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The Smart Classroom Practices in Science Courses

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Abstract: "Mathematical Analysis" is one of the most important basic courses in college mathematics, but there have always been many problems in teaching. Under the background of building "Digital China", the pace of educational informatization is also advancing continuously. This paper deeply integrates informatization means with the teaching of "Mathematical Analysis" course, constructs and implements the intelligent classroom teaching of "Mathematical Analysis", changes the traditional classroom teaching mode dominated by teaching, carries out student-centered progressive teaching, implements precision teaching, extends the classroom to all dimensions of time and space, and cultivates students' mathematical thinking ability and innovation ability.

Keywords: Smart Classroom; Smart Education; Mathematical Analysis; Information Technology; Precision Teaching

1. Introduction

Enabled by intelligent technology, it promotes the research on educational reform. The reform and innovation of education and teaching are not only the integration of forms but also the innovation of ideas. "Mathematical Analysis" is one of the professional courses that mathematics majors first learn when they enter the university. It has strong logic, rich content, and tight class hours. The traditional teaching mode mainly adopts classroom teaching and is supplemented by after-class homework. This research attempts to explore the practice of intelligent classroom teaching, with teaching in intelligent classrooms and the assistance of intelligent teaching platforms. The classroom forms are diverse, with accurate positioning before class, consolidation and expansion after class, the classroom expands in time and space, the learning methods are flexible, fully mobilizing students' learning enthusiasm, and creating a brand-new learning scene and learning situation.

2. Research Ideas

2.1 Research Status

The main members of our research team have been teaching the course "Mathematical Analysis" for more than ten years. In the past teaching process, we have found the following main problems. First, due to different students' mathematical foundations, as the course progresses, polarization will occur, causing some students to gradually lose interest in mathematics learning and thus develop a fear of difficulties. Over time, it becomes difficult for disadvantaged students to obtain a sense of learning achievement. Second, since classroom teaching is mainly conducted by teachers and there is a lot of content in each class, students only passively listen and cannot actively interact with teachers. The classroom atmosphere is relatively dull. Third, although most students can understand the lectures, they still have difficulty completing exercises smoothly. Especially for proof problems. Although they can understand the proof, it seems even more difficult for most students to write the proof accurately, rigorously, and concisely in mathematical language and symbols. In short, the current teaching is difficult to achieve the goal of cultivating students' mathematical thinking ability and innovation ability [1].

With the continuous advancement of educational informatization, many teachers in

the mathematics discipline have tried to use informatization means to optimize education and teaching. For example, Liu and Wu proposed that the use of information technology in mathematics education is conducive to showing abstract thinking and enhancing the understanding of the relevance of mathematical objects. [2] Wang 's research found that augmented reality technology has different degrees of influence on learning in different fields of mathematics. The effect of assisting geometry learning is significant and it promotes students' learning motivation. It has a greater impact on those with low learning achievements in mathematics. [3] Liu et al. carried out research and practice on intelligent teaching relying on intelligent classrooms. They mainly applied the presentation and interaction functions of intelligent classrooms to optimize classroom teaching, but the resource library and mathematical functions are used less. [4]

2.2 Theoretical Basis

The learning pyramid theory was proposed by the famous learning expert Edgar Dale. In the learning pyramid, listening, reading, audio-visual learning, and demonstration belong to passive learning. Discussion, practice, and teaching others belong to active learning. It shows in numerical form that the learning effects of traditional methods such as individual learning or passive learning are all below 30%, while the learning effects of team learning, active learning, and participatory learning are above 50%. [5]

Smart education refers to when teachers implement efficient teaching methods in a technology-integrated learning environment. Learners experience appropriate personalized learning services, making teaching possible where it was previously impossible and enhancing capabilities. Thus, it cultivates talents with good value orientations, strong action abilities, excellent thinking qualities, and deep creative potentials. [6]

Smart classroom refers to, with the support of information technology, by transforming teaching methods and integrating technology into classroom teaching, constructing a personalized, intelligent, and digital classroom learning environment, thus effectively promoting the cultivation of wisdom abilities. [7]

2.3 Path to Achieve the Goal

Inspired by theories such as the learning pyramid theory and smart education, this research uses information technology means to conduct smart classroom teaching in all aspects of teaching, learning, and evaluation. Teachers continuously improve teaching in a cyclical manner, and students master knowledge in a progressive way. Based on Sun Shuhui's smart classroom teaching structure [8], the "12+10 process" structure is proposed, as shown in Figure 1 specifically.

