Application of Formative Assessment in Linear Algebra Courses

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Abstract. Teaching evaluation is a crucial element in the educational process, significantly contributing to the improvement of teaching quality. This study identifies and addresses the shortcomings and flaws in the current assessment model for basic mathematics courses in domestic universities. Considering the unique characteristics of the student population and the widespread application of AI technology, a comprehensive formative assessment scheme is introduced. The research thoroughly examines the benefits of incorporating formative assessment into course teaching, emphasizing its potential in promoting a deeper understanding of students' learning outcomes. Moreover, the paper discusses the key aspects that need to be carefully considered during the implementation of this assessment method. Ultimately, this study aims to establish a theoretical framework and provide practical insights to optimize the teaching evaluation system, thereby enhancing overall teaching effectiveness, students' knowledge accumulation, skill development, and quality improvement.

Keywords: teaching evaluation; formative assessment; linear algebra

1 Introduction

As an important component of teaching evaluation, the assessment of university students' academic performance for credit acquisition is not only about analyzing and evaluating students' exam results to guide and motivate their subsequent course studies but also involves analyzing and researching these data to assess the teaching methods, teaching quality, and teaching effectiveness of the instructors. This process aims to improve teaching practices, meet the requirements of the course syllabus, and enhance the overall quality of education.

This paper explores the limitations of traditional assessment methods in linear algebra courses and proposes the implementation of formative assessment as a means to bridge the gap between theoretical knowledge and practical application. By incorporating formative assessments throughout the course, this approach aims to enhance students' learning experiences, promote active engagement, and provide continuous feedback that is crucial for both students and educators. The introduction of advanced technologies, including AI, in the assessment process further supports the development of

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personalized learning paths, ensuring that students achieve a deeper understanding of linear algebra concepts and their applications.

2 Current Evaluation Model Issues

As an extension of elementary algebra, linear algebra involves many high-dimensional concepts. Traditional textbooks and teaching content focus more on the structure of theoretical knowledge, neglecting the application of mathematical software, mathematical experiments, and mathematical modeling ideas [1]. This leads to students being unable to flexibly apply the knowledge they have learned to analyze and solve practical problems. The fragmentation of teaching knowledge points and the decentralization of teaching resources make it difficult for students to carry out personalized extended learning based on their own learning progress and interests [2]. However, the characteristics of the linear algebra course determine that the assessment requirements for students must include memory and understanding of concepts. This type of assessment content has clear right and wrong answers, so the assessment results rely heavily on summative evaluation, neglecting the dynamic changes in students' abilities and qualities during the learning process, resulting in untimely feedback on teaching effectiveness [3].

2.1 Incompatibility with Modern Teaching Development Trends

Although measures such as the separation of teaching and examination, the combination of usual performance with final performance, and the reform of the credit system have been implemented, with the rapid development of domestic economic transformation and new employment forms, university students' employment choices have become more diverse [4]. The current self-awareness, initiative, and enthusiasm for learning among university students are far lower than before, and the traditional assessment model can no longer adapt to current university education.

The current trend in teaching models is to emphasize the subjectivity of students in teaching activities, focus on students' participation and feedback, and shift from a teaching-centered to a learning-centered model to achieve mutual learning between teaching and learning [5][6].

In current research on teaching models, there is increasing emphasis on introducing new theories, methods, tools, and results from modern science and technology. Some teaching models have already utilized advanced scientific and technological results such as computers, laptops, projectors, mobile phones, and especially the rapid development of AI, with an increasing technological content in teaching conditions. Therefore, teachers should fully utilize the available advanced teaching conditions to design teaching models for teaching evaluation.

2.2 Incompatibility with Society's Expectations for Talent

Society has high expectations for university students' knowledge reserves, but low classroom attendance rates and students who are physically present but mentally absent are common. However, students who can truly settle down and focus on learning are even rarer. This is closely related to the current widespread poor academic atmosphere. Most courses, including required and elective courses, use a one-time final exam, leading most students to place much more importance on the final exam than on usual study, thinking that as long as they pass the final exam, they are fine. This is a common mindset under exam-oriented education [7].

