Integration of AI Technology and ZPD: Pinpointing the Zone of Student Development to Promote Educational Innovation and Efficiency Improvement

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Abstract. In the era of rapid technological advancement, AI has profoundly penetrated various sectors of society, including education. This paper explores the positive impact of AI on students' Zone of Proximal Development (ZPD), aiming to assist teachers in making more accurate judgments regarding multiple students' ZPDs and thereby enhancing educational teaching. The findings reveal that AI technology, through its application in ZPD, can provide personalized learning resources and assistance to students, as well as offer teachers appropriate teaching content and strategies tailored to students' needs. However, in the actual teaching process, the application of ZPD to teaching still faces difficulties related to students' individualization, sensitive emotions, and trust crises. Based on this, this paper puts forward the following suggestions. Teachers need to be actively trained in AI to overcome potential resistance from older educators. At the same time, teachers should focus on identifying further technological advances in ZPD and related areas to maximize the benefits of AI in education.

Keywords: AI assistance, ZPD, personalized learning.

1. Introduction

With the rapid progress of science and technology, artificial intelligence (AI) technology has penetrated all areas of society, and the field of education is no exception. In this era of information explosion, how to efficiently deliver knowledge and accurately locate students' needs has become an urgent problem for educators. The theory of "Zone of Proximal Development" (ZPD) reveals the potential areas of immature, but soon-to-be-mature, mental function development of each student in the learning process. This theory provides a new perspective for education that education is not only the instillation of knowledge but also the process of students' self-development and potential exploration.

However, in actual teaching, it is not easy to accurately determine the ZPD of each student. Individual differences in students, diversity of learning styles, and limitations in teaching resources often make it challenging for teachers to determine students' ZPD. At this time, the introduction of AI technology provides a new possibility to solve this problem technology, with its powerful data processing capability, learning analysis capability, and intelligent recommendation capability, can help students and teachers identify ZPD more accurately and provide more precise guidance for teaching.

The purpose of this paper is to explore the combination of AI technology and ZPD theory in the field of education, analyze the feasibility and advantages of AI technology in teaching, and discuss in depth the important role and difficulties of ZPD in teaching. At the same time, this paper will also explore how to use AI technology to solve the difficulty of teachers' difficulty in accurately judging students' ZPD, promote the development of education, and improve teaching efficiency. Through theoretical analysis and empirical research, this paper will provide educators with a new way of thinking and methodology to provide strong support for the innovation and development of education.

2. Feasibility and Advantages of AI in Teaching and Learning

2.1. Feasibility of AI in Teaching and Learning

AI is a class of intelligence that is demonstrated by machines rather than by humans, which is usually referred to as machines that can perform cognitive functions, such as problem-solving and learning, in ways that are relevant to the human mind [1]. AI can respond and make decisions differently depending on different environments. With continuous research, AI has become widely available in all areas of people's lives.

Technologically, AI has been better utilized as an active aid in education.AI applications have three main categories in education: personal tutors, collaborative learning, and virtual reality [1]. In the education industry, in the environment of many students and few teachers, and each student has a variety of data, AI is well adapted to the environment of the education industry through the algorithms to obtain powerful storage and analysis capabilities to record and provide timely feedback at any time. For example, in language teaching, AI can effectively achieve hierarchical teaching and personalized teaching through its functions [2]. Chinese graded reading platforms "Koala Reading", "Lemon Reading" and "Strange Reading" software combined with linguistics, psychology, and AI algorithms to realize the construction of knowledge maps of Chinese graded reading. The software combines linguistics, psychology, and AI algorithms to realize the construction of Chinese-graded reading knowledge maps and provide appropriate reading materials for students with different reading levels by quantifying the difficulty of reading. At the same time, AI provides readers with diversified reading paths, generating videos and audio to meet the readers' demands for reading in various aspects and increase their interest in reading. Finally, AI provides timely reading feedback reports to pinpoint readers' interests and reading levels. As more and more of these AIs appear in the market, there are more and more possibilities for the use of AI in the education industry.

2.2. Advantages of AI-Assisted Teaching

Nowadays, the use of AI in the classroom is considered helpful for both teachers and students, and AI has a very positive assistive effect on teaching.

For students, AI can enhance their self-confidence and efficiency in learning and help their understanding, thus providing students with a good personalized learning experience. According to Harry Barton Essel's interviews with students in the experimental group in the ChatGPT teaching experiment, many students believe that through the ChatGPT AI assistance, they can enhance their self-confidence, which comes from the fact that the AI enhances their understanding of the applicability of the sampling method and the real-world use, and at the same time, gives them personalized guidance, thus enabling them to enhance their self-confidence and efficiency [3]. They can also be given personalized guidance so that they can learn at their own pace. In summary, it can be seen that the effectiveness of AI-assisted teaching is recognized by students, and the use of AI to assist students in education is seen as feasible and efficient by students.