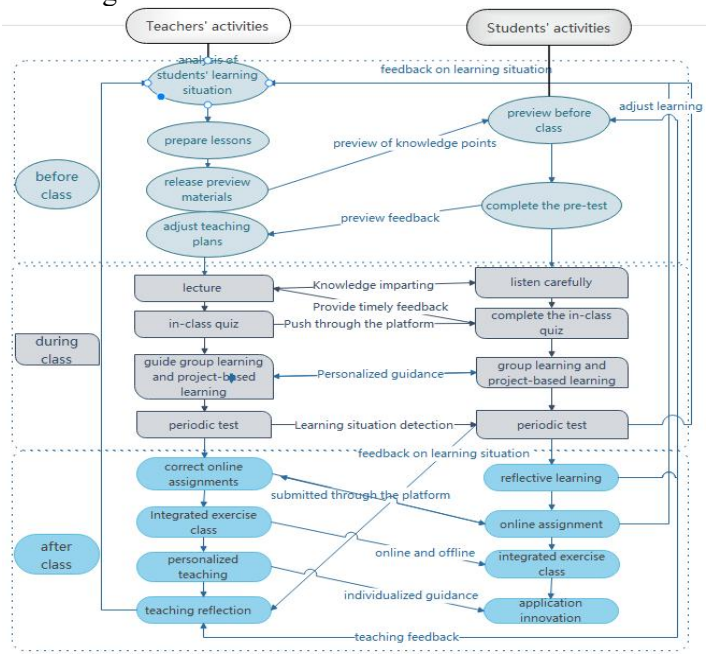

Figure 1. "12+10" Smart Classroom Model

3. Smart Classroom Teaching Practice

This research takes the 2023 students majoring in mathematics and applied mathematics at Zhejiang Normal University as the research object. The second semester of the "Mathematical Analysis" (hereinafter referred to as "Mathematical Analysis II") course is selected as the practical research. There are a total of 67 research objects. The classroom teaching reform relies on smart classrooms and the smart teaching platform (Rain Classroom), which not only has the charm of classroom teaching experience but also the spatio-temporal extensibility and convenient interaction of the smart teaching platform. Utilizing the characteristics of mathematics itself, aiming at the difficulties and doubts in teaching and the particularity of methods for solving mathematical problems, to achieve precise teaching, shifting from "imparting knowledge" to "cultivating wisdom", and using intelligent methods to cultivate students' wisdom literacy [9], as well as cultivating students' mathematical discovery ability, mathematical argumentation ability, and expression ability. This research is based on the "12+10" smart classroom model and unfolds from three dimensions of "teaching", "learning", and "evaluation".

3.1 Smart Classrooms Change the Way Teachers "Teach" and Focus on Inspiring and Guiding Students' Mathematical Thinking Processes

Taking the section "Basic theorems on the completeness of the set of real numbers" as an example. This is an important concept in mathematical analysis.

(1) Guided learning before class, being well-prepared for learning and having a guide for teaching.

The teacher releases preview content on Rain Classroom three days before class, asking students to review the content and proof process of the three important theorems: the principle of supremum and infimum, the monotone bounded theorem, and the Cauchy convergence criterion.

(2) Teaching in class, smart classroom, highlighting charm.

