
Differentiated Instruction at The Age of Smart Education

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Abstract

Introduction: Face the development of smart education and the challenges of differentiated instruction, this study is conducted to know how to establish smart differentiated instruction system based on reviewing the existing literature of differentiated instruction and smart education in order to study how to use smart education environment to enhance differentiated instruction. This system uses smart education equipped with big data, smart classroom, and technologies to enhance differentiated instruction and solves the problems of differentiated instruction faced at recent, such as teachers are unable to accurately identify the differences among students, implementation of differentiated instruction in class is complicated, and the method of students' evaluation is single. And this study attempts to practice this system in two classes of the same major in a university, in Guangdong Province, China. Through practice, it aims at exploring the problems of differentiated instruction faced at present that have been solved with the enhancement of smart education.

Methodology: This study intends to use a descriptive research method, and the research design is exploratory research. The sample for this study was from class1907 and 1908 in Major Network Engineering, with 94 students, 77 boys and 14 girls. The data mainly came from the evaluation of teaching quality and the questionnaire survey of the students on the teaching platform. This study conducts a descriptive analysis of these data in order to understand whether different teaching with the assistance of intelligence education can solve relevant problems.

Result: The results show that smart differentiated instruction employs big data technology to accumulate and analyze the data of students among smart campus platforms, solving the problem that teachers cannot distinguish student differences. Smart classroom supports to solve difficulties of the complicated implementation of differentiated instruction. Using the process data of students learning solves the problem of students' evaluation which is single-method.

Keywords: Differentiated Instruction, Challenges, Evaluation, Smart Education, Smart Classroom, Big Data.

1. Introduction

Differentiated instruction is a student-centered education concept (Tomlinson, 2017), which has been widely discussed in the educational circle. However, due to its complex implementation and great challenge, differentiated instruction is difficult to adapt to the design situation with large class numbers, therefore it is usually not used by teachers in class (Smets, De Neve & Struyven, 2020; Liu, 2017). In traditional classroom environment, it is difficult for most teachers to comprehensively grasp each student's situation before class. The common solution is to reduce class size and improve teachers' quality, so that teachers can pay attention to each student and each student can get targeted help and guidance (Wang, Y.F., Li, L., & Li, Y., 2018). Under the conditions of standard curriculum restriction, tight school schedule and heavy class management, the teachers appear to be willing and powerless (Marshall, 2016). At the same time, the contradiction between teaching efficiency and considering differences is prominent (Godor, 2021).

At present, with the application of a new generation of emerging technologies such as cloud computing, big data, Internet of Things and artificial intelligence, human beings have entered an intelligent era of comprehensive perception, reliable transmission, intelligent processing and accurate decision making (Lu, 2021), the rapid development of technologies drive the reform and innovation of education and teaching deeply, and then brings opportunities and challenges to future education (Fu, Jiang, & Chen, 2021; Zhao, & Zhu, 2019). Facing the challenges of differentiated instruction, Technologies are used to solve the problem in Education era and improve the effectiveness of teaching and learning. Some scholars pointed out that technology can be used to enhance the opportunities for differentiated instruction implementation (Stanford, Crowe, & Filce, 2010). Al-Rsa'I and Shugairat (2019) studied that used technology to driven differentiated instruction in Science Teaching.

Smart education is a product of the deep integration of technology and education as a reaction to the challenges contribute to use by information technology in the field of education (Wang, 2015). Smart education is an upgrade of information-based teaching and a collection of smart environments, smart teaching method and smart evaluation (Zhu, 2021). Differentiated instruction can be achieved through smart education, changing the traditional classroom environment to one that uses digital, intelligent smart classrooms; using diverse, linked smart tools for classroom teaching and data analysis functions to provide more accurate and comprehensive assessments of student academic development, achieving an organic blend of traditional teaching methods and modern IT teaching methods (Liu, & Dai, 2019).

1.1 Research Question

According to the challenges of differentiated instruction and the development of smart education, the research question as follows:

How to use smart education environment to enhance differentiated instruction?

What do the problems of differentiated instruction confront at present that have been solved with enhancement of smart education?

1.2 Research Objectives

This research attempts to construct smart differentiated instruction system and investigate it in practice, as well as to explore the ways which differentiated instruction can be realized in smart education and using the conditions of it, so that providing reference for the practice and promotion of differentiated instruction in China. The research objectives are as follows:

To study how to use smart education environment to enhance differentiated instruction.

To explore which the problems of differentiated instruction confront at present that has been solved with enhancement of smart education.

