REVIEW

The Application of Big Data-Based Precision Teaching in Chinese Education: Using Xichuan Experimental School in Chengdu City as an Example

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***Abstract**: In the era of big data, technology is a catalyst for change in teaching modalities. Although the notion of precision teaching is not new to the education world, its application has faced a variety of constraints due to technical issues. The advent of big data technology and the proliferation of educational data are vital factors in diminishing these constraints. Based on a review of relevant research, this study encapsulates popular application patterns of big data-based precision teaching in China and expounds on its implementation procedures, citing the practice of Xichuan Experimental School as a case study. It also discusses the challenges arising in the integration of big data into precision teaching in order to provide a broader perspective on this teaching method.*

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Introduction

IN THE CONTEXT of the accelerated development of information technology like the internet, mobile communication, and cloud computing, the amount of digital data related to human behaviors has increased exponentially, marking the entry of human society into the era of big data. Big data technology has the potential to assist people in reaching scientific decision-making, providing valuable information via analysis of datasets containing colossal amounts of data (Liu, 2014). It is also an impactful technology in the field of education. In 2012, the U.S. Department of Education's Office of Educational Technology (2012) released the report "*Enhancing Teaching and Learning Through Educational Data Mining and Learning Analytics: An Issue Brief*," which describes how data analytics and data mining were starting to be applied in education and examines the potential of such efforts for improving student outcomes and the productivity of K–12 education systems as well as the challenges being encountered. This issue brief provoked more intense interest in the educational application of big data in other countries as well. For instance, the Action Plan for Promoting Big Data Development, issued by the Chinese government in 2015, calls for actively advancing the development of educational big data to support the educational reform in China (Chen, 2015).

Recent years saw a significant increase in educational big data research. For example, Baig et al. (2020) conducted a review of 40 studies in English on educational big data, published between 2014 and 2019, to find the four primary research themes in this area: the learners' behavior and performance, modeling and educational data warehouses, improvement in the educational system, and integration of big data into the curriculum. According to Bai et al.'s (2021) study, educational big data has positive effects in realizing intelligent management of the school, optimizing teaching methods, and increasing the outcomes of educational resources. It can also play other, more specific roles, including making projections of student academic performance, giving recommendations on employment, and planning economic support for low-income students. Some researchers emphasized the significance of educational big data for the development of equitable, high-quality education (Yang, 2024). In this context, the topic of how to leverage educational big data to support precision teaching (PT) has attracted a lot of interest in the education research community. However, there is a dearth of in-depth research into the specific patterns and implementation procedures of big data-based PT. Hence, this study focuses on:

1. *Encapsulating common big data-based PT modalities in China by reviewing the existing literature.*

2. *Expounding on its implementation procedures by analyzing the experimentation of Xichuan Experimental School in this area.*

Literature Review

The concept of "precision teaching" was first advanced by Ogden Lindsley in the 1960s, under the influence of Skinner's behaviorist learning theory and procedural teaching theory (Wu, 2020; Evans et al., 2021; An, 2021). Some researchers made the observation that the method of PT was based on three ideas from Skinner's research: student behavior being treated as the variable; the frequency of the behavior in question being adopted as an indicator of behavioral change; and the Standard Celeration Chart (SCC) being used as a tool for data display (Vargas, 2003; Wu, 2020). The initial purpose of this teaching technique was to help students identify the improvements to make and to enable their teachers to have a clear understanding of their mastery of a skill or body of knowledge (Binder, 1998; Wu, 2020). In PT, fluent responding, characterized by accuracy and speed, is often used as a mastery criterion. Fluent behavior includes enhanced skill retention and maintenance, endurance, stability, and easy application to novel settings and stimuli (Binder, 1998; Ramey et al., 2016). Over the years, the concept of PT has undergone certain modifications. Based on their review of PT's evolution and prior definitions of this teaching method, Evans et al. (2021) conceptualized it as a system for precisely defining and continuously measuring the student's learning behavior in multiple dimensions and analyzing behavioral data via the SCC for the purpose of facilitating the teacher making timely, data-driven decisions and accelerating the recurrence of desirable behaviors in students. They also gave a summary of PT's core features, including accelerating behavioral repertoires, precise behavior definitions, continuous observation, dimensional measurement, the SCC, and timely and effective data-based decisions. On the other hand, despite it being considered an effective teaching method, particularly in special education for children with developmental disabilities (Ramey et al., 2016), PT has exhibited limitations due to a lack of technological support, such as the inability to track and measure student learning behavior as accurately as expected (with capabilities being limited to recording time spent on learning and frequency of certain learning behaviors) and the imposition of additional burdens on teachers and students caused by the manual manipulation of recording (Fu & Tang, 2017; An, 2021). This has hindered its widespread application.

