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Teaching Quality Evaluation based on Student's Zone of Proximal Development (ZPD) Prediction

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Abstract: The evaluation of teaching quality for university professors is a topic of common concern in the current reform of higher education evaluation. In light of the issues such as the lack of objective and scientific quantification in the majority of current university evaluations, as well as the significant manpower and time costs involved, a new approach for evaluating the teaching quality of university professors based on the students' Zone of Proximal Development (ZPD) is proposed. Firstly, the multidimensional data of university students are analyzed to identify the key factors related to the performance of a specific course. Machine learning algorithms are then used to predict the students' ZPD for that course. Secondly, by considering the difference between the predicted ZPD and the actual ZPD, taking into account the students' initial potential and their educational achievements, a more scientific evaluation of the professors' impact is conducted. The extent to which professors help students reach and surpass their ZPD, as well as expand their own potential, is measured to assess the teaching quality. By establishing an evaluation mechanism centered on the Contribution Index based on ZPD improvement, the predicted growth of students' ZPD is combined with their actual growth, quantifying the impact of professors' teaching quality in a meaningful way. This provides a more reliable and valid method for evaluating the teaching quality of university professors.

Keywords: Zone of Proximal Development (ZPD); Prediction; Teaching Quality Evaluation; Machine Learning Algorithm; Big Data.

1. Introduction

As China places great emphasis on undergraduate teaching and talent development, the Ministry of Education's Assessment Center has established a comprehensive undergraduate teaching assessment system that centers around self-assessment, institutional evaluation, professional accreditation assessment, international assessment, and regular teaching monitoring [1]. Universities, therefore, have developed an internal teaching assessment system composed of student evaluations of teaching, teacher self-assessment, peer review, and managerial evaluation, and have established relevant policies to assess teaching quality.

The methods of university teaching quality assessment primarily involve subjective evaluations by students and teaching peers. Student-centered evaluations are based on the principle that students are the main beneficiaries of teaching. However, there is growing skepticism about the credibility of student evaluations. The key issue is that student performance is multifaceted, with complex and inconsistent evaluation indicators. Moreover, relying solely on grades cannot fully reflect the diversity of teaching or the strategies that teachers may be forced to adopt. Peer review is considered more reliable due to its professionalism [2], but it is resource-intensive and inefficient, and is typically used only as a supplementary assessment method.

Both methods exhibit subjectivity, relying on human-designed surveys, without objective data analysis of the teaching process and outcomes. This shortcoming is partly due to the weak data analysis capabilities of most institutions, which cannot integrate educational data in a timely manner, and assessments often focus only on the roles of teachers and students, rarely considering the holistic perspective of student development. Overall, the current university teaching assessments lack objectivity and require substantial human and time resources.

Assessing the quality of teacher instruction is an important issue in the field of education. It plays a significant role in improving educational quality, optimizing the allocation of teaching resources, and cultivating high-quality students.

In the digital and information technology era, schools have accumulated a large amount of student data, including academic records, ongoing assessment scores, and behavioral information, opening possibilities for data-driven development area predictions. Predictions can help educators identify and intervene in student learning problems early on. Schools can allocate teaching resources more effectively and devise solutions to improve teaching strategies [3]. By correlating development area predictions with actual contributions to growth, teachers can understand the issues in their teaching and thereby adjust the curriculum, optimize teaching plans, improve teaching effects, and enhance teaching quality. The evaluation results can provide direction for professional development, helping teachers to improve their teaching skills and promote career development. Schools and educational administration departments can use the evaluation results to strengthen teacher training, improve teacher performance appraisals, and refine decision-making bases [4]. Organization of the Text

2. Research Foundation

2.1. The Connotation and Current Research Status of the Zone of Proximal Development Theory

The Zone of Proximal Development (ZPD) theory, proposed by the former Soviet educator and psychologist Lev Vygotsky, has become a core concept in modern educational theory and practice, providing us with an easily understandable and unique framework for learning and

development. Vygotsky believed that learning and development are social processes, where the development of students is influenced not only by their prior knowledge but also by their interaction with experienced guides in their environment. The core theory is that each student has their unique potential for learning [5]. He posited that each student has two levels in their developmental process: the actual development level and the potential development level. The actual development level describes the student's ability to complete tasks independently, the current level at which they can handle problems alone, while the potential development level describes the capabilities and developmental level that students might reach with appropriate support and assistance from experienced instructors such as teachers. The ZPD represents the gap between these two levels, signifying the potential learning and development that students can currently achieve with the assistance of relevant interactants [6].