2. Literature Review

2.1 Differentiated Instruction

Differentiated instruction is widely known and achieved attention of researchers and educators around the world (Subban & Round, 2015; Tomlinson, 2000). Differentiated instruction is considered as a teaching approach which is flexible, adjustable and focused on the student diversity (Palieraki & Koutrouba, 2021). Teachers need to consider and plan multiple approaches for students, in order to maximize the growth and potential of their students based on their individual needs (Tomlinson, 1999). Tomlinson and Imbeau (2010) stated that differentiated instruction was a philosophy, a way of thinking about teaching and learning. Smale-Jacobse et al. (2019) agreed that differentiation is “a philosophy of teaching rooted in deep respect for students, acknowledgment of their differences, and the drive to help all students thrive”. Others (Deunk, 2018) considered it as a teaching method or educational strategy. In China, differentiated instruction also mostly seen as a strategy or method for improving teaching (Liang, 2018).

Existing literature has recorded that differentiated instruction has a positive impact on learners' development and achievement, critical thinking, learning motivation, self-perception and attitude, communication skills (Al-Shaboul, Al-Azaizeh & Al-Dosari, 2021).

Differentiated instruction is consistent with the theoretical hypothesis of constructivism (Millen & Gable, 2016). In a quasi-experimental study, students in classrooms with differentiated instruction performed better than those in classrooms with no differentiated instruction (Valiandes, 2015). Other researches revealed that differentiated instruction can also narrow the achievement gap of students, improve the relationship between students and teachers and educators, increase students' learning motivation (Ginja & Chen, 2020), improve their attitude towards learning and knowledge acquisition, improve students' performance, and improve their ability and talent (Al-Rsa'I & Shugairat, 2019).

Although differentiated instruction is considered effective for students' academic development in the existing literature, teachers and students are confronted with many challenges due to various factors in the implementation process. The main challenges of its implementation come from the complexity of its own operation, the limited number of well-trained teachers, teachers' attitude and belief towards differentiated instruction, the large class size, the insufficient facilities and other factors (Ginja & Chen, 2020). As mentioned earlier, technological developments have brought opportunities to address the operational difficulties of differentiated instruction, such as scholars have designed and developed a prototype of a user-centered intelligent tool that can be used to help teachers practice differentiated teaching in the classroom (Cha & Ahn, 2020). At the same time, according to the existing literature, differentiated instruction is implemented in the traditional classroom teaching environment, so there is an important gap in current research whether the transformation of teaching environment can help solve the current challenges of differentiated instruction.

2.2 Smart Education

Smart education, as the integration of technology into education, is an advanced form of educational informatics, causing changes in the teaching philosophy, teaching models, teaching methods and learning styles (Martín, Alario-Hoyos & Kloos, 2019; Morgado, Lencastre & et al, 2021). In the past decade, smart education has attracted more researchers. The Figure.1 below is a visualization of a search on the CNKI database in China using the subject term "smart education", based on the results, depicting the trending trend of growth in smart education research over the past decade, from 581 articles in 2016 to 1373 articles in 2021. During the five-year period, the number of publications has nearly tripled. In 2020, Covid-19 hit the world, which was the real turning point for smart education researches. China began to put forward to build smart education in the national level in 2021.

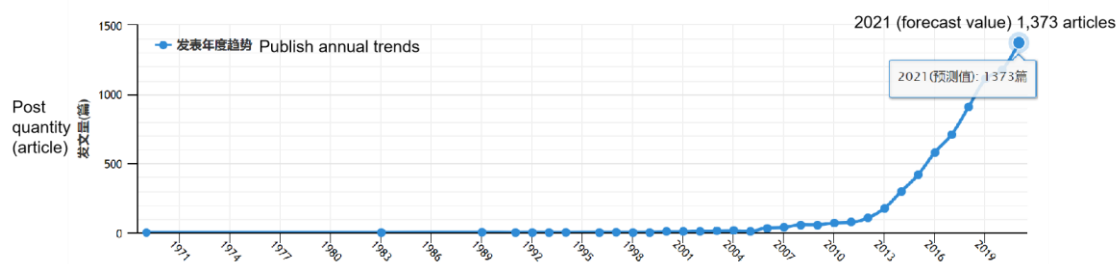


Figure 1: Trends in smart education research, taking the CNKI database as an example

