Construction of a Hybrid Learning Effectiveness Evaluation Model Based on Self-developed APP

Take the Actual Teaching Case of the Award-Winning Course "Signal and System" as an Example

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Abstract. At present, there are many blended teaching methods relying on the "Internet + Education" model, but most of them use existing software or online platforms, which inevitably leads to the problem of "less targeted and more limited". In addition, the data analysis for testing the effectiveness of blended learning is relatively single, which inevitably leads to the problem of insufficient persuasiveness and expressive power .

Committed to solving the above problems, this article first develops a course learning assistant app based on Android studio, and implements the function of students building learning mainlines online and revisiting knowledge points offline. Secondly, in order to test the learning effectiveness, a push forward evaluation model of "Online Participation and Gain Calculation - Offline Satisfaction and Improvement Estimation (PGC-SIE)" was proposed, which comprehensively analyzes the effectiveness of blended teaching and lays the foundation for building a course brand.

Keywords: Blended Teaching · Signal and System · APP Development · Evaluation Model

1 Introduction

Blended teaching [1] represented by the "online + offline" education normalization integration model is the general trend, and how to enhance learning performance and achieve quantitative evaluation is particularly important.

On the one hand, in recent years, in order to improve the quality of blended learning, the "information tools + blended learning" model has become the first choice for innovating existing solutions, which has gradually transformed information technology from an auxiliary means of teaching to an essential basic resource for teaching. According to relevant surveys [2], the total number of educational APPs in China has exceeded 70000, providing technical support for blended learning.

Typical apps include "Xiaochalkboard" [2], "Student's guide of super star learning" [3], "Rain Classroom" [4], etc. They not only provide functions such as classroom live

D. Kumar et al. (Eds.): IEIT 2023, AHSSEH 10, pp. 1116–1123, 2023.
https://doi.org/10.2991/978-94-6463-230-9_133

streaming, message board interaction, and homework correction to showcase the advantages of online learning, but also meets the needs of blended learning in the context of the "Internet + Education" era, with strong universality and wide applicability. However, such apps also have problems such as low matching of teaching resources and weak targeting, insufficient course integrity due to fragmented knowledge systems, and low readability and intuitiveness due to complex operating functions. From this, it can be seen that it is particularly important to design specialized APP tailored to the characteristics of the course and simplify the operating interface to help students build the course main line.

On the other hand, in order to comprehensively analyze the teaching effectiveness of the improved plan, scholars' evaluation model has gradually shifted from "combination of online and offline" to "combination of advanced technology and multimedia resources" [5] and "multiple mixing of teaching methods and evaluation applications". However, there are still issues with imprecise analysis results and overly broad footholds [6], so it is particularly important to establish targeted models to assess the mastery of course knowledge points.

This article focuses on the two key points mentioned above and completes the following two tasks: first, design a dedicated APP for this course to improve the teaching mode, and secondly, construct a refined evaluation model to achieve application innovation, ultimately achieving the purpose of providing substantive suggestions for the learning effectiveness evaluation of blended learning.

2 Development and Display of the "Signal and System" Learning Assistant APP

2.1 System Functional Architecture Design

The APP effectively connects teaching and learning, and its architecture design is shown in Fig. 1.

Before class, teachers will integrate resources and upload them to the platform for students to preview independently. Students discover questions from the knowledge map and obtain key and difficult points based on the questions during class. The corresponding functions of the APP mainly include knowledge map interface navigation, interactive recording and video sharing, and course mainline mind mapping.

After class, students will build a knowledge module upload platform by themselves, and the teacher will grade each module one by one to achieve individualized teaching. At the same time, teachers analyze students' knowledge mastery from their works and adjust teaching strategies. The corresponding APP functions mainly include student feedback after class, student independent testing, and custom drag and drop construction of knowledge point modules.