PT began to garner the attention of Chinese academia around 2010. In 2016, Professor Zhu proposed the idea of leveraging IT to support precision teaching, an advocacy largely driving PT towards the direction of technological infusion (Zhu & Peng, 2016; Wu, 2020). The Chinese education community typically viewed PT as a technology-optimized teaching technique (Peng & Zhu, 2017), with the following capabilities: recording, tracking, and analyzing data on students' learning processes using IT-based devices; applying these data to directing the instructional design, teaching decision-making, and tailored instruction of the teacher; providing data-based learning remedies and improvement support to the students (An, 2021). In addition, the initiation of research on how to use IT to modify PT in China coincided with the time when technologies like big data and visualization were in accelerated development. In this context, it was natural for Chinese researchers to set about experimenting with integrating big data into PT. Their research findings reveal multiple benefits of big data-based PT, including tracking and recording data in more dimensions aside from the frequency of a certain learning behavior; using artificial intelligence to extract data that appeared unmeasurable in the past, such as the learner's emotions; and automating data collection, processing, and presentation to reduce manual labor (Guo et al., 2019). As a result of governmental promotion of digital education and the popularization of digital teaching platforms in recent years, digital educational data have expanded on an immense scale (Wan et al., 2019), providing a solid foundation for the development of big data-based PT. Driven by the advanced technologies and large-scale data resources, PT in China has matured considerably and has been accepted as a novel teaching approach (Shi et al., 2022). The relatively conclusive definition of big data-based PT in Chinese academia is that it is a teaching approach leveraging big data technology to precisely project teaching objectives, content, and activities; precisely evaluate students' performance; and make the teaching processes and outcomes quantifiable, traceable, and adjustable (Wang et al., 2018; Wan et al., 2019).

Common Big Data-Based PT Modalities in China

Based on the traditional PT method, Chinese researchers have developed various implementation patterns of big data-based PT. Despite the variations between them, underlying them are four principles, according to most researchers: focusing on measurable student learning behavior data (including overt and covert behavior); gauging the learner's performance with multiple indicators; applying learning analytics; and using student performance data to support instructional decision-making (Wang et al., 2018; Wu et al., 2022).

The IT-assisted PT modality advanced by Zhu and Peng (2016) is deemed a prototype of big data-based PT (Wu, 2020). It is a system characterized by the cycle of four steps: (1) precise goal setting; (2) development of pertinent teaching materials and teaching processes; (3) recording and visualization of student performance; (4) data-based decision-making. In the first step, the notion of recursion is applied to the setting of teaching or learning objectives. In the second, the uniform textbooks are adapted into digital textbooks that can be used for micro video-based, interactive learning, and the teaching is enacted with four tactics: stratified teaching within the class, group cooperative study, self-directed learning, and collectively interactive, generative learning. For the third step, statistics and visualization tools are used to present student learning behavior data in an efficient manner. For the fourth step, the PT analysis software is employed to assist the teacher in determining the effectiveness of the current teaching practice in reaching the expected teaching or learning objectives (Zhu & Peng, 2016).

Fu and Tang (2017) developed a PT model from the teachers' standpoint, which consists of three dimensions: the establishment of teaching objectives, the design of teaching processes, and teaching evaluation and projection. The developers of the model argued that establishing quantifiable teaching objectives was the primary process in PT, as explicit teaching objectives are the starting point of all teaching activities as well as the criteria for judging the outcomes of teaching. The teaching process framework of this model, based on the procedural teaching theory, includes the following processes: establishing a teaching resource library, measuring and recording students' performance as indicated by their completion of the exercises from the library, and providing targeted interventions in accordance with the student's learning circumstances. The model's teaching evaluation relies heavily on technological devices for collecting and analyzing data about students' learning progression and giving real-time feedback to students and teachers as well as keeping parents updated on their children's progress in learning. Teaching projection is about making predictions of the student's performance in the ensuing period based on the records of their performance in the preceding periods and other data and recommending pertinent improvement moves or learning strategies accordingly.