The researches of Smart Education focused on how teachers can change their teaching philosophy from traditional teaching to information-based teaching and master the necessary information technology to better control the classroom under new teaching formats (Yan, & Zhu, 2020); the design of classroom teaching with the assistance of intelligent teaching systems (Zhu, Z.T., 2021; Zhao, & Yu, 2021; Daniela, 2018), rich teaching resources through personalized recommendations based on big data and student data profiling systems (Zheng, Dong, & et al., 2019), intelligent online question-answering and refined dynamic assessment of learners' learning outcomes (Zhu, Z.T., 2021; Galina & Natalia, 2018); exploring different pedagogies for smart education, such as class-based differentiated instruction, group-based collaborative instruction (Zhu, Yu, & Riezebos, 2016) and inquiry-based, experiential, and interactive instruction; among the changes in learning strategies, researchers have proposed class-based flipped classroom, individual-based personalized learning and mass-based generative learning (Uskov, Bakken & et al, 2017).

2.3 Smart education calls for a new teaching mode

The ideal of smart education is student-centred, teacher-led and technology-assisted, with an intelligent, pervasive and personalised teaching and learning experience that enables the generation and development of learner smart (Zhu, & He, 2012). However, the mainstream teaching and learning model in schools is still dominated by the teacher-centred, one-way lecture and passive reception by students and its variants (Wang, & Li, 2021). The inherent contradiction between the concept of smart education and the mainstream teaching model is becoming more and more prominent. At the same time, in the traditional "full classroom" model of teaching, technology and subject teaching are superficially integrated into the teaching process, even as it reinforces the traditional model of teacher-controlled, student-passive, knowledge-replicating teaching and learning (He, 2018). Smart education has broken through traditional classroom teaching during the New Coronary Pneumonia epidemic and in the post-epidemic era, transforming the time and space of teaching and realising teaching forms such as MOOC, flipped classroom and blended teaching, but in practice, some teachers still use traditional teaching methods to prove the above point. At the same time, the

new generation of students, known as “digital natives”, who is the targets of smart education, have changed their cognitive, attitudinal and behavioural habits (Huang, Liu, & et al, 2019). As a result, the call for new teaching and learning models is growing, and the development of smart education is facing a “crisis of teaching and learning models” (Huang, 2014) and the question “Why is the essence of education and teaching not fundamentally changed while technology is booming?” questioned (Yu, & Chen, 2018). Professor He Ke-kou (2015), a Chinese scholar known for his research on the structure of teaching and learning, argues that research and innovation is required to effectively transform the traditional teaching and learning structure of teaching and learning. Therefore, according to the essence and philosophy of smart education, the new teaching model faces a more diverse range of learners, with features such as pedagogical multiplicity, pathways and assessment plurality. Among them, new technological tools and platforms conform to the rules and characteristics of application in classroom teaching, promoting student cognition and contextual teaching (Wang, 2015); teaching formats are not limited to face-to-face; teaching objectives change from teaching to development, and teaching methods are mainly self-directed, cooperative and inquiry-based learning (Hu, Liu, & et al, 2019); teacher-student relationships are teacher-led and student-led; the teaching platform realizes resourcefulness, intelligent guidance, accurate reference and multiple assessments; and provides students with adaptive learning content and personalized services around their individual characteristics and different needs (Huang, R.H., 2014).

2.4 Differentiated instruction needs to be supported by new forms of education

According to the review of research on differentiated instruction, it is clear that differentiated instruction is likewise faced in practice with the constraints limited by traditional teaching and learning and the expectation of a new educational form or educational ecosystem suitable for the smooth practice and development of differentiated instruction. This is because effective pedagogical methods have to be adapted for the new model of organization and development of education, combined with the need and use of differentiated learning through modern methods adapted to students' individual characteristics of knowledge (Niculescu & Obilişteanu, 2016). Differentiated instruction follows the concept of student-centre, respect for students' differences and the service of their individual development, and to a large extent fits with the individuality, precision, optimisation and collaboration of smart education (Zhu, Z.T., 2021). In exploring teaching models suitable for smart education, Zhu (2021) mentions that differentiated instruction, precision teaching and adaptive learning are suitable for smart education, among which he believes that differentiated instruction is better. Differentiated instruction in the face of the increasingly diverse differences of students, teachers cannot assess the individual characteristics of these differences with their own existing experience. The smart technology-backed platform in smart education, on the other hand, can use big data

