Exploration and Practice of Research-Based Teaching Model in Application-Oriented Universities under the Digital Background

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Abstract. Driven by the dual forces of digitalization and the transformation of application-oriented universities, the research-based teaching model has become a critical path to break through the flatness dilemma of traditional teaching and cultivate innovative architectural talents. Based on educational theories and the disciplinary characteristics of architecture, this paper systematically combs the construction logic and practical approaches of the research-based teaching model in application-oriented universities under the digital background, demonstrates the value of paradigm innovation of the research-based teaching model in architectural education, enhances educational quality through technological empowerment, promotes educational equity, cultivates talents adapting to the needs of the digital era, and provides theoretical support and practical references for the educational reform of architecture in application-oriented universities.

Keywords: Digital background, Application-oriented universities, Research-based teaching model, Architectural education

1 Introduction

1.1 Research Background and Significance

With the rapid development of technology, artificial intelligence “AI” is reshaping the education landscape at an astonishing pace. Application-oriented universities are urgently required to respond to the cultivation of high-quality applied talents, explore new paths for the integration of AI and education, and face the pressing need for transformation and upgrading. As an indispensable part of social development, the discipline of architecture has also seen its development needs continuously change and adjust with social progress, prompting the discipline to continuously improve itself and pursue independent innovation to adapt to the evolving times. As early as 50 years ago, John Hannoh, President of Michigan State University, pointed out at the annual meeting of the Association of American Universities: "Only college students who have mastered solid professional capabilities and firm moral beliefs can face the challenges of the future world." [1]

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Students majoring in architecture not only need to possess solid professional knowledge, but also need to have innovative thinking, practical abilities, professional capabilities and ethics to adapt to the rapidly changing market demands. As an important base for cultivating applied talents, the innovation of the teaching model in application-oriented universities is particularly crucial. By constructing a research-based teaching model, universities can not only stimulate students' learning interests, but also cultivate their autonomous learning and innovative abilities, so as to better meet the social demand for high-quality architecture professionals. In addition, the implementation of the research-based teaching model is also helpful for enhancing teachers' professional qualities and teaching abilities, promoting the mutual growth of teaching and learning, and forming a virtuous cycle.

1.2 Research Status Quo and Problems

Currently, the traditional teaching model typically involves instructors adopting a lecturing or cramming approach, where students passively receive knowledge. This spoon-feeding teaching method often overlooks individual differences among students, and its standardized content lacks pertinence and practicality, making it difficult to meet the modern society's demands for applied talents. In contrast, research-based teaching places greater emphasis on cultivating students' active exploration and practical abilities, which has garnered extensive attention in recent years. Notably, technological breakthroughs are rewriting teaching rules: many universities are leveraging online platforms to foster digital thinking and continuously innovating the educational ecosystem by collecting behavioral data. Digital transformation and upgrading represent the inherent requirement for current higher education to adapt to evolving circumstances.

For the architecture major in application-oriented universities, the traditional teaching model often focuses on the imparting of theoretical knowledge and the application of software skills, while neglecting the cultivation of practical operation abilities and innovative thinking. With the rapid development of the construction industry, there is an increasingly urgent demand for high-quality applied talents with innovative spirit and practical abilities. Therefore, how to effectively implement research-based teaching in architecture education has become a key issue that needs to be solved urgently. On the one hand, during the process of implementing research-based teaching in many universities, the integration and optimization of teaching resources are ignored, resulting in less than ideal teaching effects. On the other hand, due to the lack of an effective evaluation system and incentive mechanism, it is difficult for research-based teaching to be truly implemented. There is also a very important aspect. Research-based teaching needs to be combined with applied academics, but applied academics are often not highly regarded in application-oriented universities. The vast majority of universities regard teaching as the most important task and do not attach enough importance to scientific research. In addition, the promotion of research-based teaching also faces practical dilemmas such as insufficient teaching staff and backward teaching facilities. All these require us to think deeply and actively explore[2]. In order to improve the teaching quality of the architecture discipline and the talent cultivation effect, it is necessary to propose practical solutions to these problems.

2 Theoretical Basis of Research-Based Teaching in Application-Oriented Universities

2.1 School-Running Orientation of Application-Oriented Universities

Application-oriented universities are institutions of higher learning with the school-running orientation of "application". Their goal is to apply the knowledge, theories and experiences learned at school to various fields of society and solve practical problems in professional positions. Application-oriented universities mainly cultivate senior applied talents who meet the needs of production, construction, management and service at the front line. The core of this is to serve the development needs of the local economy and society [3]. Education must be closely combined with industries, which complements the adjustment and upgrading of the regional industrial structure. Therefore, application-oriented universities should especially focus on cultivating students' problem-solving abilities, innovative spirit, practical abilities, as well as a strong sense of social responsibility [6]. This requires application-oriented universities to change the traditional teaching model.