According to Zhang and Mou's (2018) observation, student learning would undergo a transition from the one-size-fits-all approach to a more individual needs-targeted, personalized learning method with the assistance of big data. Hence, they worked to develop a PT model aimed at personalized learning by integrating novel instructional approaches like the flipped classroom and new technologies such as big data, learning analytics, adaptive learning, and educational information processing. Central to this model are the students' profiles, based on which a PT procedure is established, including before-class learning protocol design and preliminary projection of learning outcomes, in-class teacher-student interaction and stratified directions, and after-class self-directed learning. The before-class process is meant to enable the student to master the basic knowledge that is in line with their individual cognitive levels through stratified learning materials and to help them set their own learning objectives according to the analysis results of their engagement levels and completion of these before-class activities. In the in-class process, the teacher selects the appropriate teaching method to suit the subject matter of the lesson and conducts stratified instruction in accordance with the previously established personalized learning objectives. In the after-class process, the students use the adaptive learning platform to perform autonomous practice and try to improve their mastery of relevant knowledge by utilizing the individualized learning resources and adopting the learning paths recommended by the platform. Other researchers, such as Jiang et al. (2020), Liu et al. (2020), Wang (2020), and Xing (2020), have also developed their own big data-based PT patterns with the before-class, in-class, and after-class teaching processes. Commonalities of these PT modalities include: (1) collecting basic data of students via the pre-test before class and creating their profiles to facilitate the teacher establishing individualized teaching objectives and materials (Ren, 2017; Liu et al., 2020); (2) implementing in-class teaching that suits the students' academic level based on the prior analysis of their learning foundations (Wang, 2020); (3) giving the students additional, customized learning materials in the form of after-class assignments to help them improve their weaknesses (Jiang et al., 2020).

In addition, certain researchers created their data-driven PT modalities by following the procedure of technological use of big data. For example, Wang, Gao, and Ye (2024) developed a PT model with five basic components, namely, educational data collection and screening, educational data mining and analysis, identification of student characteristics, intervention strategy selection, and intervention effect evaluation. Subsequently, drawing on Qin' and Zhang' (2019) research findings, Wang, Wang, and Fan (2024) simplified the model to retain four components: data collection, analysis of student prior knowledge repertoires and determination of teaching objectives, teaching implementation, and teaching intervention.

To recap, all these PT modalities enable the teachers to reach more scientific, precise instructional decisions through applying data mining and learning analytics and, in the meantime, support student learning by serving the different needs of the learners, posing differential teaching objectives, materials, and interventions to them. The validity of these PT patterns has been verified by empirical studies. For instance, Xing (2020) applied a big data-based PT model to the teaching of "advanced mathematics" to find it could improve the frequency of teacher-student interaction and the efficiency of student learning. According to Guo et al.'s (2021) two-year field study of PT's implementation in 51 experimental schools, the use of big data-based PT modalities produced ideal effects in all these schools across the board, significantly enhancing the teachers' senses of achievement and professional competence and heightening the students' learning satisfaction as well as improving their academic performance.

Implementation Procedures of Big Data-Based PT: Xichuan Experimental School's Practice of PT

Traditional PT is typically enacted in the sequence of the following six procedures: (i) Determine the types of learning behavior to be measured and set teaching objectives; (ii) prepare pertinent teaching materials and exercises; (iii) record the frequency of learning behaviors in students and their performance; (iv) represent the data in the form of SCC; (v) evaluate student performance using SCCs and make instructional decisions; (vi) adjust teaching objectives and teaching design according to the revised instructional decisions and initiate the next round of PT (Jiang et al., 2020; Evans et al., 2021). Big data-based PT basically follows this sequence, though with certain variations. This section is devoted to an analysis of implementation procedures of big data-based PT, using Xichuan Experimental School as an example.

To start with, it is necessary to look at the reasons for this school's adoption of big data-based PT in regular instruction. First off, behind this practice is the school's philosophy of teaching management, namely, "evidence-based decision-making." This policy emphasizes the importance of data collection and analysis for scientific teaching decision-making. Moreover, the school adopted PT to address the problems with the teachers' instruction as revealed by a survey of its classroom enactment. These problems include the teachers' lack of in-depth comprehension of the curriculum program and course standards, improper teaching behavior, and inadequate understanding of their students. The school strengthened its provision of in-service training for its teachers to improve their knowledge on curriculum standards. For the other issues, big data-based PT, it is believed, could be the judicious solution.