Vygotsky pointed out that learning and development possess a social cooperative nature, meaning that the relationship between the teacher's instruction and the student's development is very close; that is, teaching achieves development, sparking a series of internal developments. In this process, it is necessary to pay special attention to the state of the students or the process of being in a developmental period, rather than simply focusing on the learning functions they currently possess [7]. As shown in Figure 1.

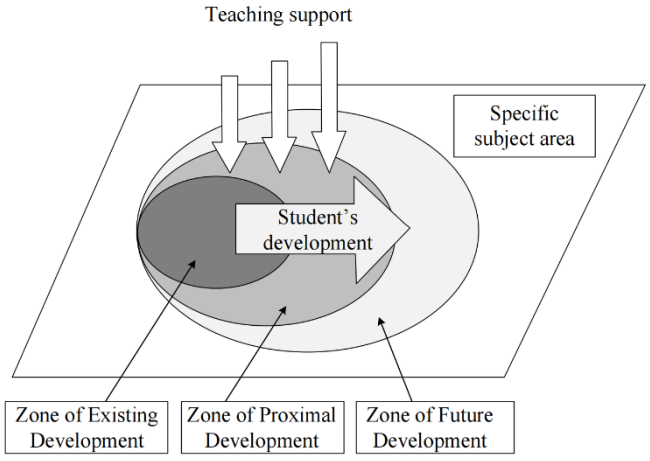


Figure 1. Diagram of the Student's ZPD

Traditional teaching primarily focuses on the differences in students' current learning abilities, paying little attention to their potential, thus making it difficult to implement teaching tailored to individual aptitudes. The concept of the "Zone of Proximal Development" reevaluates the relationship between teaching and development, proposing a dynamic assessment of capabilities. It necessitates the collection of extensive student data, which is seldom gathered and analyzed in conventional teaching, thereby hindering the accurate assessment of students' zones of proximal development and the implementation of precise teaching [8].

The "Zone of Proximal Development" theory indicates that before teaching, one should grasp the students' current and potential development levels and the gap between them. Teaching should take place within the zone of proximal development, based on the current level of development, to gradually advance students toward their potential level. This process transforms the potential level of development into the current level, expanding the scope of the current level to achieve a new zone of proximal development. Teaching in this new zone aims to drive development. In this cycle, the zone of proximal development is dynamic, constantly moving into new areas [9], as shown in Figure 2.

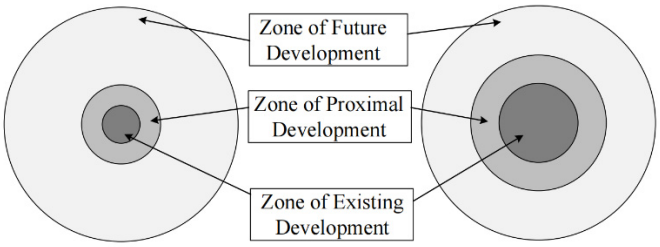


Figure 2. Dynamic Changes of the ZPD

In the past, the zone of proximal development served as a conceptual range and a guideline for instructional behavior. The theory of the zone of proximal development is commonly employed in the design of curricula for primary and secondary education, and in various subjects, it is predominantly used for descriptive assessment. At present, it is mainly directed by teachers, with subjective delineation primarily through tests, questionnaires, interviews, etc. [10-11]. In China, the range involved in the students' zone of proximal development has not been clearly defined, and no metrics have been proposed for the specific indicators that influence this range. The delineation results are rather subjective and superficial, broadly categorized into classes such as A/B/C, often based on "experiential judgment," lacking a data-driven evaluation. Early determinations of the factors influencing the zone of proximal development were also difficult. Most schools adopt a single static method of evaluation, with standards based solely on test scores, excluding students' learning habits and cognitive abilities.

2.2. Empowerment through Big Data Technology

The recent development zone theory runs through the entire process of students' learning development and teachers' teaching practice. With the aid of this theory, utilizing educational data for student performance prediction, academic early warning, and teacher teaching quality evaluation is an important issue in the field of education. It contributes to the advancement of higher education evaluation reform, and holds significant meaning for improving the level of education and the quality of talent cultivation, as well as optimizing the allocation of teaching resources[12].

