OUTCOMES-CENTERED CURRICULUM DESIGN OF AR TECHNOLOGY BASED ON BLENDED TEACHING

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ABSTRACT

In order to strengthen the construction of a scientific and reasonable AR technology curriculum system with obvious industry characteristics, and make its learning more substantial, interesting and efficient, this paper proposes to systematically design its expected learning outcomes, teaching content and requirements, class hour allocation of each teaching link, the implementation plan of practical teaching project, course assessment, and evaluation, and teaching methods and means of AR technology curriculum by utilizing the design framework of outcomes-centered curriculum based on TOPCARES. In addition, in order to bring into great play to the autonomy of teachers and students, and further stimulate the enthusiasm and creativity of students during the process of AR learning, this paper proposes a high-level design method of outcomes-centered blended teaching, and advocates to carefully design and develop the teaching resources for blended teaching according to the characteristics of teaching content, students' needs, environment, and conditions, etc. At present, we have formed an outcomes-centered AR technology teaching system with level 3 project running throughout, with basic modules, advanced modules and extension modules gradually progressing and complementing each other, and have developed a large number of supporting teaching resources, which can ensure the smooth progress of blended teaching and obtain good learning outcomes.

KEYWORDS

Augmented Reality, Blended Teaching, TOPCARES, CDIO Syllabus Outcomes, Integrated Curriculum

INTRODUCTION

Outcomes-centered curriculum system implies that when a curriculum is planned and designed, the expected learning outcomes (ELOs) should be clearly identified and considered in the formulation of its curriculum plan at first. After that, the course contents, practice projects, learning activities, teaching methods, and assessment and evaluation scheme should be designed or chosen to be consistent with the achievement of the ELOs. And then, we need to gather evidence from multiple sources to prove whether the ELOs have been achieved. Finally, the evaluation results need to be feedback in time to ensure that elements in the teaching and

learning environment are acting in concert to promote the achievement of ELOs (Yu et al., 2019).

In this paper, we will take the construction of the AR technology course as an example to systematically explain how to carry out the outcomes-centered blended teaching design and practice under the guidance of TOPCARES education methodology. Here, TOPCARES is an integrated talent cultivating model with the obvious characteristics of Neusoft creatively put forward by Dalian Neusoft University of Information (DNUI) in 2008 by inheriting, integrating, and innovating the latest achievements of CDIO international engineering education reform (Wen, 2011).

It is the crystallization of the educational and teaching reform achievements of DNUI over the past ten years and has been widely recognized by the international engineering education community in recent years (Wen, 2011; Yu, 2013; Yu, 2016). Recently, with the blended teaching has become an important trend of higher education teaching reform, the focus of DNUI's TOPCARES teaching reform has shifted to blended teaching. In order to accelerate the reform of blended teaching based on TOPCARES, AR Technology course took the lead in participating in this round of reform and has become one of the pilot courses of blended teaching reform. Up to now, our AR Technology course team has carried on a series of pioneering exploration and practice in the aspect of blended teaching reform, and achieved good learning outcomes in the actual teaching process.

In the next section, an outcomes-centered theoretical framework for curriculum design based on blended teaching is proposed. Then, the curriculum design and practice of AR Technology based on blended teaching are systematically described. Finally, the research work of this paper is summarized, and further research is prospected.

AN OUTCOMES-CENTERED CURRICULUM DESIGN FRAMEWORK

As for outcomes-centered curriculum design, TOPCARES requires that teachers take into account questions such as "What to teach," "How to teach," "How to learn," "Where to learn," and "How to assess" on the basis of a full investigation and research of the curriculum, and combine the imparting of curriculum knowledge with the cultivation of students' ability organically, and design the teaching contents, teaching methods and organizational forms in an integrated way, and develop the teaching material and construct the teaching resources in a standardized way, so as to ensure that students can learn and apply what they have learned, and achieve the ELOs (Yu et al., 2019). Under the guidance of TOPCARES education and teaching philosophy, we put forward an outcomes-centered curriculum design framework that can meet the needs of blended teaching, as shown in figure 1. It mainly includes the following steps:

Step 1: Clearly identify students' learning needs by conducting regular curriculum investigation and research. Here, we suggest that teachers should fully investigate and study the current situation and development trend of curriculum-related industries, job opportunities, and science and technology, and know more about the actual situation of students' learning, self-development, curriculum construction, and school running.