In the physical classroom, the teacher first conducts a test of students' preview effect through Rain Classroom. All students are asked to narrate the content of the three theorems previewed. Three students are randomly selected to give the proof process of the three theorems respectively. The projection function is used for display, so the teacher can test the preview effect on the spot. Combining PPT and using blackboard writing, the content and proof process of the nested interval theorem, the finite covering theorem, and the accumulation point theorem are given. The digital function of blackboard writing in the smart classroom is used to completely record the blackboard writing process. When students watch the video again, they can reason again following the blackboard writing to check for omissions and fill in gaps. During the process of narrating these three theorems, the teacher inserts some classroom tests through Rain Classroom, such as "distinguish which ones are nested intervals" and "use the finite covering theorem to prove the boundedness of continuous functions on a closed interval". This helps to grasp students' understanding of concepts and the application of theorems in a timely manner. Smart classrooms can also be demonstrated with the help of auxiliary tools. For example, during the process of explaining the nested interval theorem, the teacher uses Geometer's Sketchpad to dynamically display the conclusion of the theorem, allowing students to understand the theorem more intuitively. The teacher uses the live streaming function of Rain Classroom to record the entire classroom process. In the smart classroom, it is convenient for teachers to carry out various teaching methods, which is beneficial for classroom interaction between teachers and students and among students.

(3) Review after class, online and offline, classroom expansion. The teacher releases after-class assignments and some relevant online learning resources on Rain Classroom, such as "The Origin of Numbers" on Bilibili. In the limited classroom teaching time, due to differences in students' acceptance abilities, some students may have problems of not understanding or keeping up. Using Rain Classroom, students can view classroom videos at any time. By watching videos to review knowledge points, they can find and solve difficult problems in a timely manner. For other doubts, they can mark as "don't understand" and give feedback to the teacher. For example, in this class, students marked the

"finite covering theorem" the most, indicating that students still cannot understand this theorem well. The teacher replies to students' questions in a timely manner on the platform and reviews it in time in the next class to achieve precise teaching. This also helps with differentiated and personalized learning and guidance. Reviewing helps to solve doubts and gain new knowledge. This course adopts a combination of online and offline exercise classes, which solves the problem that it is difficult for teachers and students to arrange exercise classes at a suitable time outside of normal teaching. The explanations are more targeted, and students who cannot be present can also choose a time to watch the exercise class again.

3.2 Smart Classrooms Change the Way Students "Learn" and Fully Train Students' Mathematical Thinking Abilities.

(1) Goal-oriented learning with timely and effective feedback. The learning of mathematics is inseparable from practice. After-class exercises are the understanding and application of mathematical thinking. In the past, there was a time lag in submitting, grading, and returning assignments. This research uses the assignment submission function of Rain Classroom. Students can take a photo and upload their completed assignments or directly write and submit assignments on a tablet. Teachers can conveniently grade assignments through Rain Classroom and give feedback to students in a timely manner. By promptly grasping the learning situation through the problems reflected in the assignments and giving students feedback on the current learning content in a timely manner, it can promote students' effective learning.

(2) TBL (Team-Based Learning) promotes collaborative progress. Utilize the advantages of smart classrooms to carry out group learning (Team-Based Learning, abbreviated as TBL), and fully utilize educational technology means to build students' learning motivation and ability. Students with different mathematical foundations form groups. Mutual help can be formed within the group so that students with poor foundations will not fall behind. Group members must complete assignments independently, and the group also needs to complete some assignments together. For example, in the teaching of "Basic theorems on the completeness of the set of real numbers", the teacher forms groups of three people to jointly complete the "proof of the equivalence of two of the six basic theorems on the completeness of real numbers". After having a group, a group discussion session can be added in the classroom to increase interaction between teachers and students and competition among groups, thus enlivening the classroom atmosphere and no longer making mathematics classes lifeless. Through TBL, students' ability to prove propositions in mathematical language can be improved. Group members can grade and discuss proof problems, and get feedback in a timely manner. This allows students to understand the description of mathematical language symbols in proofs as soon as possible and judge whether each step is correct. Let group members represent each group to demonstrate in class so that teachers can judge students' mastery of proof problems and further improve teaching strategies.