While the school's in-class PT includes those basic PT procedures, it has prominent advantages over the traditional PT pattern. First, it leverages big data-driven online classroom teaching platforms (e.g., Smart Study Companion) and terminal devices like the Classroom Feedback Machine (with the feature of recording students' answers to the teacher's questions) to gather and analyze data, as opposed to the traditional PT's reliance on manual manipulations on the part of the teachers and students. These platforms and devices can make real-time records and give statistical analyses of behavioral data of students, facilitating the teacher's timely knowledge of students' performance. Following the completion of a lesson, the digital systems will produce an overview of the class enactment to assist with the teacher's understanding of the overall progress of the class. Second, the data collected are not just about the student's performance in answering questions but also about the thinking process of the student. After the student gives the initial answer, the teacher will try to discern the reasons for their answers by asking follow-up questions and observe the changes in their thinking by asking them to represent their answers for the second time. In addition, the digital systems also record and analyze students' other in-class behaviors. Data on the duration of group discussions, group discussion findings, and student representations can help the teacher develop a more comprehensive picture of the students' personality traits, learning habits, and other details. Third, the digital systems also record behavioral data of the teachers. The teacher can correct their improper teaching behavior by examining their own classroom performance or discussing with other teachers' improvement measures through studying the replayed footage of the class.

Furthermore, Xichuan Experimental School extends big data-based PT to after-class assignment management, creating a digital homework management system spanning procedures from homework design to homework assignment, homework completion tracking and analysis, and teacher intervention. During homework design, the teacher needs to mark each question with the subject matter and academic level it involves and limit the questions for one assignment to a reasonable amount. On top of that, the format of homework is unified to make sure it is presented on A4-size paper with prescribed font and spacing, facilitating the collection of data as well as the management of homework. For the homework assignment, the school sets up a variety of templates for teachers teaching different subjects, each explicitly specifying the type of questions, number of questions, and level of difficulty. It also stipulates the provision of multiple configurations of questions with various levels of difficulty to cater to students in distinct academic strata. The provision of menu-based, tailored assignments is intended to enhance the role of homework in promoting knowledge development of each individual student.

The school adopts the method of "teacher marking followed by machine scanning" for the procedure of data collection, with which the teacher marks the students' homework first and has students correct the wrong answers before sending it for machine scanning so that the students' completion of homework and the teacher's marking work can both be transmitted to the school's central system. The teacher can read the collected data in the system at any time through apps on mobile phones, computers, and other terminals, and the student can receive feedback on their homework through apps on the said devices. Since its founding in 2018, the school has conducted nearly 6,000 times of homework data collection, with a total of 673.35 million data entries into the school system. The analysis results of these data serve as the groundwork of the teacher's interventions. There are mainly two types of interventions administered by the teachers. One is to correct the mistaken answers by the students and provide them with individualized supplementary exercises. To put it in a more specific way, the teacher focuses on expounding on those questions for which 60% of students gave wrong answers and gives the student extra learning materials targeted at their respective weaknesses as evidenced by the data from the school's homework management system. The second type of invention is about remedial instruction. The teacher classifies the students' mistakes based on the machine's statistical analysis of data on student wrong answers and gives additional tutoring and reinforcements in subsequent instruction to address the inadequacies in students.

The implementation of big data-based PT in Xichuan Experimental School's classroom instruction and homework management has endured for years and proves productive. The school's graduates have received higher grades in academic proficiency tests, physical fitness assessments, and comprehensive competence evaluations than their counterparts from other schools in Chengdu City.

Discussion

Our review of existing big data-based PT modalities and implementation procedures shows that big data-enabled educational technology applications have superseded the SCCs as PT tools. Typical big data processing procedures, including data collection, data processing and integration, data analysis, and data interpretation (Liu & Zhang, 2014), have posed a substantial impact on the PT implementation pattern. Although the integration of educational big data makes no difference to the essence of PT, that is, making evidence-based instructional decisions with the learners' behavioral data and paying attention to their individuality (Hao & Guo), big data-based PT outperforms traditional PT with its advantage of having higher efficiency in data collection and analysis. The automated data processing instruments enable teachers and students to reach improved outcomes without changing the basic classroom processes. Also, big data-based PT helps enhance the role of the teacher, making them more observant of the individual differences in their students and preventing them from administering homogeneous teaching interventions (Luo et al., 2019; Ji et al., 2020; Bai et al., 2022). In addition, the data collected in PT augment the students' understanding of their academic state and assist with their adjustment of learning behavior, which is unquestionably conducive to the realization of personalized learning.