In the age of intelligence, big data technology provides support and leadership for the transformation of educational evaluation. Wiley et al.[13] note that student thoughts and the application of concepts can be evaluated through machine learning and natural language understanding technologies, with the results showing high accuracy. Yang Xianmin et al. [14] propose that by utilizing technological means and methods, a systematic, scientific, and comprehensive collection, processing, and analysis of various educational data can be conducted to make objective judgments about educational activities, moving from empiricism to data-driven approaches, and from vague to precise assessments. Zheng Yanlin and Liu Haimin [15] suggest using technology to effectively collect and integrate various student data for

multi-dimensional, comprehensive, and in-depth evaluation, transforming fragmented evaluations into systematic evaluations. Zhu Chengchen and Yan Guangfen, [16] point out that technology shifts educational evaluation from "focusing on results" to "focusing on processes," and from "singular examination evaluations" to "multi-dimensional comprehensive quality assessments." Educational evaluation supported by technology transforms "traditional educational evaluation" into "intelligent educational evaluation," thereby truly advancing towards "smart evaluation."

Synthesizing the understanding of domestic and international scholars on the application of intelligent technology to educational evaluation, it is evident that the empowerment of educational evaluation through big data will be an inevitable trend in future development. It entails fully leveraging the advantages of big data, machine learning algorithms, and other intelligent technologies to innovate and develop traditional educational evaluation, to improve the processes and methods of educational evaluation, and to enhance the digital and intelligent level of educational evaluation. The goal is to achieve scientific, objective, and efficient evaluation and feedback, thereby promoting the reform and development of the educational enterprise. However, since big data empowerment of educational evaluation is still in its initial stages of development, intelligent educational evaluation still faces certain practical dilemmas in aspects such as evaluation concepts, forms, environment, and decision-making.

3. The Application of ZPD Forecasting in Teaching Quality Evaluation

Traditional teaching methods often focus on the differences in students' existing abilities while neglecting their developmental potential, which often makes it difficult to achieve true individualized teaching. The theory of the "Zone of Proximal Development" (ZPD) proposed by Vygotsky aims to address the relationship between teaching and student development, leading to the concept of dynamic capability assessment. Past dynamic capability assessments were mostly teacher-led, using questionnaires, interviews, and tests to roughly determine students' abilities, relying heavily on "experiential judgment," which is time-consuming, labor-intensive, and overlooks students' potential learning habits and cognitive abilities, resulting in subjective and rough results. This study is based on educational big data, with multidimensional data measuring student abilities at its core, using machine learning algorithms for analysis, to implement dynamic capability assessment in a more scientific, accurate, and efficient manner. It is not only student-centered but also an innovation in evaluation theory and methods, enriching the theory of the Zone of Proximal Development [12].

Utilizing big data's multi-dimensional exploration to predict ZPD, the study evaluates students' dynamic growth and proposes referencing the A/B/C/D/F grade point division methods of many foreign schools and universities for the preliminary division of ZPD. Students' course performance ZPD groups are determined, combined with multi-dimensional data characteristic indicators, and classified predictions are made with the help of big data algorithm tools to explore the range to which students belong. It also proposes using the growth improvement between students' predicted ZPD and actual ZPD to measure the contribution of teachers, exploring teacher teaching quality evaluation from a new perspective.

Teachers' teaching quality is measured by the degree to which they help students reach and exceed their own ZPD and develop and expand their potential. By establishing an evaluation mechanism centered on the ZPD improvement contribution indicator, combining students' ZPD forecasts with actual growth contributions, and quantifying teachers' teaching quality with actual ZPD growth, a new method with greater reliability and validity is provided for evaluating the teaching quality of college teachers.

Assuming that students' ZPD prediction and actual improvement growth come from the teacher's work input and method improvement, that is, teaching support, we define this as teacher contribution.

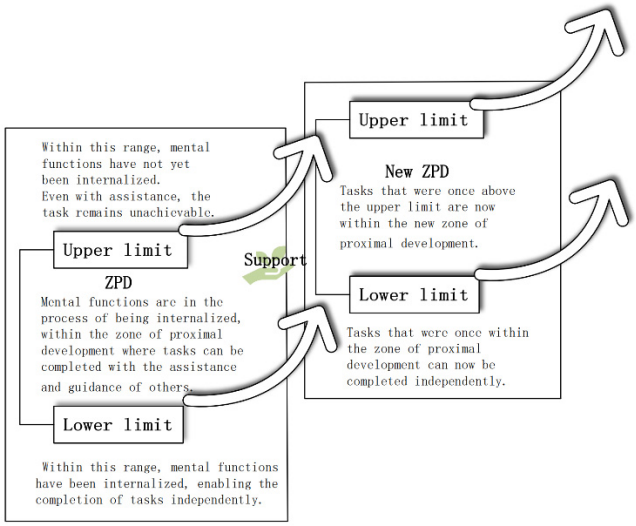


Figure 3. Dynamic Change meaning in the ZPD

The influence of teachers on students' learning progress can be understood as follows: Figure 3 shows the student's growth progress. If students grow as estimated, the ZPD will reach the predicted level. If students realize their academic potential or even grow higher, the actual ZPD growth reaches a higher stage than expected. The achieved and surpassed level of ZPD growth, referred to as growth value D (develop), is attributed to the guidance of educators, which is the contribution of teaching support, as shown in Figure 4.