Step 2: Reasonably formulate the overall teaching objective of the course according to the learning needs of the students and the orientation of the course in the professional talent

cultivating program. Here, the overall teaching objective is a comprehensive overview of the ELOs of the course.

Step 3: Carefully draw up the list of ELOs of the course by comprehensively analyzing the overall teaching objective, the characteristics of the course, and the TOPCARES ability index system that should be supported by the course. It is worth noting that the list of ELOs here is written for students rather than teachers, which should take full account of students' performance rather than teaching activities (Trinh & Nghia, 2014). In addition, the ELOs here refers not only to the learning outcomes to be delivered but also to the students' learning experience and the value realized by students (Stevens & Levi, 2013). In this sense, a curriculum is a learning process based on a series of ELOs that have a clear, logical relationship with each other.

Step 4: Scientifically develop the targeted curriculum syllabus by scientifically planning and designing the cultivation path to achieve the ELOs. Once the correct cultivation paths are established, the corresponding teaching contents, teaching methods, and means, assessment, and evaluation scheme will be clear.

Step 5: Systematically organize the teaching contents and requirements of this course according to the curriculum syllabus. In addition, all teaching contents, including theoretical teaching, practical teaching, and special activities, are further subdivided into online and offline teaching and learning contents according to the requirements of blended teaching and the cultivation path of the ELOs.