Nevertheless, the challenges of big data-based PT should also be acknowledged. First, many researchers have raised the concern that this teaching approach may nurture the "technology-first" mentality in teachers and distort the normal instructional progression. Second, the policy of "assisting teaching and learning with assessments" in big data-based PT may magnify the existing emphasis on tests, skewing PT towards "precision practice of exercises." Third, the current use of big data technology remains focused on the overt behaviors of learners, which may mislead the teacher to pay attention only to their academic performance while disregarding their psychological and emotional development (Wang et al., 2021). Fourth, when the school adopts machine-generated data as criteria for gauging the performance of the teachers and students, they may face the temptation to adapt their behavior only for better data outcomes, sacrificing the real meaning of education. Last but not least, the application of educational big data puts the privacy of the educators and the educated at risk. A portion of schools deploy cameras in the classrooms to monitor the behavior of teachers and students, potentially threatening their privacy security.

Conclusion

Amid the ongoing advancement of digital education in China, schools at all education levels have worked to expeditiously improve their digital environments. As a result, new technologies, such as the learning platform, mobile app, digital terminal, and wearable device, become popular in Chinese primary and secondary schools. The regular application of digital technology in teaching activities has promoted the generation of educational big data. The adoption of data mining and learning analytics has made a significant difference to the teaching modalities, the education evaluation system, and educational decision-making of the school. This study encapsulates the explorations of big data-based PT modalities among Chinese researchers to find that this teaching method is effective in resolving issues with the traditional PT due to its ability to provide instant, more precise feedback while also being beneficial for the realization of personalized learning in students. In China, a portion of schools have introduced big data-based PT into their regular instruction and have achieved considerable outcomes, which potentially propels its popularization in the entire education world across the country. Yet, as a non-traditional teaching approach, it faces a lot of challenges. For instance, its implementation demands up-to-par digital competence in teachers, posing a new requirement to teacher education and training. In addition, the colossal workloads of data collection and processing associated with the large size of ordinary Chinese schools may hamper the long-term execution of this instructional method in China, calling for further improvement of relevant technological devices.

References

An, F. (2021). Precision teaching: Evolution, current application, and educational value. *Curriculum, Teaching Materials, and Methods*, 41(8):56-62. DOI: https://doi.org/10.19877/j.cnki.kcjcjf.2021.08.010

Bai, X., Gu, X., Yin, H., Wu, M., & Hu, B. (2022). Data-driven precision teaching: Perceptions, practical paths, and challenges. *E-education Research*, 43(4):77-84. DOI: https://doi.org/10.13811/j.cnki.eer.2022.04.011

Bai, X., Zhang, F., Li, J., Guo, T., Aziz, A., Jin, A., & Xia, F. (2021). Educational big data: Predictions, applications and challenges. *Big Data Research*, 26:100270. DOI: https://doi.org/10.1016/j.bdr.2021.100270

Baig, M. I., Shuib, L., & Yadegaridehkordi, E. (2020). Big data in education: a state of the art, limitations, and future research directions. *International Journal of Educational Technology in Higher Education*, 17:1-23. DOI: https://doi.org/10.1186/s41239-020-00223-0

Binder, C. (1988). Precision teaching: Measuring and attaining exemplary academic achievement. *Youth Policy*, 10(7):12-15.

Chen, W. (2015). An interpretation of the Action Plan for Promoting Big Data Development. *iChina*, 2015(10):11-14. Available at: https://kns.cnki.net/kcms2/article/abstract?v=UjEBX92ALNERuSmqP9nvC4zGEixBnsTy97kDsb9laUKUbaBMlOPYGYFUixnxa90wChEdReyRhJkPtQItf_NOoJQ_Udm56DwjeMfvH-OwGpVzfTtMlkWMjadKRiFjFXnPgs46BnG0V5ginXH0Z_cZScN8XSx3sqTjS-BTrjpYQFbJA0Aa7aLeyQ==&uniplatform=NZKPT&language=CHS

Evans, A. L., Bulla, A. J., & Kieta, A. R. (2021). The precision teaching system: A synthesized definition, concept analysis, and process. *Behavior Analysis in Practice*, 14(3):559-576. DOI: https://doi.org/10.1007/s40617-020-00502-2