to profile learners, effectively solving the difficulties of teachers who are tired and find it difficult to assess students' differences objectively (Peng, & Zhu, 2021). In addition, the advantages that smart education has over traditional education allow teachers to save more time and effort when using differentiated instruction, as well as to use the rich educational resources of smart education to meet the individual needs of students based on accurate algorithms to achieve precise education. The organisation of the differentiated instruction process is also made easier in the flexible smart classroom. The assessment of learning effectiveness is achieved dynamically through educational platforms and enables learning prediction for students (Yang, Li, & Wang, 2019). In short, the dilemmas encountered in differentiated instruction can be resolved in the smart education with the help of intelligent technology. This may be a technologically optimistic idea, but the new pedagogical ecology built by smart education gives new hope for the optimization and development of differentiated instruction (He,2018). For example, it brings the visualization of knowledge presentation, the ease and speed of teaching feedback, the rapid and massive collection of data, and the accurate recommendation of learning resources.

Through the above literature, the hand in hand between smart education and differentiated instruction is based on the common need for personalisation, flexibility and creativity in the classroom, and the educational equity embedded in the philosophy of both, which aims at promoting the holistic and free development of human beings (Tang, 2018; Peng, et al, 2018). Both smart education and differentiated instruction are attempts by researchers to change situation that traditional education is not suitable for modernizing education, with the intention of breaking down the various barriers that exist in traditional instruction that restricts learners from being able to get the most out of their development according to their individual characteristics (Liu, 2017). However, the existing literature is still seldom to research how to integrate smart education with differentiated instruction to achieve the talent development goals of modern education. Therefore, the design of this research practice differentiated instruction in the context of smart education, will focus on making their two-way virtuous cycle and promoting each other that truly achieves effective teaching, engaged teaching, and relaxed teaching (Huang, 2014), so that the two will not be a gimmick of modern education and lose the concept of education (Zhao, Z.G., & et al, 2021).

3. Methodology

3.1 Research design

This study intends to use descriptive research method, and the research design is exploratory research. This study intends to design a differentiated instruction model under smart education and explore how to practice it in two classes of a university. The sample for this study was from class1907 and 1908 in Major Network Engineering, with 94 students, 77 boys and 14

girls. There are 47 students (39 boys and 8 girls) in Class 1907 and 38 boys and 9 girls in Class 1908. The data of this study mainly came from the evaluation of teaching quality and the questionnaire survey of the students on the teaching platform.

3.2 Research Framework

Based on the Tomlinson's classical difference teaching model (1999), the smart differentiated instruction system is designed. The system takes pre-class, in-class and after-class as nodes. The data integration of Data cloud platform from smart Education is used before class to Portrait for students, so as to facilitate teachers to know about the status of learners before class and design differentiated objectives. The cloud teaching the resource platform is used to establish a resource database and push differentiated learning materials before class according to students' data portraits. In class, the environment of the smart classroom is used to assist teachers in differentiated instruction, and dynamically adjust the teaching content, progress and method. After class, teachers conduct a learning evaluation according to the teaching platform, and use the data platform to track the students' learning effect. In order to know about the results of smart differentiated instruction, analysis the data from evaluation of instructional quality in the teaching platform and questionnaires.

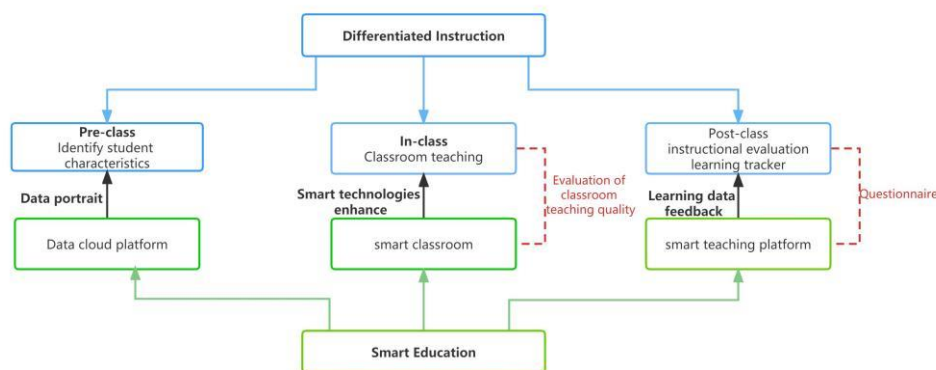


Figure 2: Research Framework

4. Results and Discussion

The construction of smart differentiated instruction system should take students as the centre (Laid, Zhang, & Chang, 2010). On the basis of respecting students' the original difference and ensuring the quality of talent training, using smart education technology provides personalized learning support for students and provides technical support for teachers' teaching, maximizes the satisfaction of students diversity and differentiation learning needs (Lu, 2021), in order to solve the problems that teachers face in the process of operating differentiated instruction.