Students often engage in concentrated cramming before the final exam, "not burning incense usually but hugging Buddha's feet in times of trouble." Students do not truly understand and master the relevant theoretical knowledge and methods [3]. Some students hope that teachers will kindly highlight exam questions before the exam, while others simply "let it go" and give up on themselves. Even worse, some students take risks and prepare to cheat, which, even if they luckily pass the exam, does not mean they have met the course syllabus's requirements. Instead, this exam-oriented mindset gradually spreads, passing from one generation of students to the next [5].

2.3 Incompatibility with University Students' Development and Progress

"Scores, scores, scores, the students' lifeline." A one-time exam can put great pressure on students, not only failing to objectively and accurately assess a student's learning but also having a negative impact, fostering poor academic and exam conduct [4]. In some cases, it may even delay outstanding students' development in areas such as awards, further studies, studying abroad, and job applications.

"Exams, exams, exams, the teacher's magic tool." Exams, as an important teaching method, are not only used to check students' mastery of course knowledge but also to help teachers discover problems in students' learning and in their own teaching methods, progress, and arrangements. However, the current exam model cannot provide timely feedback, making it difficult for teachers to address students' or their own problems in the current cohort [2].

3 Specific Implementation of Formative Assessment in Linear Algebra Courses

Linear algebra contains many knowledge points suitable for formative assessment, including basic matrix operations, determinant calculations, solving linear equations, basic concepts of vector spaces, linear transformations, eigenvalues and eigenvectors, matrix diagonalization and similarity transformations, inner products, and orthogonality [1].

Formative assessment breaks the traditional one-time final exam model, where the assessment results used to be concentrated at the end of the semester. Instead, the new model disperses assessments throughout the learning process of the entire course. The

final course grade consists of at least three parts: regular assessments (including class participation, in-class quizzes, homework, etc.), periodic tests (including unit tests, midterm exams, knowledge quizzes, term papers, research reports, etc.), and the final exam [6].

3.1 Effectively Promoting Student Learning

The implementation of formative assessment can adopt a combination of standard and non-standard answers based on course content and teaching needs [3]. Through pilot exams in the School of Information, School of Chemistry, and other schools for the linear algebra course over several years, the expected results have already been achieved. The exam questions are based on the course syllabus, testing the knowledge and abilities that students should possess, with wide coverage and a focus on key teaching points.

Formative assessment is conducted among first-year university students, counteracting the misleading belief instilled by some high school teachers that "you can play freely once you get into university." It helps students deeply realize from their own learning experience that entering university does not mean relaxing their studies or lowering their self-expectations. By spreading the course assessment throughout the semester, it prevents most students from developing the bad habit of not working hard during the semester but cramming before the final exam. It promotes students to seriously attend classes, study, review, and consolidate their knowledge regularly, improving the learning atmosphere and achieving the goal of promoting learning through assessment, which enhances students' quality [7].

Since the final grade in formative assessment is determined by the weighted combination of each chapter's exam results and the final comprehensive exam, it prevents a single poorly performed or opportunistic exam from negatively impacting the final course grade. This assessment method is fair and reasonable for every student, and it can more accurately reflect their learning situation [5].

3.2 Effectively Improving Teaching

Formative assessment allows the teacher to timely discover students' mastery of the taught knowledge based on the exam results of each chapter, and to focus on supplementary explanations of the problems encountered in students' learning. More importantly, teachers can adjust the teaching progress and content based on students' performance feedback, thereby improving teaching effectiveness and quality [3].

Leveraging educational big data collection technology, intelligent learning systems can record students' learning trajectories in homework, exercises, exams, Q&A sessions, and other aspects, enhancing the formative and value-added evaluation of students. At the same time, it can precisely identify students' learning weaknesses and weak knowledge points, dynamically predict each student's learning status, progress, and knowledge level, and help teachers implement precise evaluation and teaching.

Methods Used in Formative Assessment Include:

Classroom Discussions: Instant questions and discussions during class assess students' comprehension.

Problem-Solving Reports: Students are required to submit problem-solving reports to demonstrate their thought processes and calculation steps.

Oral Presentations: Students deliver oral presentations to evaluate their communication skills and understanding of concepts.

Online Interactions: Interactive exercises and real-time feedback on online learning platforms.

These formative assessment methods enable teachers to gain a more comprehensive understanding of students' learning progress and depth of understanding, thereby providing more targeted guidance.