(3) PBL promotes students' in-depth learning. Project-Based Learning (abbreviated as TBL) promotes learning through reporting and presentation to find the gap between what one has learned and what one has mastered. For example, in the middle and later stages of this course, students can choose one of the projects such as "the difference between improper integrals and definite integrals", "methods for finding indefinite integrals", "classes of integrable functions", etc., conduct in-depth research, complete course papers and give reports. This research deepens observation and presentation into the course and improves learners' enthusiasm for learning. As mentioned in "On Teachers", "It is difficult for people to have no doubts." Observation and presentation require digesting and understanding one's existing knowledge points. Driven by goal tasks, students digest course content, organize presentation content, and their logical thinking is fully exercised. [10]

3.3 Dynamic and Static Evaluations Covering the Whole Process

Traditional teaching only sets final exams to test the learning level of a semester. Smart classrooms make teaching evaluations diversified. In addition to static evaluations such as two formal written exams in the

middle and end of the term, it also adds in-class tests, assignments, group learning, project-based learning evaluations, etc., and launches diversified dynamic evaluations covering the whole process. Students can better grasp their own learning status and adjust and improve learning efficiency in a timely manner.

Students' total course evaluation scores = in-class tests (10%) + assignments (10%) + group learning (10%) + course papers (20%) + midterm exams (20%) + final exams (30%).

4. Analysis of the Practical Effect of Smart Classrooms

To test whether smart classroom teaching is effective and understand students' satisfaction with smart classroom practice, comparative analysis is conducted through SPSS software.

4.1 Score Analysis

A paired samples t-test is conducted on the scores of Mathematical Analysis I (before the implementation of smart classrooms) and Mathematical Analysis II (after the implementation of smart classrooms). The test results are shown in Table 1. It is found that after one semester of smart classroom teaching practice, students' scores in Mathematical Analysis have been significantly improved ($t(66) = -9.997$, $p<0.001$).

Table 1. Paired Samples T-test of Scores before and after Smart Classroom

	Paired differences					t
	Mean	Standard deviation	Standard error of the mean	95% confidence interval of the difference		
				Lower limit	Upper limit	
Mathematical Analysis I-Mathematical Analysis II	-15.985	13.088	1.599	-19.177	-12.793	-9.997***

Note: *p<0.05; **p<0.01; ***p<0.001

In order to further understand whether the pass rate and excellent rate of students have improved, a chi-square test was performed on the pass rate (60 points for passing) and excellent rate (90 points for excellence) of the scores of and Mathematical Analysis II. The results are shown in Table 2. As can be seen from the table, the excellent rate of Mathematical Analysis II has slightly increased, and the pass rate has greatly increased. There is a significant difference in the pass rates of the two scores ($\chi 2 = 24.638$, $p < 0.01$).

Table 2. Difference Analysis of Excellent Rate and Pass Rate before and after Smart Classroom

	Excellent rate		χ^2	Pass rate		χ^2
	Not excellent	Excellent		Not qualified	Qualified	
Mathematical Analysis I	98.5%	1.5%	2.792	59.7%	40.3%	24.638**
Mathematical Analysis II	92.5%	7.5%		17.9%	82.1%	

Note: *p<0.05; **p<0.01

4.2 Analysis of Smart Classroom Satisfaction Questionnaire Survey

To further understand students' feelings about using smart classrooms, we designed a smart classroom satisfaction questionnaire. The questionnaire uses a 5-point Likert scale and conducts investigations from aspects such as satisfaction with the smart classroom teaching environment and satisfaction with the smart classroom teaching effect. Satisfaction with the teaching environment includes satisfaction with various aspects such as hardware facilities, sound effects, desk and chair conditions, and teacher's proficiency in operation. Satisfaction with teaching effect is investigated from aspects such as whether it is helpful for pre-class preview and post-class review, whether it is helpful for promoting teacher-student interaction and carrying out group cooperation, and whether it is helpful for improving learning enthusiasm and teaching efficiency.