Table 1. Main Differences between Research-based Teaching and Traditional Teaching

Object of Study	Research-based Teaching	Traditional Teaching
The Role of Students	Active Learners	The Status of Passively Accepting Knowledge
The Role of Teachers	Guides and Facilitators of Learning	Knowledge Imparter
Learning Objectives	Cultivate research abilities, innovative thinking, and comprehensive qualities	Master specific knowledge points
Learning Content	Flexible content, emphasizing the combination of disciplines and the solution of practical problems	Fixed teaching materials and knowledge points
Learning Methods	Autonomous learning, group discussions, experimental research, etc.	Classroom lectures, exercises, and examinations
Evaluation Methods	Focus on process evaluation, including students' research processes, innovative abilities, and teamwork abilities, etc.	Taking examination results as the main evaluation standard
Teaching Resources	It requires more resources, such as laboratories, libraries, network resources, etc., to support students' independent research.	Mainly rely on teaching materials and teachers' explanations.
Teaching Environment	It requires a more open and flexible teaching environment, such as laboratories, research rooms, etc.	It is usually carried out in the classroom, and the environment is relatively simple.
Teaching Effect	Students can better understand knowledge, improve their learning interest and enthusiasm, and cultivate the abilities of autonomous learning and lifelong learning.	Students may passively understand knowledge and lack innovative thinking and practical abilities.

Unlike the traditional teaching model, the research-based teaching model emphasizes the research-based learning approach. In the traditional teaching method, it is a process of teachers instilling knowledge into students. However, in the process of research-based teaching, students actively engage in learning[8]. This not only increases students' interest and enthusiasm but also contributes to the cultivation of their autonomous learning and lifelong learning abilities(Table1). Moreover, research-based teaching places more emphasis on the combination of disciplines. Through curriculum integration, students can study different types of courses and use knowledge from multiple disciplines to solve practical problems, which can also expand their knowledge scope and greatly improve their comprehensive qualities.

2.2 Research-Based Teaching Model

Research-based teaching should focus on problems. Its main purpose is to arouse students' interest in exploration and help them form the abilities to discover, analyze and solve problems during activities such as experiments and explorations [4]. Another important aspect is the process of knowledge generation, which requires students to continuously raise doubts, think carefully and create during the learning process, and form their own cognitive structures [5].

Research-based teaching also needs to focus on the combination of theory and practice. For example, educational activities should be carried out for students through forms such as case investigations, on-site visits, and project research, enabling them to master more theoretical knowledge in practice and improve their practical abilities. This teaching model places more emphasis on whether students can flexibly apply the knowledge they have learned to solve problems in real life, and cultivate talents with a certain theoretical foundation and strong practical abilities. If the education and teaching in application-oriented universities want to achieve good development, they need to position the content of talent cultivation as research-based teaching[9].

Unlike other disciplines that merely impart knowledge, architecture teaches students how to innovate in design and integrate theory with practice. Due to the broad scope of this discipline, its content involves not only architectural design itself [13] but also many other fields and aspects, such as environmental issues, sustainability, and artistic concepts. This requires students to integrate technologies and ideas from diverse domains, increase hands-on practice in real-world work, use modern software for simulation, and participate actively to meet industry demands for interdisciplinary talents. Architectural design also attaches great importance to the design process. Through continuous deduction, repeated trial-and-error, deepened thinking, and constant refinement of design schemes, students enhance their innovative capabilities. Therefore, architecture should encourage students to dare to explore unknown directions and ventures, take bold actions, and forge new paths through continuous experimentation. However, such teaching can only be achieved under a specific pathway model.

Faculty transformation also plays a critical role in the research-based teaching model, collecting multi-dimensional data on students' learning behaviors, emotional states, and academic performance through digital portraits.