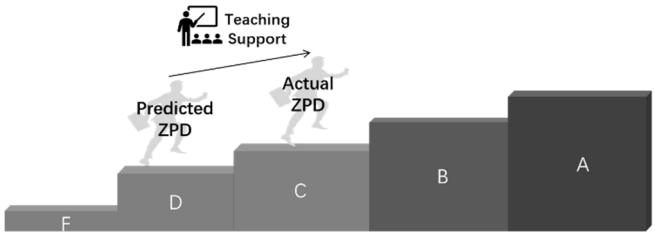


Figure 4. Diagram of Teacher's Contribution Improving ZPD

Therefore, the concept of contribution is proposed to measure the teaching quality evaluation of teachers.

Models are used to predict the dataset of each teacher group. When the actual label = predicted label, it indicates that the teacher has helped the student reach the predicted ZPD, counting D=1 for reaching the mark; when the actual label is one level higher than the predicted label, it indicates that the teacher has actually helped the student reach and surpass the predicted ZPD by one level, counting D=2 for exceeding; when the actual label is two levels higher than the predicted

label, it means the teacher has actually helped the student reach and surpass the predicted ZPD by two levels, counting D=3; when the actual label is three levels higher than the predicted label, it means the teacher has actually helped the student reach and surpass the predicted ZPD by three levels, counting D=4; and so on, adding up the "positive contributions," with the formula as follows:

$$D_{Positive} = \sum_{i=1}^{p} D_i \quad (1)$$

The manuscript should include a conclusion. In this section, summarize what was described in your paper. Future directions may also be included in this section. Authors are strongly encouraged not to reference multiple figures or tables in the conclusion; these should be referenced in the body of the paper.

"The formula for the average positive contribution is as follows:

$$\overline{D_{Positive}} = \frac{1}{p}\sum_{i=1}^{p} D_i \quad (2)$$

Conversely, if the actual label is one level below the predicted label, count D=-1; if the actual label is two levels below the predicted label, count D=-2; if the actual label is three levels below the predicted label, count D=-3; if the actual label is four levels below the predicted label, count D=-4; and so on, summing up the 'negative contributions', with the formula as follows:

$$D_{negative} = \sum_{j=1}^{q} D_j \quad (3)$$

The formula for the average negative contribution is as follows:

$$\overline{D_{negative}} = \frac{1}{q}\sum_{i=1}^{q} D_i \quad (4)$$

Since there is a difference in the number of students taught by each teacher, it is not possible to use the absolute value increase of grade levels to evaluate the teaching quality between different courses. Therefore, the absolute value increase of each student's ZPD grade is averaged by weighting, calculating the total average contribution degree = (positive contribution + negative contribution) / (number of positive samples + number of negative samples), with the formula as follows:

$$D_{Total} = \frac{D_{Positive}+D_{negative}}{p+q} \quad (5)$$

4. Conclusion

In response to the current lack of objective and scientific quantification in the evaluation of teaching quality by most university teachers, and the high cost of evaluation, a new evaluation model based on the prediction of students' Zone of Proximal Development (ZPD) is presented. Drawing on the grading methods of A/B/C/D/F used by many schools and universities abroad, the pre-division of the Zone of Proximal Development is proposed. Led by big data, it explores multidimensional data feature indicators and uses machine learning algorithms for classification prediction to explore the category of the interval to which students belong. This is the first exploration of the applicability of the Zone of Proximal Development theory in the dimension of big data. By combining the predicted ZPD with the actual ZPD level difference, considering the student's initial potential ability and the outcome after education, the teacher's impact is assessed more scientifically. The level of teaching quality is measured by the degree to which teachers enable students to reach and exceed their own Zone of Proximal Development and to develop and expand their potential. By establishing an evaluation mechanism centered on the ZPD contribution degree index, combining the prediction of the student's Zone of Proximal Development with actual growth enhancement, and quantifying the teaching quality of teachers with the actual meaningful growth of the Zone of Proximal Development, a new method that considers reliability and validity is provided for the evaluation of teaching quality of university teachers. The research methods and ideas provide a reference for researchers, as well as for teachers, students, and educational administrators to improve learning and teaching behaviors, management methods, and decision-making, with practical guiding significance."

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