A total of 67 questionnaires were distributed this time, and 67 valid questionnaires were retrieved. First, the reliability and validity of this questionnaire were analyzed. Through reliability tests on dimensions such as teaching environment satisfaction and teaching effect as well as the total scale, the Cronbach's alpha coefficients are 0.863, 0.946, and 0.955 respectively. It can be seen that the reliability of each dimension and the total scale is relatively high. Through factor analysis of the scale, it is found that the KMO value is 0.908, and the concomitant probability of Bartlett's sphericity test is 0, which is less than 0.05, indicating that this scale has good structural

validity. The questionnaire survey found that students participating in smart classroom teaching have relatively high satisfaction with the smart classroom environment and the smart classroom teaching effect, with mean values all above 4.4. The mean values of satisfaction with various indicators of smart classroom teaching effect are also basically above 4.4. All mean values are above 4.2. Among them, the satisfaction with the playback function is the highest, with a mean value reaching 4.78. The satisfaction of some indicators of smart classroom teaching effect is shown in Table 3.

When asked what is the most attractive feature in smart classrooms, 62 out of 67 students chose "being able to review courses after class", accounting for 92.5% of the total number. In the survey on whether students review after class, it is found that 98.5% of students will consolidate knowledge points by reviewing classroom videos. Among them, 70.1% of students often review by watching videos. The video review function of smart classrooms is deeply loved by students and has become a part of the learning of most students. In the survey on which type of classroom students like to have classes in, 94% of students choose smart classrooms, and many students have expressed positive evaluations (for example, "very good", "quite good", etc.). It can be seen that smart classroom teaching has brought them a completely new and good experience. Students generally like the teaching environment, teaching form and learning atmosphere of smart classrooms.

Table 3. Descriptive Statistics of Satisfaction of Some Indicators of Smart Classroom Teaching Effect

	N	Minimum value	Maximum value	Mean	Standard deviation
Smart classroom is very helpful in the preview link before class	67	2	5	4.22	.867
High teaching efficiency	67	2	5	4.60	.605
The form of information transmission is more abundant	67	1	5	4.63	.693
The classroom atmosphere is very lively	67	3	5	4.43	.701
Students are more active in participating in learning	67	2	5	4.42	.762
The interaction between students and teachers in smart classroom is more frequent	67	2	5	4.36	.773
The classroom test link is very helpful	67	3	5	4.57	.633
The group discussion function can promote communication between student groups	67	2	5	4.40	.818
The after-class review link is very helpful	67	3	5	4.78	.517
Acceptance of using Rain Classroom (online) to explain exercise classes	67	1	5	4.45	.840
Teaching in a smart classroom is very helpful for learning "Mathematical Analysis"	67	1	5	4.55	.744
The form of grouping is very helpful for learning "Mathematical Analysis"	67	2	5	4.36	.811

5. Research Conclusions

5.1 Smart Classrooms Make Teaching and Learning More Precise, and Teachers and Students Become a Community of Learning

University teachers generally have studied deeply in their respective professional fields for many years and have sufficient knowledge reserves. They are already very familiar with professional knowledge, creating a knowledge gap with college students who have just entered school. Especially for science and engineering disciplines like mathematics, students feel that the subject knowledge is unfathomable before they get started, but teachers find it so simple that they cannot understand the difficulties students have in learning. Through this classroom reform, teachers learn how to provide more precise teaching assistance through various feedback from students, and students and teachers become a community of learning.

5.2 Smart Classrooms Combine the Advantages of Traditional Teaching Methods and information Technology

The unique feature of traditional teaching methods is that through means such as blackboards, chalk, on-site calculations and blackboard writing, the teacher's teaching process is basically synchronized with the students' understanding and thinking, thus being more conducive to the cultivation of students' imagination, understanding ability and thinking ability, and more conducive to students' perception, meaning construction and mastery of the knowledge and methods they have learned. Smart classrooms help students experience the teaching charm of teachers in physical space, the pleasure of face-to-face communication with peers, and the diverse experiences in the intelligent teaching environment. The unique feature of information technology is that it can make the visualization of knowledge presentation in the

form of dynamic, intuitive, high-speed and repeated reproduction. The teaching assistance platform is a continuation of classroom teaching and a tool for interaction and communication between teachers and students. The smart classroom teaching reform effectively integrates physical space and information space, improving the classroom teaching effect.