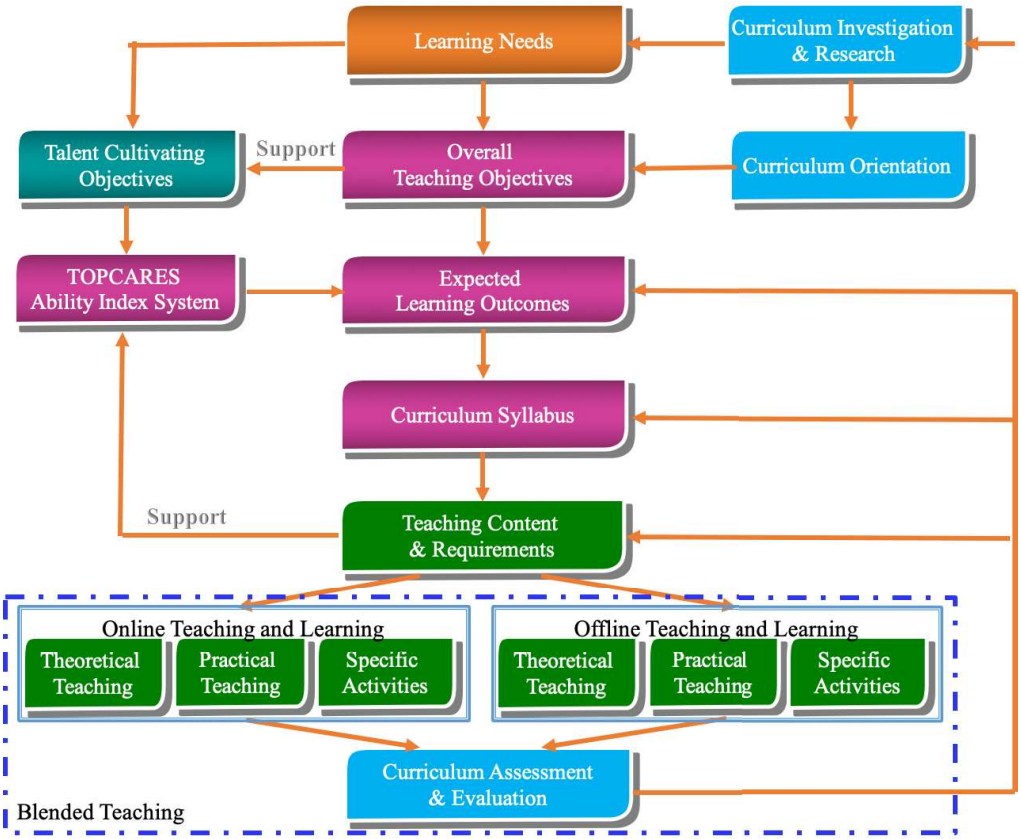

Figure 1. TOPCARES Theoretical Framework of Curriculum Design

Step 6: Reasonably formulate the formative and summative assessment scheme and evaluation standards of the curriculum. Its purpose is to create a fair, competitive environment, enable students to get timely and comprehensive feedback, help students develop critical thinking, and help teachers to test the achievement of students' ELOs and improve their teaching skills purposefully (Yu et al., 2019). In the process of teaching implementation, it is required to regularly collect and timely feedback assessment and evaluation information, so as to promote the continuous improvement of curriculum construction.

Step 7: Standardize all teaching contents of the course, and make clear requirements on the teaching methods and organizational forms suggested to be used by teachers, the learning methods and resources suggested to be used by students, and teaching conditions to be met in the teaching and learning process (Nilsson, 2010).

According to the above introduction, a good and specific list of ELOs is obviously the key to the success of curriculum construction. For this reason, we propose that the principle of SMART should be followed when formulating the ELOs (Yu et al., 2019), that is,

(1) ELOs should be **Specific** rather than general. It is suggested to use behavioral verbs to describe ELOs as much as possible, such as Bloom's Taxonomy Action Verbs.

(2) ELOs should be **Measurable**. It is recommended that you ask yourself what activities or tasks can be used to evaluate whether students have really achieved their ELOs and to what extent they have achieved them.

(3) ELOs should be **Achievable**. They must conform to the level of students and convince them that they can be achieved through reasonable efforts.

(4) ELOs should be **Relevant** to the students' life or career goals and contribute to the achievement of the final goals.

(5) ELOs should be clear **Time-bound**. They must be in line with the learning period and total class hours of the course.

CURRICULUM DESIGN AND PRACTICE OF AR TECHNOLOGY BASED ON BLENDED TEACHING

In order to deepen the understanding of the theoretical framework of outcomes-centered curriculum design based on TOPCARES, we will take the AR Technology curriculum as an example to describe how to apply it in more detail.

Course Introduction

AR Technology is one of the main courses of digital media technology, which is explicitly required by the national standard for teaching quality of animation, digital media art, and digital media technology. Its prerequisite courses include Object-oriented Programming, User Experience Design, Foundations of Game Engine, Game Programming Basics, Foundations of Game Design, etc. It requires students to be able to fully apply the knowledge, skills, tools, and technologies they have learned before, such as object-oriented programming, product prototype development, interactive media development, to the AR technology training and project practice. Its follow-up courses include Virtual Reality (VR) Technology, VR Application

Development, Comprehensive Training of Digital Media Technology, and Graduation Design (Thesis), etc. It still requires students to master the AR development technology, and design and develop a practical and original AR application with certain technical complexity and good user experience. Obviously, the effective achievement of its ELOs will play an important role in consolidating what has been learned in the early stage, and guiding and paving the way for the successful implementation of the follow-up practical teaching and training. Moreover, it will also play a very important role in the construction of professional characteristics and the achievement of the talent cultivating objectives.

Next, we will systematically introduce how to apply the proposed theoretical framework of outcomes-centered curriculum design to implement the blended teaching design and practice for this course.

Step 1: Identify Students' Learning Needs

In order to identify students' learning needs for this course, we regularly investigate the needs of employers, students, teachers, and other stakeholders. Through a lot of investigation and research, we find that:

For the employers, they often hope that students' AR technology, knowledge, and their AR development abilities should be presented in a visible, measurable, and applicable patterns.