For teachers, AI can improve the efficiency and quality of teaching. According to Xiaoyang Shu's experiment, students participate in AI in the process of post-course assessment, i.e., through online self-assessment of assignments, and give the generated data to the teacher as a reference [4]. By referring to the assessment data, teachers can further understand the students' deficiencies, give personalized tutoring, and adjust the teaching plan. For another, the experiment found that the machine focused on assessing objective content, including grammar, syntax, and vocabulary, while the teacher focused on assessing more complex and subjective content, including grammar, syntax, and vocabulary. complex and subjective content, including line layout, argumentation style, and rhetorical structure. This means that the assessment methods of teachers and AI can complement each other, in other words, the assessment methods of AI can become another important supplement for teachers to assess the level of students, and to improve the evaluation system of students in teaching.

In summary, AI-assisted teaching has many advantages, but how to expand this advantage, and make full use of AI technology, so that it can assist teaching to a greater extent and improve the quality of teaching? This paper argues that the combination of AI and ZPD may be a better path.

3. The Concept and Implications of ZPD

3.1. The Concept of the Zone of Proximal Development

The zone of proximal development is an important theory developed by Vygotsky. The theory overcomes the limitations of the assumptions of its predecessors. For example, the more extreme theoretical assumption is that development is independent of learning and that development is equivalent to learning. Based on the theory that developmental theorists such as Koffka and Gestalt believed that learning and development do not coincide, i.e., that development is a larger set than learning, it explores two issues in greater detail. First, the general relationship between learning and development. Second, the specific manifestations of that relationship in the child's learning process.

The definition of Zone of proximal development is the zone between the actual zone delineated by the range of an individual's ability to solve problems independently and the zone delineated by the range of an individual's ability to solve problems cooperatively or under the guidance of others, i.e. the level of potential development [5].

ZPD is associated with students' problem-solving ability as shown in the figure below (Fig.1): The innermost zone, The Actual Zone, refers to the learner's ability to solve problems independently, in learning that indicates that the student has mastered the concepts and can apply them independently. The middle zone, the Zone of Proximal Development, is the distance between a learner's potential level of development when solving problems independently and when solving problems under adult guidance or in collaboration with more capable peers. The outermost zone is the level that the learner would not be able to reach even if provided with the help described above [6].

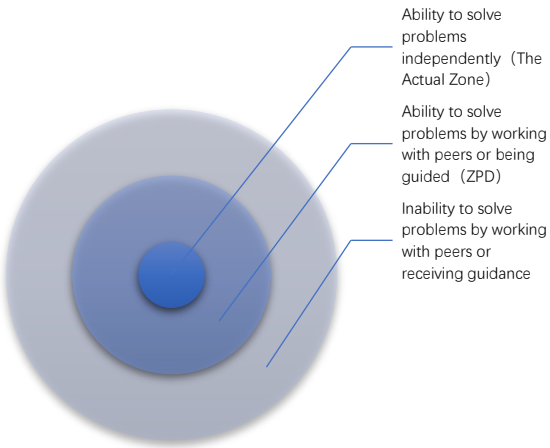

Figure 1. Meaning of Each District of ZPD.

3.2. The Difficulties Encountered by the Zone of Proximal Development (ZPD) in Actual Teaching

Although ZPD plays a very important role in guiding children's teaching, the process of forming ZPD is difficult in the actual teaching process. According to Svanhild Breive's experimental study, when working with peers to co-create the ZPD, the ZPD will easily be on the verge of collapse [7]. This is because, in the process of cooperation with peers, firstly, each person needs to be responsible for interpreting his/her own chosen strategy, i.e. to be brave enough to take risks in the process of implementation of that strategy. Secondly, both parties need to trust and rely on each other to react and act positively on each other's proposals. Only when the above two conditions are realized simultaneously can the ZPD be promoted to expand outward and be formed. In the process of

formation, if the strategy chosen is faulty, it may lead to the failure of the activity, which in turn further aggravates the collapse of the ZPD.

Therefore, the practice of listening and accepting others' opinions, and the practice of taking the risk of failure, are key to co-create ZPD. What the teacher has to do is to protect this ZPD from collapsing in the process of formation, which requires the teacher to make certain interventions in the process of ZPD formation. One of them is to develop students' ability to listen well and accept the opinions of others. This is an essential element in the formation of ZPD in group work. Secondly, by reducing the risk of failure as mentioned above, the teacher can make the students more confident about the activity and the feasibility of their proposal. Instead of discussing the first point in this paper, this paper will focus on the second point: risk prevention and control, which allows students to achieve better expectations by reducing useless costs.

What the teacher can do is to formulate a model that is closer to the students' real ZPD, and based on that, propose a difficulty that the students will work together to solve, so that the solution to that difficulty is realistic. One of the difficulties is that it is difficult to define the exact ZPD for a particular student, let alone the ZPD for all students in a large class of 30 or 40 students.