4.1 Students data portrait helps solve the problem that teachers cannot distinguish student differences.

Big data decentralized educational administration system, teaching platform, student business system, campus card system, access control system, library system, network billing system and other information systems (Deng, 2019). Through the convergence and fusion of transaction data, monitoring data, external reference data and process data in various intelligent education systems through algorithms, students' behaviors in school can be visualized. Through the method of "data portrait", vivid "panoramic individual" can be carefully drawn, and three-dimensional presentation of students' differences, such as native place, grades, hobbies and so on. For example, through the entrance survey to understand the basic information of a grade of students in the major Computer Science and Technology (Shi, Peng, & Tong, 2019). The situation of students in Class 1907 and 1908 can see the table 1 as follows which can compare the basic situation of students in this class and other classes or other majors. The information data of Class 1907 and 1908 collected from the "Reading Activity" held in the platform is shown in Table 2. The score given by the dynamic information of students participating in the reading activity, the higher score is, the more students are interested in reading. Two separate tables, unless the teacher carries out the correlation analysis, will not be able to know the relationship between data and data and reveal students' interest tendency, behavior tendency and so on. Therefore, by relying on big data operation, the data of the two tables can be fused to help teachers quickly and directly understand the correlation behind the data of students' behavior and better understand students. This improves the accuracy and efficiency of teachers in identifying differences among students.

Table 1: Excerpts from the student basic information data

Name	Faculty	Major	Class	Occupational Aspiration
Zhang Sheng	Faculty of Computer	Network Engineering	1907	Program Manager
Wang Qiang	Faculty of Computer	Network Engineering	1907	Developer Programmer
Chen Hao	Faculty of Computer	Network Engineering	1908	Network Engineering Developer Programmer

Table 2: Excerpt from dynamic information data of students in "Reading Activities"

Book Name	Zhang Sheng	Wang Qiang	Chen Hao
Management (13th Edition)	null	0	2

How will the Black Swan cope with the unpredictable future	10	null	0
AI product Manager - PM Training Manual in AI era	6	0	4
Classic examples of Python Machine Learning	4	8	8
Deep Learning Algorithm Principle of Tensor Flow and Programming Practice	8	10	null

“0” means that the book does not match the students’ major/interest, and “null” means that the book matches the student’s major/interest but is not read.

4.2 Smart classroom assists to solve difficulties of the complicate implementation of differentiated instruction.

Smart classroom has become equipped with wireless communication personal digital equipment sensors and virtual learning platforms, and has become a high-tech classroom with intelligent characteristics such as personality coordination, intelligent tracking tools, and intelligent activities (Jin, Xing, & Yang, 2019). Smart classroom is not only the current “intelligent control classroom”, but on the basis of intelligent control, it should use 4K High-Definition live broadcasting, holographic projection teaching, AR immersive interactive learning and other teaching methods, and more importantly, add the wisdom of artificial intelligence. Artificial intelligence technology is used to assist the teaching process, with artificial intelligence acting as the “teaching assistant”. Through the data-intelligent teaching platform, this “teaching assistant” helps teachers realize the analysis of the influence of learning behavior, the analysis of the path of learning behavior and the correlation analysis of students’ behavior, timely adjust teaching and give students more needed, more interested and easier to understand knowledge (Deng, Xu, & Hou, 2020).



Figure 3: Students participate in smart classroom

Smart classroom provides students with a more suitable and comfortable learning environment (Ioannou & Ioannou, 2020). In order to know about students' satisfaction about teaching in smart classroom with using differentiated instruction, students need to participate in teaching evaluation activities in the educational administration system after the end of the course. From the class of 1907 and 1908, the number of students participating in the evaluation was 94, and the number of effective students participating in the evaluation was 84. The total score of teacher evaluation after calculation was 90.6129. From Rows 3, 6, 7, and 8 of Table 3, most students agree with the implementation of differentiated instruction in the smart classroom.