For the curriculum team and even the department of digital media technology, they especially hope that the course will have distinct industry characteristics, can effectively develop students' TOPCARES abilities, achieve influential honors and achievements at home and abroad, and effectively support the achievement of the cultivating objectives and graduation requirements of digital media technology.

For the students, they really want to have at least one XR (the general term of AR, VR, and MR) project practical experience, one certificate of award for a high-level professional competition, one intellectual property related to digital media technology, one high-quality graduation thesis, one high-level representative XR work, and one good employment opportunity upon graduation.

To sum up, it is clear that helping students design and produce excellent AR work will be the core task of this course.

Step 2: Formulate the Overall Teaching Objective

By systematically sorting out the priority of learning needs of this course and combining the development status and trends of AR-related industries and technologies, we further clarified the overall teaching objectives of this course, namely:

"Based on the popular game development tools Unity and the world's leading AR platform Vuforia, this course will introduce the basic theory and technical methods of AR application design and development, such as AR video, AR animation, AR special effects, AR interaction, and AR games, step by step and comprehensively. This course will implement a blended teaching model, which is driven by actual AR projects, with the training of TOPCARES abilities as the mainline, and organically combines online and offline teaching. Through the study of this course, it can help students to establish the knowledge system of AR project development, master the techniques and methods of AR application design, development, and testing,

cultivate the ability of team cooperation and innovative practice of students, and the ability to design and to develop an original AR application with certain technical complexity, better user experience, and certain practicability by comprehensively applying the knowledge that they have learned before."

Step 3: Draw Up the List of ELOs

By further dividing the overall teaching objectives of this course into three levels: knowledge, ability, and quality, then mapping them to some specific TOPCARES ability indicators, and designing the corresponding training path for each ability, we draw up a list of ELOs according to the proposed SMART principle above (Yu et al., 2019), as shown in Table 1.

Table 1. List of ELOs for AR Technology Course

Classification of Learning Objectives	Expected learning outcomes	Supported TOPCARES-CDIO Level 3 Capability Indicators	Training path
Knowledge	Summarize the development history of AR	1.4.1 Knowledge related to XR application development	Teaching Visiting
	Describe the definition and category of AR		
	Explain the differences and connections between AR, VR and MR		
	Describe the working principle and main components of AR system		Demonstration
	Install and configure AR development environment		
	Use the Vuforia SDK to implement image recognition, cuboid recognition, cylinder recognition, object recognition, user custom recognition, virtual button and other functions		
	Describe the current situation and development trend of AR industry	1.3.3 Knowledge related to digital media industry	Teaching
Ability	Write AR project design plan and give oral report	4.1.3 Written communication 4.1.4 Electronic and multimedia communication 4.1.6 Verbal and interpersonal communication 8.6.4 Development project management	Project-based learning
	Make AR project development plan according to software engineering standardization requirements		
	Write project report according to software engineering standardization requirements		
	Produce a video for work presentation, make a PPT for project report, and make a defence speech on the project site		
	Design and develop a simple AR video application	3.1.5 Solutions and recommendations 8.8.1 Design implementation process	Case teaching Practice teaching Project teaching
	Design and develop a simple AR animation application		
	Design and develop a simple AR special effect		
	Design and develop an AR interactive large screen application		
	Design and develop an AR application with a clear theme and practical value that integrates video, animation, visual effects and interaction by teamwork	2.4.2 Integrated innovation capability 4.3.2 Teamwork operation 8.8.1 Design implementation process	Project-based learning Inquiry learning
	On-site installation and debugging, test and optimize the effect of works	8.9.1 Operational design and optimization	
Quality	Attendance on time, no reason to leave early, and complete and submit assignments on time	5.1.2 Learning attitudes and habits	Autonomous learning
	Actively learn new knowledge and incorporate it into the individual works		
	Use individual or team works to participate in subject competitions or exhibitions	5.3.2 Attitudes and habits towards honors	