2.2 Functional Implementation Display and Explanation

The app is developed using Android studio, supporting both English and Chinese, and consists of two interfaces: the main interface (Fig. 2) and the logic diagram display and

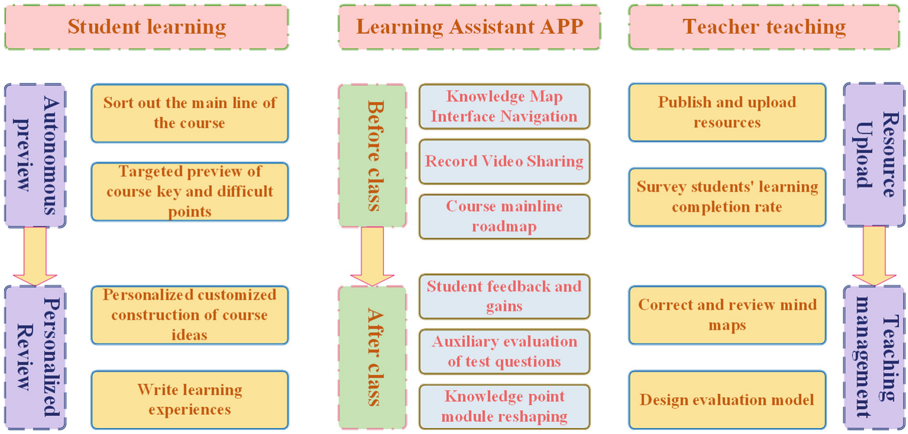


Fig. 1. Application Conception of System Functional Architecture

editing interface (Fig. 3). The main interface uses recyclereview to display the list, and the interface is expanded and collapsed by inheriting the Adapter class from recyclereview. The display and editing interface are used to display the logical architecture of each lecture and provide editing functions. Students can build their own modules here and zoom in/out the display interface in real-time.

To ensure the continuous impact of the curriculum and achieve the goal of life-long education [7], a detailed evaluation model should be established based on the data obtained from technical analysis.

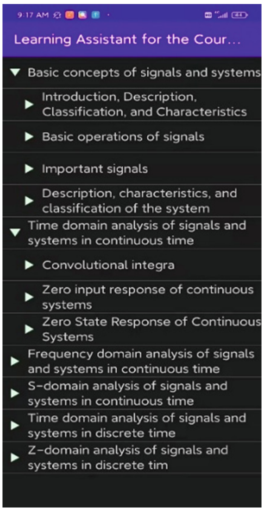


Fig. 2. The main interface

Fig. 3. The display & editing interface

3 Design of a Hybrid Teaching Effectiveness Evaluation Model for Improved Methods

By using our developed app and combining existing software platforms to improve teaching methods, it can be seen from the large amount of learning data generated during online learning that students' learning outcomes have improved, such as the score of each question, the number of interactive messages, and so on.

However, whether the students in front of the screen actively participate and have specific gains, and the degree of mastery of knowledge points cannot be intuitively measured, which requires designing a calculation model to achieve detailed analysis.

In addition, although offline test results can help teachers improve the process of subsequent teaching, grade data is often only counted and lacks detailed and effective characteristic analysis, which makes it difficult to intuitively obtain the key points that should be changed in teaching. Therefore, it is necessary to design analysis models to update teaching content.

3.1 Designing a Sense of Participation and Gain Model Based on Online Student Learning Data

We found that the review and barrage functions of online software often indirectly reflect students' high sense of participation and full sense of gain. To measure students' mastery, we establish the following model for quantitative analysis.

3.1.1 Introduction to the Sense of Participation Model

Introduce formula (1) to measure student engagement:

$$\begin{aligned} &\textit{Sense of participation} \\ &= \frac{\textit{The total number of barrages during classroom interaction}}{\textit{Course frequency}} \end{aligned} \tag{1}$$

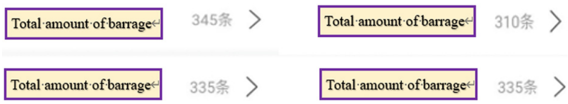


Fig. 4. Statistics of bullet barrage in online classrooms

We incorporated the number of bullet barrages obtained by the app (Fig. 4) into Eq. (1) and solved it to obtain 331 results, indicating a good sense of interaction and participation in the classroom. In addition, there are a total of 45 students in the small class teaching, with an average of 7 speeches per person, which fully demonstrates the motivation of the majority of students.