5.3 Smart Classrooms Fully Reflect Student-Centeredness

Professor Po-Shen Loh once said, "If I were to give Chinese math teachers a piece of advice, it would be to give students more time to exercise their thinking ability." [11]. Smart classrooms highlight students as the main body and attach importance to thinking training. The diversified thinking training of students before, during, and after class provides students with more thinking opportunities and time. The classroom is no longer a one-sided lecture. In the teaching process, independent learning ability is increased, thinking activity time is increased, and thinking depth is enhanced. Smart classrooms take into account the needs of students at all learning levels, are conducive to students' reflective learning, and are conducive to teachers to carry out personalized and differentiated teaching assistance. Teaching is more targeted and effective, enhancing students' learning confidence, stimulating students' interest, and truly allowing students to experience the fun of thinking and exploring mathematics learning, arousing their self-confidence and gradually cultivating their self-efficacy, and helping students gain a sense of accomplishment in learning.

6. Conclusion

Empowered by technology, smart classrooms bring a new experience to "Mathematical Analysis". The smart classroom teaching practice of the "Mathematical Analysis" course has received overall praise from students. However, some problems were also found during the research process. In terms of hardware, smart classrooms mainly consist of interactive projection and large-screen display, weakening the traditional blackboard writing function. For purely science and engineering disciplines, the blackboard writing function of traditional teaching is indispensable. It is hoped that in the construction of smart classrooms, in view of the needs of science and engineering courses, the digital blackboard writing function will be more perfect. In terms of group learning, teachers need to design group discussion questions more reasonably to effectively stimulate students' interest in discussion. Regarding the problem of differences between groups in group learning, in future teaching, the way of forming small group members still needs to be optimized to make the groups more balanced. In addition, the use of mobile phones in smart classrooms leads to insufficient concentration of students. And the live broadcast and playback function of the smart teaching platform makes some students think that they can watch the playback after class and not listen carefully in class.

In general, the practice of smart classrooms in this research has indeed brought some conveniences and promotional effects to students' learning and has achieved a certain degree of technology empowerment. However, there is still a long way to go to give full play to the greater role of smart education. For example, intelligent question banks, smart assignments, intelligent push, intelligent learning companions, etc. will all be our research directions in the future.

References

[1] Jin Lingyu, Fang Shaomei, Liu Wenyan. Some understandings and experiences of the teaching reform of Mathematical Analysis. College Mathematics, 2012, 28(04):25-30.

[2] Liu Yongmei, Wu Libao. Value analysis of information technology in promoting the education of basic mathematical thoughts. Journal of Mathematics Education, 2017, 26(01):41-46.

[3] Wang Luona. Review and prospect of the application status of augmented reality technology (AR) in mathematics education. Journal of Mathematics Education, 2020, 29(05):91-97.

[4] Liu Zhe, Su Xinbing, Du Xuanjie. Research on mathematics classroom teaching behavior in smart classroom environment. Journal of Mathematics Education, 2020, 29(04):44-51.

[5] Jiang Yanling, Xu Tong. Application and practice of the pyramid theory of learning

effectiveness in flipped classroom. China Educational Technology, 2014(07):133-138.
[6] Zhu Zhiting, He Bin. Smart education: A new realm of educational informatization. E-Education Research, 2012, 33(12):5-13.
[7] Tang Yewen, Pang Jingwen, Zhong Shaochun et al. Construction methods and case studies of smart classrooms in information technology environment. China Educational Technology, 2014(11):23-29.
[8] Sun Shuhui, Liu Bangqi. Smart Classroom. Beijing Normal University Press, 2016. Preface + 52.
[9] Chen Jing. Smart teaching model based on Whitehead's educational thought. Teaching and Management, 2014(18):114-116.
[10] Liu Qiaojue, Xing Lidong. Application and thinking of Feynman technique in undergraduate circuit courses. Guide of Science & Education (late issue), 2020, (03):156-157.
[11] Yuan Zhibin, Po-Shen Loh. The key to mathematics education: exploratory reading, computational reasoning, speculative communication, and happy learning - Dialogue with Professor Po-Shen Loh, head coach of the US national Olympic mathematics team. Journal of East China Normal University (Educational Sciences Edition), 2022, 40(04):117-126.