Step 4: Develop the Curriculum Syllabus

Considering that there are still some practical problems in the actual teaching process, such as students' works are mainly based on imitation and lack of innovation, students' many ideas can't be implemented, the quality and complexity of AR works are not high, and the ability of independent learning and comprehensive application is insufficient, the curriculum team proposes to integrate the software engineering ideas and standards into AR project practice, introduce professional competitions and current frontiers into AR project topics, incorporate independent learning and project complexity into the assessment requirements, and apply OBE implementation principles and the modular and integrated curriculum design method to build an outcomes-centered teaching content system with level 3 project running throughout the whole, and with the basic module, advanced module and expansion module gradually progressive and complementary, as shown in Figure 2. Here, the outcome of the level 3 project is an AR game application with a clear theme and practical value, which integrates video, animation, special effects and interaction, and other features and is designed and developed by students through group cooperation (Yu et al., 2019).

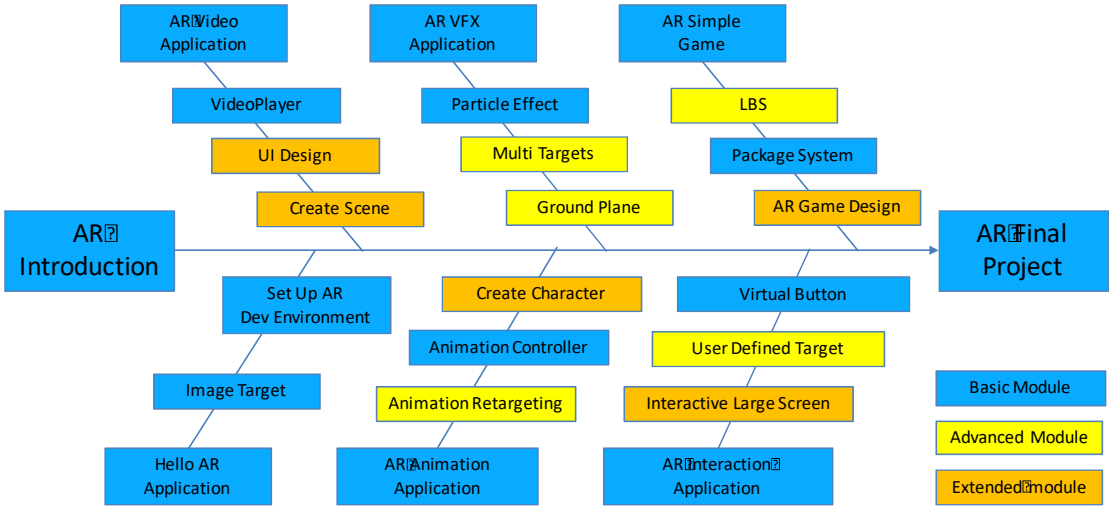

Figure 2. Teaching Content System of AR Technology Course

Then, we systematically plan and design the way to achieve each expected outcome, the teaching methods, and means of all teaching contents, the cultivation path of each TOPCARES ability, and then develop the curriculum syllabus of this course.

Step 5: Organize the Teaching Contents and Requirements Based on Blended Teaching

With the rapid development of the new generation of information technology, blended teaching has become a key point and an important way to promote the reform and development of higher education in China. In order to meet the needs of blended teaching and effectively support the achievement of ELOs, on the basis of the above-mentioned teaching content system, we have designed the teaching content, teaching requirements, key points, and difficulties, as well as teaching implementation suggestions of each unit scientifically and reasonably. Moreover, we have further clarified the contents and requirements of pre-class, in-class, and after-class teaching and learning. An example of this is shown in Figure 3.

