, and studies the teaching of "core concepts" in depth from the perspective of "learning progression". The teaching of "core concepts" is studied in depth from the perspective of "learning progression". After combing through, it can be found that current research in the field of mathematics on the theory of learning progression has been more fruitful in the Algebra, Graphics and Geometry, and Probability segments.

4. Implications of Learning Progression Research for Mathematics Education

4.1 Setting Clear Teaching and Learning Objectives in Terms of Learning Progression

Students are expected to undergo conceptual shifts during the learning process. Before a student learns a concept, there must be a certain cognitive foundation, which may have correct or incorrect notions. This requires further understanding on the part of the teacher, and if there are misconceptions, they need to be corrected.

4.2 Design the Teaching and Learning Process Based on the Learning Progression Framework to Break through Barriers to Progression

Learning progression reflects the process of change in the thinking level of students when they learn a core concept. Teachers need to reflect on and constantly sort out the key points, difficulties, and error-prone points of conceptual teaching, so as to further refine the teaching process, set up a reasonable problem situation, ask questions scientifically and effectively, and transform the basic concepts into basic questions to deepen students' understanding of the concepts.

4.3 Apply Learning Progression Theory to Teaching and Learning Evaluation and Implement Dynamic Management

Apply the learning progression theory to teaching evaluation, use the learning progression theory in the evaluation after the implemen-

tation of the classroom, to find out the strengths and weaknesses of the lesson, which will attract the attention of students and teachers, so as to enhance the effectiveness of teaching. As teachers in the new era, they need to have some control over the cognitive trajectory of students' learning, so as to promote students' cognitive progression.

5. Future Directions for Research

5.1 Pedagogical Research on Promoting Students' Progression in Mathematics Learning

While current research has discussed students' level of mathematical thinking primarily from an assessment perspective, how to facilitate students' progression in regular math instruction is an issue that is rarely addressed. Teaching and learning in all areas of mathematics is a larger and more specific issue, and to do so, we must consider what kind of mathematics curriculum should be provided to students and how mathematics instruction should be evaluated.

5.2 Constructing Norms and Standards for Assessing Students' Mathematical Ability

Although a lot of work has been done in the current study, it is a systematic project that requires large samples, repeated expert consultation, questionnaire surveys and student tests, and even more in-depth thinking and making original designs. There are still some problems that need further in-depth thinking and research, such as the reliability and validity of the compiled survey tools need to be improved, the sample size taken in the survey is not large and the area is not wide enough, and the repeated validation is not enough.

5.3 Intelligent Assisted Teaching and Personalized Learning

Through intelligent technology, learning resources can be personalized, learning effects can be assessed, and learning problems can be diagnosed, thus providing learners with more accurate learning guidance and support. Learning progression research in the field of mathematics can make use of these technological means to tailor personalized learning paths and teaching strategies for students according to their different characteristics and needs, so as to improve the learning effect.

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