3.1.2 Introduction to the Sense of Gain Model

Introduce formula (2) to measure students' sense of gain (mastery level):

$$\begin{aligned} &\textit{Sense of gain} \\ &= \sum_{j=1}^{15} \omega_j \left(\left(\sum_{i=1}^{N} \frac{\textit{Number of correct answers to questions}}{\textit{Total number of questions}} \right) / N \right) \end{aligned} \tag{2}$$

j represents the current knowledge point, with a total of 15 points. ω_j represents the weight of each knowledge point, with 8% assigned to key points and 4% assigned to difficult points. N is the total number of participants in answering the questions of this knowledge point, so the accuracy rate of the current knowledge point is $\left(\sum_{i=1}^{N} \frac{\text{Number of correct answers to questions}}{\text{Total number of questions}} \right) \Big/ N$. The specific parameters are listed in Table 1.

From Table 1, it can be seen that students' participation in key content areas is higher and their accuracy is also higher. Although students' participation in difficult content areas has decreased, it is gratifying to see that there are still a few cases of high accuracy. From this, it can be seen that in the future, classroom design should be strengthened based on students' mistakes and confusing points. By calculating the data in the table according to Eq. (2), the students' sense of achievement is 90.28%, which indicates that the students have basically mastered the key and difficult content and have good classroom learning effects.

3.2 Design a Question Type Analysis Model Based on Offline Test Score

Establish the following intuitive model for measurement through analysis of previous years' grades and test paper quality:

3.2.1 Visual Display Model for Learning Effectiveness

Test students' learning effectiveness with a moderately difficult test paper and compare their grades over three consecutive semesters. From Fig. 5, it is evident that using our developed APP to improve the blended classroom teaching mode significantly improves the average grade of the teaching class. Further analysis shows that the proportion of

Table 1. Summary of Online Student Participation Test Data

j	ω_j	N	Accuracy
1. Classification of the system	8%	43	97.6%
2. Convolutional integral	8%	45	90%
3. System response calculation	8%	45	98.9%
4. Characteristics of spectrum	8%	45	97.7%
5. The Symmetry of Fourier Transform	4%	40	62.5%
6. The Linearity of Fourier Transform	8%	44	90.9%
7. Analysis of Sampling Theorem	8%	43	81.4%
8. Frequency domain system response	4%	41	75.6%
9. Laplace transform	8%	44	97.7%
10. The Linearity of Laplace Transform	8%	45	95.6%
11. The Shift Property of Laplace Transform	8%	45	88.9%
12. System response in the S domain	4%	44	97.7%
13. Unilateral Laplace transform	8%	45	95.6%
14. Determination of convergence domain	4%	40	85%
15. Stability conditions of the system	4%	37	67.6%

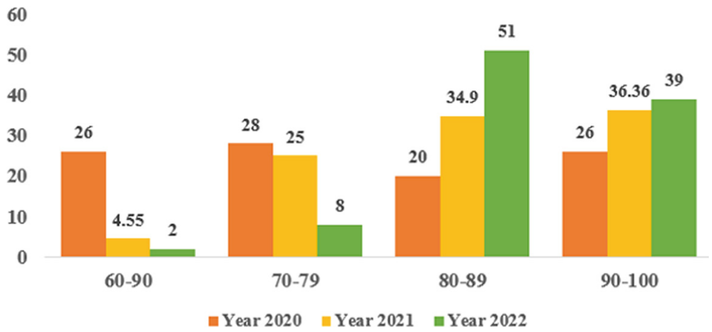
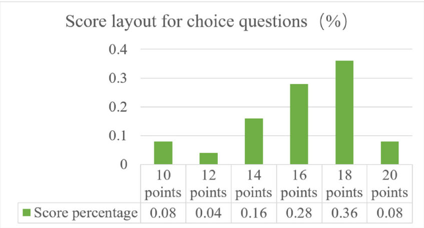