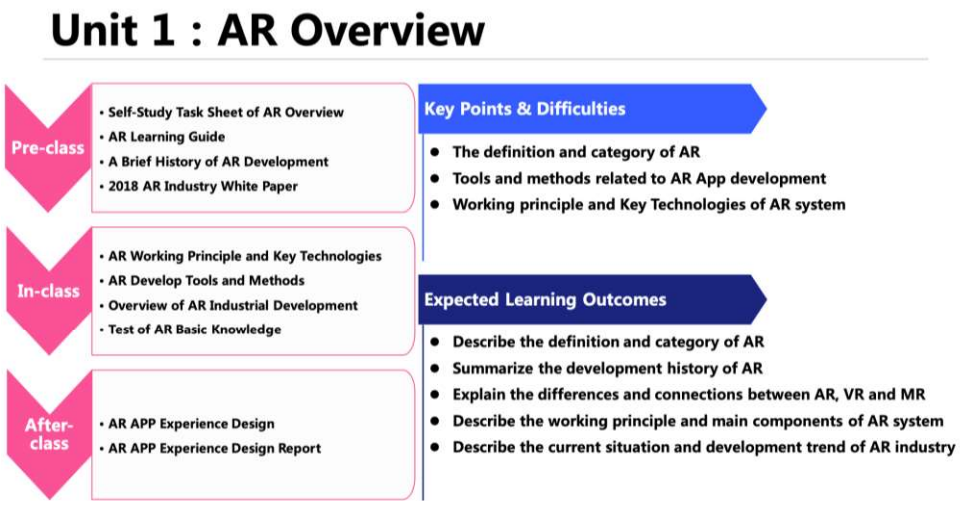

Figure 3. Design Example of Teaching Content

Step 6: Carry Out the High-Level Design of Blended Teaching

As an important part of teaching content and requirements, the main task of the high-level design of blended teaching is to give a brief description of how to implement effective blended teaching for specific teaching content. It requires us to design scientifically and systematically how to organically integrate pre-class, in-class, after-class, online and offline learning tasks and teaching activities around teaching objectives, and clearly explain the teaching methods and means used, learning outcomes evaluation schemes, learning support services that can be provided, etc.

Step 7: Formulate Assessment Schemes and Evaluation Criteria

ELOs are the core of curriculum construction and the primary basis for the establishment of assessment and evaluation criteria. In order to reasonably evaluate the achievement degree of students' ELOs and to create a fair competition environment, we adopt a comprehensive assessment method combining formative assessment and summative assessment, and construct a diversified assessment mechanism including classroom test, homework, project roadshow, and final defense (Yu et al., 2019), as shown in Figure 4.