Table 3: Results of teacher teaching quality evaluation

Evaluation Index	Single Average	Satisf-action	Weigh-tiness	A (Score 92)	B (80)	C (70)	D (60)	E (50)
1. Teaching objectives is clear.	91.14	91.143	0.3	78	6			
2. Teaching content is substantial, the knowledge point is clear, the information is rich, and teacher can pay attention to the academic front trends of the subject.	90.71	90.714	0.3	75	9			
3. Teacher teaches content of moderate depth and difficulty, and can provide appropriate bibliography and guidance for students' different needs.	90	90	0.4	70	14			
4. Good interaction between teaching and learning.	91.14	91.143	0.2	78	6			
5. The teaching method is appropriate and practical for students to understand and use.	91	91	0.2	77	7			
6. The teaching language is vivid and easy to understand; Teacher is good at solving the difficult points, pays attention to the cultivation of students' innovative consciousness and ability, encourage independent thinking, and pay attention to the optimization of	91.14	91.143	0.2	78	6			

students' learning methods.								
7. Homework and examination forms are various, and can be timely correction and guidance, fair and reasonable score.	91	91	0.2	77	7			
8. Be good at using all kinds of modern teaching means.	90.29	90.286	0.2	72	12			
9. Fair and friendly to students, but also strict requirements.	91	91	0.25	77	7			
10. Rich professional knowledge and good teaching skills.	91	91	0.25	77	7			
11. The teaching language is accurate and standardized, the teaching mood is full, and the teaching style is simple and confident.	91	91	0.25	77	7			
12. Teacher has strong teaching organization management ability and communication and coordination ability, and can fully and effectively control and use the teaching time and space.	88.43	88.429	0.25	59	25			
13. Compared with other teachers, your overall evaluation of this teacher is:	90.29	90.286	1	72	12			

4.3 Different learning evaluation is accepted to solve the problem of accurately differentiated instruction evaluation.

Evaluation is a difficult problem in differential teaching. Evaluation includes process evaluation and result evaluation. Usually, it is easy for teachers to complete the result evaluation, but there is also the problem of single evaluation method (Yu, 2021). What is more important is that teachers often neglect the process evaluation because of limited time and energy (Yan, 2021). Therefore, with the help of the above big data technology, this study implemented the activity of "Annual Student Report". This activity is the collection and statistics of students' behavior data in a year. Students' data portraits are classified into data labels. Different data labels represent different student conditions. Secondly, according to

different data labels, 88 different learning evaluation messages are written, which are classified and pushed according to different data images of students. After logging in to the campus platform, students of the two classes can see their learning and living conditions in the past year in the form of three-dimensional data display. In the subsequent questionnaire survey, students' satisfaction with personality evaluation formed by this activity is shown in Figure 4.

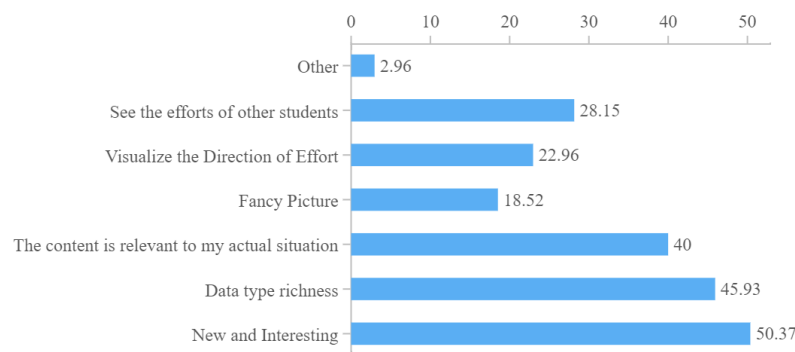


Figure 4: Students' Satisfaction

This preliminary practice research uses the data and visualization advantages of big data technology, so that students can intuitively understand their own learning and living conditions, which is also a way to guide students to review their status in the past year, and remind students to do a good job in the new year's learning career planning. In this practice, students' preferences are obtained from the data platform. The content of the annual evaluation closely centers on students' preferences. In particular, personalized comments empower students with positive words, awaken students' inner strength, and encourage students to understand the current situation, face up to the current situation, change the current situation, and break through the current situation.

5. Conclusion

The starting point of smart education is to serve teaching. This study tries to construct a differentiated instruction mode assisted by smart education and puts it into practice. The results show that the technology and platform in smart education solve some problems of traditional differentiated instruction, provide a more comfortable learning environment with the help of smart classroom, adapt to the trend of education informatization and future talent cultivation and development, and guide students to gradually complete various learning exercises. Smart education enhances differentiated instruction to achieve the predetermined training goals and the essence of teaching quality improvement services. This kind of teaching mode reform is the significance of "smart education" and also the trend of differentiated

education development in the future.

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