Fu, D. & Tang, L. (2017). Big data-based precision teaching. *Modern Educational Technology*, 27(7):12-18. DOI: https://doi.org/10.3969/j.issn.1009-8097.2017.07.002

Guo, L., Yang, X., & Zhang, Y. (2019). Recent advancements and development directions of precision teaching in the era of big data. *E-education Research*, 40(10):76-81+88. DOI: https://doi.org/10.13811/j.cnki.eer.2019.10.011

Guo, L., Yang, X., & Zhang, Y. (2021). The design and practical validation of the data-driven precision teaching supporting framework. *E-education Research*, 42(4):85-92. DOI: https://doi.org/10.13811/j.cnki.eer.2021.04.012

Hao, J. & Guo, J. (2022). The implementation of intelligent technology-enabled precision teaching. *E-education Research*, 43(6):122-128. DOI: https://doi.org/10.13811/j.cnki.eer.2022.06.016

Ji, X., Cheng, J., & Zhang, Y. (2020). Precision teaching in the era of technology. *E-education Research*, 41(9):102-107. DOI: https://doi.org/10.13811/j.cnki.eer.2020.09.015

Jiang, Q., Li, Y., & Qian, S. (2020). A big data-based precision teaching modality for tertiary education. *Higher Education Exploration*, 2020(11):31-35. Available at: https://kns.cnki.net/kcms2/article/abstract?v=UjEBX92ALNFaWLIuVnQBLYIcRS8hJNUC7aMTMJG3RUvnPuXE7SVEA5bZHxZJ-i16JN24YCZ0DBHK5vaDPe0y7bWjgfMFUAcnbqbD0bcyc6QZHKc6XOHmMR3yEqcUiCHEiGdn8Ssb6zZY8zhYVFCzS9RNve8e2qZDcXqgI4IROJeKyYYtTtAdjw==&uniplatform=NZKPT&language=CHS

Liu, F. (2014). A literature review of the application of big data in education. *Modern Educational Technology*, 24(8):13-19. DOI: https://doi.org/10.3969/j.issn.1009-8097.2014.08.002

Liu, N., Wang, Q., Xu, L., & Yu, S. (2020). The promotive role of educational big data for precision teaching: Practical research using the platform "Smart Study Companion" as an example. *Modern Educational Technology*, 2020(4):12-17. DOI: https://doi.org/10.3969/j.issn.1009-8097.2020.04.002

Liu, Z. & Zhang, Q. (2014). A literature review of the big data technology. *Journal of Zhejiang University (Engineering Edition)*, 2014(6):957-972. Available at:

https://link.cnki.net/urlid/33.1245.T.20140228.1312.001
Luo, Y., Xie, X., & Dong, S. (2019). Precision teaching in Junior secondary physics education. *China Educational Technology*, 2019(1):48-53. Available at: https://link.cnki.net/urlid/11.3792.G4.20190103.1544.018
Peng, H. & Zhu, Z. (2017). Assist learning with measurement: The central component of precision teaching in the context of smart education. *E-education Research*, 38(3):94-103. DOI: https://doi.org/10.13811/j.cnki.eer.2017.03.015
Qin, D. & Zhang, L. (2019). An evaluation of in-class precision teaching: Challenges and optimization measures. *E-education Research*, 40(11):63-69+77. DOI: https://doi.org/10.13811/j.cnki.eer.2019.11.009
Ramey, D., Lydon, S., Healy, O., McCoy, A., Holloway, J., & Mulhern, T. (2016). A systematic review of the effectiveness of precision teaching for individuals with developmental disabilities. *Review Journal of Autism and Developmental Disorders*, 3:179-195. DOI: https://doi.org/10.1007/s40489-016-0075-z
Ren, H. (2017). Big data-based precision teaching: Development paths and implementation conditions. *Heilongjiang Higher Education Research*, 2017(9):165-168. Available at: https://kns.cnki.net/kcms2/article/abstract?v=UjEBX92ALNEKrE-nKJwdMRm0eD-7GeluKS1Qs2V4HfjHsgXQhgGCKqDuVdPWQNrrNuNaSkeU4TlRFlrFc4DT4yUwbPrVoFw_sVXhIgCU1aS2NWalYGJ2Q0TJ3nmGkjyFKza3vOgpeST7D4YCHOo_uwQTC9HpTdhZS92E-P4b1xqNBQ8W4p0puA==&uniplatform=NZKPT&language=CHS
Shi, X., Zhang, J., & Tian, M. (2022, September). A summary and current analysis of research on precision teaching in China. In Fourth International Conference on Computer Science and Educational Informatization (CSEI 2022) (Vol. 2022, pp. 46-52). IET. DOI: https://doi.org/10.1049/icp.2022.1452
U.S. Department of Education, Office of Educational Technology. (2012). Enhancing Teaching and Learning Through Educational Data Mining and Learning Analytics: An Issue Brief. Washington, D.C.
Vargas, J. S. (2003). Precision teaching and Skinner's legacy. *European Journal of Behavior Analysis*, 4(1-2):80-86. DOI: https://doi.org/10.1080/15021149.2003.11434221
Wan, L., Huang, Z., & Huang, H. (2019). Big data-driven precision teaching: The operational framework and implementation paths. *Modern Educational Technology*, 2019(1):31-37. DOI: https://doi.org/10.3969/j.issn.1009-8097.2019.01.005
Wang, H. (2020, August). The Construction and Practice Research of Data-Driven Precision Teaching Model. In 2020 International Symposium on Educational Technology (ISET) (pp. 43-47). IEEE. DOI: https://doi.org/10.1109/ISET49818.2020.00019
Wang, L., Wang, X., & Fan, M. (2024). The construction and application of precise teaching mode based on educational big data. In 2024 International Symposium on Educational Technology (ISET) (pp. 411-415). IEEE. Doi: https://doi.org/10.1109/ISET61814.2024.00087
Wang, L., Xia, L., & He, W. (2021). Bringing precision teaching back on track: Towards human-machine collaboration. *E-education Research*, 42(12):108-114. DOI: https://doi.org/10.13811/j.cnki.eer.2021.12.015
Wang, Y., Li, L., & Li, Y. (2018). The big data-based precision teaching model. *Modern Educational Technology*, 2018(7):5-10. DOI: https://doi.org/10.3969/j.issn.1009-8097.2018.07.001
Wang, Y. J., Gao, C. L., & Ye, X. D. (2024). A data-driven precision teaching intervention mechanism to improve secondary school students' learning effectiveness. *Education and Information Technologies*, 29(9):11645-11673. https://doi.org/10.1007/s10639-023-12238-x
Wu, W. (2020). The Evolution of Precision Teaching and Reflections (master's thesis). Zhejiang Normal University. DOI: https://doi.org/10.27464/d.cnki.gzsfu.2020.000101
Wu, X., Chang, J., Lian, F., Jiang, L., Liu, J., & Yasrab, R. (2022). Construction and empirical research of the big data-based precision teaching paradigm. *International Journal of Information and*

Communication Technology Education (IJICTE), 18(2):1-14. DOI: https://doi.org/10.4018/IJICTE.313411

Xing, L. (2020). The construction and empirical validation of a precision teaching-based blended learning model. *China Educational Technology*, 2020(9):135-141. Available at: https://kns.cnki.net/kcms2/article/abstract?v=UjEBX92ALNEYN8qZu5LJwi3q-_oBAG-DfnBp3ruK12TEitNGWcucVAxuQp7Ez9HrhOKcCR1cDw1GSa22omBFpA87Z0Bw6DFC8D0_ylND1X6Dw6GgyoXbLGSke9vm0b1QGlQovzrbVnzgRWQS1cHYsWxAgeAdmuBV8AS-GqDBHUuWwCZ-7Tukeg==&uniplatform=NZKPT&language=CHS

Yang, T. (2024). Comprehensive practice education via “cloud-based study tours”: A case study of the comprehensive practice curriculum in the Tianfu New district, Sichuan province, China. *Science Insights Education Frontiers*, 23(2):3799-3809. DOI: https://doi.org/10.15354/sief.24.or623

Zhang, X. & Mou, Z. (2018). The design of a precise teaching model for personalized learning in a data-driven learning environment. *Modern Distance Education*, 2018(5):65-72. DOI: https://doi.org/10.13927/j.cnki.yuan.2018.0053

Zhu, Z. & Peng, H. (2016). Highly effective teaching supported by information technology: Optimizing the outcomes of precision teaching. *China Educational Technology*, 2016(1):18-25. Available at: https://link.cnki.net/urlid/11.3792.20160105.0832.006

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