The course is structured according to its chapters, with assessments conducted after the completion of certain chapters. The final course grade is determined by combining the scores from each chapter test and the final comprehensive exam according to a specific ratio. For students who fail a chapter test, a retest opportunity is provided; otherwise, they will need to retake the course.

3.3 Accumulating Experience with Formative Assessment

In formative exams, it is necessary to introduce elimination and reward mechanisms. If a student fails the first exam in a chapter, they have the opportunity to take a make-up exam. If they pass the make-up exam, they can proceed to the next chapter's exam. If they still do not pass, they cannot take the next chapter's exam.

To motivate students' enthusiasm and initiative, students who pass the first exam in a chapter but are not satisfied with their grade can apply for a "score improvement make-up exam" to improve their grade in that chapter. Additionally, students who perform well, with a grade of 95 or above in a chapter exam, can apply to take the next chapter's exam. If they maintain a grade of 95 or above, they can continue to apply for the next chapter's exam. If they complete all chapter exams in advance, they only need to take the final comprehensive exam for the course [3].

3.4 Adapting to the Development Trend of AI Technology

The intelligent tutoring system used in the course can help students understand the basic concepts of linear algebra, such as matrix operations and vector spaces. When students encounter problems during practice, they can use the system to obtain detailed answers and explanations. Using natural language processing technology, the system can understand students' questions and provide personalized tutoring and suggestions [6].

Automated evaluation and feedback: Using AI systems to automatically score students' assignments and exercises. The system can identify students' mistakes and provide immediate feedback to help students correct errors. The AI scoring system not only saves teachers' time but also ensures fairness and consistency in scoring.

Resource generation and optimization: Some ed-tech companies have developed AI tools that can automatically generate linear algebra exercises and quizzes based on students' learning progress and understanding level. These exercises can include matrix operations, linear transformations, eigenvalues, etc. The difficulty and type of exercises can be dynamically adjusted according to students' performance, ensuring that students always practice at an appropriate challenge level.

4 Conclusion

Through the teaching practice of formative assessment, the goal of promoting learning through assessment has been achieved, improving students' learning enthusiasm, self-discipline, and initiative, enhancing students' learning atmosphere and habits, stimulating students' learning potential and passion, and greatly enhancing the teaching effectiveness of the relatively abstract basic course of linear algebra [3].

The digitized linear algebra course effectively promotes students' active and in-depth learning by linking knowledge points with high-level, innovative, and contemporary teaching resources. It breaks the traditional teacher-student structure, shifting to a new "teacher-student-machine" ternary interactive teaching paradigm, utilizing AI technology to achieve personalized guidance and feedback, helping to improve the quality of innovative talent cultivation.

Drawing on the teaching process and exam methods of linear algebra, the reform of formative assessment can gradually be extended to the teaching of courses such as probability theory and mathematical statistics, and advanced mathematics.

References

1. Zhang Sumei, Yang Dianwu: Linear Algebra. Science Press, Beijing (2022).
2. Carla Madalena Santos, Rubia Amanda Franco, Diego Leon, Daniel Bovolenta Ovigli & Pedro Donizete Colombo Júnior. Interdisciplinarity in Education: Overcoming Fragmentation in the Teaching-Learning Process. International Education Studies (10), 71-77(2017).
3. Zhang Peilong: Application of Formative Assessment in Linear Algebra Courses. Journal of University of Jinan (Science and Technology) (Suppl 2),112–114(2017).
4. Yu Wensen, Liu Jiafang, Hong Ming: Fundamentals of Modern Teaching Theory. Northeast Normal University Press, Changchun (2007).
5. Zhang Hongtao, Cao Yangjie: Exploration and Practice of Formative Assessment Mode. China Electric Power Education (25), 66–67 (2013).
6. Xu Fang, He Yajuan, Ma Li: Design and Practice Research of Undergraduate Course Progressive Assessment System: A Case Study of Soochow University. Journal of Xinzhou Teachers University (2), 106–110(2020).
7. Joanne M. Lewohl. Exploring student perceptions and use of face-to-face classes, technology-enhanced active learning, and online resources. International Journal of Educational Technology in Higher Education(20): 48 (2023).