Additionally, the teacher can monitor the direction of the student's proposal to prevent the proposal from running too far off course and failing to solve the problem. This reduces the cost of forming ZPD for students and raises their self-confidence to some extent. For example, when practicing geometric proofs in math, a student may arrive at an incorrect inference based on observing a geometric figure and believing that a particular inference is correct by default, e.g., by defaulting that the angle is a right angle, which leads to subsequent processes being based on this irrational proposal, which is costly and ineffective. The teacher can inform the student of what the error is by monitoring in advance, before the subsequent invalid reasoning that takes a huge amount of time, so that the student can find an alternative angle and think differently. One of the difficulties is that it is very difficult for a teacher to monitor a class of students ahead of time, and one of the very likely scenarios is that a student who has already paid a huge cost of time to complete the puzzle based on an incorrect inference finds the teacher and realizes that the approach was wrong from the beginning.

4. Possibilities and Paths for Integrating Artificial Intelligence with ZPD

4.1. Possibilities, Trends, and Difficulties in Integration

To solve the above dilemmas to achieve the effect of risk prevention and control, the introduction of AI is a good way.

For the first challenge, through the above-mentioned features of AI, including its powerful data storage, data processing ability, etc., AI can collect the following information: students' existing knowledge level, various feedback information, including students' self-feedback, teachers' evaluation, and peers' comments [8]. Next, AI can analyze the relevance of such information in detail, i.e., fully compare the internal feedback with the external feedback to establish a better understanding of the feedback information. Based on this, the AI can help the student to set challenging goals that are closely related to the feedback, i.e., to set an action plan that highly overlaps with the range of ZPD competencies within the student's reach. As the plan is completed, the AI can continue to gather information to further refine and fine-tune the feedback model. The formation of a feedback model for multiple students within a class allows the teacher to achieve a relatively accurate delineation of the ZPD of 30 to 40 students so that the teacher can assign students topics that match their ZPD zones and provide personalized instruction.

For the second problem, AI can also for students to form the ZPD process proposed solution direction for real-time monitoring, to give some timely advice and corrections, and reduce the cost of students making mistakes.

4.2. Recommendations and Visions for the Integration

4.2.1. Integration of teachers with AI technology

With the adoption of AI technology in education, teachers, especially veteran teachers, are commonly faced with technological unfamiliarity and resistance. This stems from fear of new technology, reliance on old methods, and concerns about potential risks. However, AI technology brings not only tool changes but also innovations in educational concepts and methods. Therefore, it is crucial to strengthen teacher training. It is recommended that the education sector organize regular AI technology training, schools set up study groups, and establish consulting services and feedback mechanisms to support teachers' smooth integration into AI teaching.

In addition, in the process of classroom teaching, teachers can use AI to help in the design of lesson plans, the allocation of learning tasks based on ZPD, and the design of teaching objectives [9]. Firstly, they can collect the learning background and prior knowledge of students or learning groups; secondly, they can reasonably combine that knowledge with the learning tasks of the lesson to achieve the teaching objectives in the best way; thirdly, they can allow students to be assigned to learning groups that are complementary to their abilities to expand the potential zone.

4.2.2. Directions of AI technology in recognizing ZPD

Currently, the use of AI technology to recognize students' ZPD is still in the development stage. However, with technological advances, such as deep learning and natural language processing, it is expected to recognize students' ZPD more accurately and provide precise guidance for teaching. At the same time, there is a need to pay attention to potential issues such as privacy protection, technology reliability, and student dependence to ensure the healthy development of the technology.

AI technology can promote the diversification and standardization of teaching evaluation, thereby facilitating educational progress [10]. Through the big data model therein, AI can embed evaluation into the teaching process and conduct a comprehensive evaluation of students by adding teaching evaluation indicators, such as students' knowledge comprehension, application practice, and innovation migration, to achieve a system that integrates evaluation, teaching, and learning. Further research may be needed for the quantification and scripting of the above evaluation criteria.

5. Conclusion

In the thesis, the combination of AI technology and ZPD theory in the field of education is discussed in depth, and the feasibility and significant advantages of AI technology in teaching are demonstrated. Through detailed analysis, the core role of ZPD in teaching is recognized, i.e., it can accurately locate the learning potential and development direction of students and provide personalized guidance for teaching. However, it is clear that in actual teaching, it is often difficult for teachers to accurately judge students' ZPD, which has become an urgent problem.

The introduction of AI technology provides new ideas and methods to solve this difficulty. By intelligently analyzing students' learning data, behavioral patterns, and feedback, AI technology can more accurately assess students' ZPD and provide personalized learning resources and teaching strategies accordingly. This not only helps to stimulate students' learning potential but also improves the relevance and efficiency of teaching, thus promoting the development of education.

Although there are still some challenges and limitations in the application of AI technology in the field of education, such as data privacy, technical reliability, and other issues, these issues are expected to be gradually resolved with the continuous progress and innovation of technology. The combination of AI technology and ZPD theory will play a more important role in the field of education, bringing teachers and students a more high-quality and efficient teaching experience.

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