Fig. 5. Comparison of the distribution of students' grades within three semesters (%)

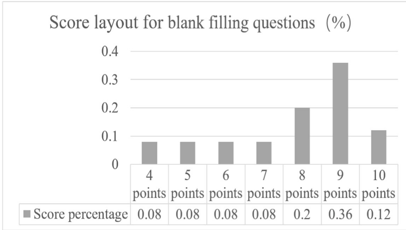
people in the low score range (60–79 points) decreases, while the proportion of people in the high score range (80–100 points) increases. Especially for those who scored between 80 and 89, their proportion in 2021 increased by 14.9% compared to 2020, with a year-on-year increase of 74.5%; Its proportion in 2021 increased by 16.1% compared to 2020, with a year-on-year increase of 46.1%.

3.2.2 Statistical Model for Question Type Distribution

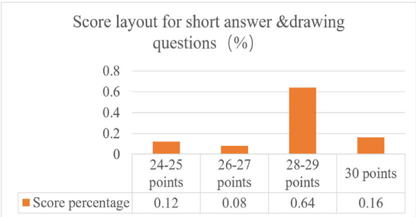
Refine the entire test paper into four parts and analyze them one by one (Fig. 7) to obtain:



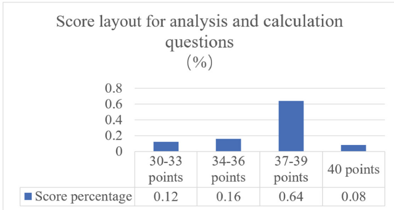
(a) Choice questions



(b) Blank Filling Questions



(c) Short answer & drawing questions



(d) Analysis & calculation questions

Fig. 6. (a) Choice questions, (b) Blank Filling Questions, (c) Short answer & drawing questions and (d) Analysis & calculation questions

Most choice questions are set as application questions. Despite being challenging, it can be seen from Fig. 6 (a) that three students still achieved full marks, and 48% of students scored 18 or above. This indicates that students can master the difficulties points through our improved learning methods and have an understanding of the engineering background of mathematical formulas. The calculation types in the fill in the blank questions account for 30%. Although the complexity has increased, it can be seen from Fig. 6 (b) that 58% of students still score 9 or above, indicating the effectiveness of flipped classroom use. It not only effectively inspires students to pay attention to details and correct each other in a timely manner, but also encourages students to discover easy mistakes on their own. Short answer &drawing questions emphasize divergent thinking and more emphasis on independent creation. As shown in Fig. 6 (c), 96% of students scored 25 or above, while 4 students scored full marks. It can be seen that students can use the method of drawing mind maps in the APP to create, which is greatly beneficial for the main thread learning and understanding of subsequent professional courses. The analysis and calculation questions cover important points throughout the book, with strong logic and numerous knowledge points. Despite the complexity, as shown in Fig. 6 (d), 88% of students still score 35 or above, and even two students achieve full marks. It can be seen that after using the APP in their spare time, students have a clear understanding of the logical relationships between chapter knowledge points, learned to learn thinking, and also mastered thinking methods .

4 Conclusion

Under the development trend of "New Infrastructure Construction" in education, it is necessary to continuously search for specific implementation methods of blended teaching that adapt to the construction of "New Engineering and Technical Disciplines". This article combines the actual teaching case of "Signals and Systems" and mainly focuses on: (1) updating teaching strategies through the development and application of an APP, highlighting the forward-looking and distinctive nature of the PGC-SIE model. (2) Design mathematical models based on online and offline student learning data to evaluate the effectiveness of teaching implementation, demonstrating the scientific and innovative nature of the PGC-SIE model. Ultimately, the above two points will be used to enhance teaching effectiveness and create a teaching brand.

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