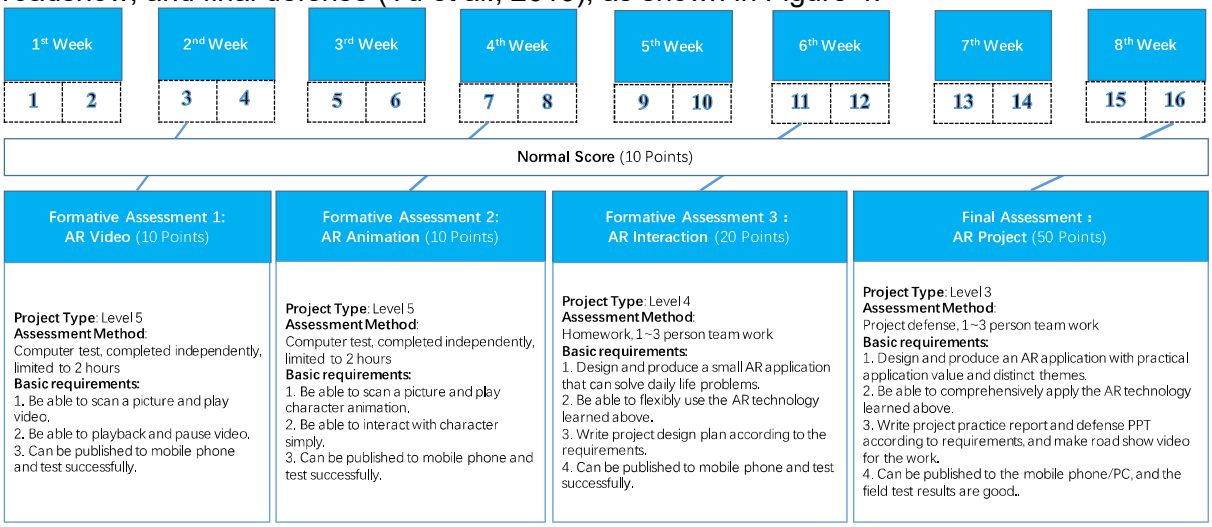

Figure 4. Assessment and Evaluation Scheme of AR Technology Course

Meanwhile, in order to standardize the performance evaluation criteria, enable students to get timely and comprehensive feedback, as well as to help teachers purposefully improve the level of teaching, we have constructed and implemented a series of evaluation criteria suitable for formative assessment and summative assessment. All these evaluation criteria are based on the ELOs and pay attention to the examination of students' abilities such as communication and teamwork, analysis and problem solving, innovative thinking, and learning.

Step 8: Design & Develop All Online and Offline Teaching Resources

The standardized construction and efficient application of teaching resources is an important guarantee for the smooth implementation of blended teaching and the achievement of ELOs. Therefore, we organize all teaching resources in a granulated way based on the core concept of the subject, the relationship between teaching content and resources, set up the teaching context, and form a resource set that focuses on knowledge points/skill points and clearly expresses the knowledge framework. Then we carefully select and develop all teaching resources that match the pre-class, in-class, after-class, online, and/or offline learning tasks according to the ELOs, discipline characteristics, students' cognitive rules, and different blended teaching methods.

Blended Teaching Implement

At present, all teaching resources of AR technology course have been developed in accordance with the corresponding construction standards, including curriculum standards, teaching calendar, course guidance, teaching materials, and handouts, lesson plans, teaching courseware (PPT), teaching micro-videos (covering all the key points and difficulties of the course), teaching cases, excellent example works, assessment-related materials (such as assignments, practical projects, test papers, etc.), project material resources and source code, reference materials and learning guidance materials (such as FAQ, self-study task list), etc., and have passed the first acceptance of DNUI with excellent evaluation results.

Up to now, all teaching resources have been uploaded to the school's blended teaching management platform. After a round of blended teaching practice, DNUI specially set up a review team composed of the education experts from the functional departments such as teaching management and quality assurance, the professional teachers from the teaching school and department, and the experts from outside school to evaluate the implementation effect of blended teaching of this course. According to the feedback evaluation results, we know that through the implementation of the blended teaching reform, this course can stimulate the majority of students' learning interest, generally improve students' learning initiative and the achievement of ELOs to a great extent. In addition, more than one-third of the students have won some honors in some academic and professional competitions and applied for software copyrights or patents by using the outcomes of level 3 project of this course. In general, this blended teaching course has achieved initial results in the construction stage, achieved the expected goal, and its evaluation result is excellent.

Unfortunately, there are still inevitable problems in the implementation process of blended teaching, such as:

Due to the great diversity of individual students, the difficulty of personalized guidance for teachers is increased.

Because students learn several courses at the same time, they cannot make full use of the after-class time to study.

Due to the insufficient interactive design of the learning platform, it is not very helpful to support students' independent and cooperative learning.

Due to the lack of artistic appeal in the design of teaching micro-video, its attraction is insufficient. All these problems and challenges need to be overcome and solved in the future.

CONCLUSION

In order to effectively improve students' learning satisfaction and guarantee the achievement of ELOs, this paper proposes an outcomes-centered theoretical framework for curriculum design based on blended teaching, and take AR Technology curriculum as an example to describe how to apply it to implement the blended teaching reform and practice of this course. Although this course has achieved good results through a round of blended teaching practice, there are still some problems mentioned above. However, developing, implementing, and evaluating outcomes-centered curricula are complex, multifaceted, and iterative processes. In the future, we will further standardize and optimize the proposed outcomes-centered theoretical framework for curriculum design based on blended teaching with the deepening of TOPC teaching reform, optimize the design and update the teaching resources, and introduce artificial intelligence technology in the blended teaching implementation process, in order to further improve the quality of blended teaching.

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