3 Construction Path of the Research-Based Teaching Model in the Field of Architecture

3.1 Collaborative Education Mechanism

The application of school-enterprise joint projects in the field of architecture gives new meaning. Connecting theory with practice helps improve students' professional abilities, and also exercises their practical operation and problem-solving abilities. It can also bring a lot of practical case materials to teachers, enrich the course content, and improve the quality of the courses. And students can make better use of the opportunities brought by the projects, learn more knowledge in the projects, and continuously apply it to practical projects. When enterprises incorporate technical problems into the talent cultivation plan of universities, schools can carry out talent cultivation and teaching arrangements normally and reasonably, giving full play to their own advantages. Since it is necessary to form cross-professional teams for work, experts from different fields will gather together to discuss problems. It is this kind of cross-border thinking that generates new professional fields and more creativity during the process of communication and collision [4]. The school-enterprise joint projects do not exist simply, but signify a new form of in-depth and extensive collaborative cooperation and knowledge sharing.

3.2 Modular Curriculum Design

Different from the traditional single and linear teaching method, the knowledge system is modularized, and each "module" has a theme. The aim is to master a technology through systematic learning. Case analysis enables students to better use the theoretical knowledge they have learned for effective evaluation; the detailed operation steps make hands-on practice a crucial step, and finally a complete design work is formed [7]. At the same time, when teachers implant scientific research projects into it, it can make the learning more flexible, enabling students to become practitioners of their own achievements and deepening their scientific research abilities and practical levels.

Modular curriculum design can also integrate knowledge among different courses, thus forming a more comprehensive knowledge system. Breaking the inherent disciplinary boundaries is conducive to the cultivation of comprehensive talents. Incorporating environmental science into architecture courses can make students pay more attention to the design of sustainable buildings, and introducing information technology can make architectural works more intelligent, thus enriching students' learning process and helping to stimulate their innovative thinking.

3.3 Integration of Science Education and Research

The essence of the integration of science education and research is that education influences scientific research, and scientific research nourishes education. In other words, it is to use the achievements of scientific education and teaching to mutually feed knowledge and information, and open up to students and society with a more positive

attitude [15]. In this way, it can not only ensure the timely and effective update of teaching content, but also form a good cycle environment for disciplinary development and academic progress. The integration of science education and research gives students the opportunity to participate in scientific research work, and students become one of the components of the entire scientific and technological work. This has many benefits. The most direct one is that it enables them to gradually accept the fact that they are scientific workers. Secondly, they will become fearless and full of curiosity about all scientific projects. They can experience how real scientific research is conducted, dare to question and reflect, and have the courage to explore the unknown and learn how to face problems. When they find problems in practice, they will not give up easily. Such personal experiences will benefit them throughout their lives and help them develop the habits and abilities of lifelong learning.

3.4 Digital Transformation of Education

Table 2. Characteristics of Digital Education

Element Category	Composition Content	Technical Support	Ecological Function
Behavior Subject	Teachers (Learning Guides) Students (Autonomous Researchers) AI (Intelligent Tutors)	Network Platform Learning Situation Analysis System	Form a Role Conversion Mechanism Between Teachers and Students
Learning Environment	Professional classrooms/laboratories, Virtual spaces (educational metaverse), hybrid spaces (VR/AR enhanced scenarios)	Through the online course system, digital resources such as multimedia, animations, knowledge bases, and virtual scenarios are utilized. Data analysis tools are employed to create an interconnected, intelligent, and flexible learning space.	Teachers promptly evaluate the learning environment and propose improvement suggestions for implementation in the next revision phase. Improve learning efficiency, promote personalized education, and break through the time and space limitations of traditional education. Enhance architectural design experience through virtual models.
Interaction mechanism	Teacher-student discussions (online discussion forums), student-student collaboration (virtual project teams), human-computer dialogue (NLP question-and-answer systems)	Build cross-time-and-space cognitive scaffolding with digital tools, and AI algorithms recommend resources based on students' behavioral data (such as learning progress and knowledge blind spots)	Construct multi-dimensional feedback systems, adaptive learning systems, and intelligent tutoring tools to improve learning efficiency AI identifies students' emotional states and adjusts teaching strategies
Evaluation system	Process data (platform logs), competency portraits (digital badges), collective wisdom (peer reviews)	Three-dimensional evaluation system for research-based teaching	Achieve developmental evaluation and ecological health monitoring

Make full use of internet resources to build a digital platform and achieve online-offline integrated teaching. With students as the main body, the network platform constructs an organic integration of humans, machines, and courses. Through the online teaching platform, students learn first, and teachers teach later. Teachers conduct timely and effective learning situation analysis, continuously optimize the knowledge structure, and adjust teaching strategies based on the analysis to form a dynamic role conversion mechanism. The learning ecosystem built by the network platform is dynamic, featuring knowledge flow and self-organizing evolution. In the digital context, students can access more high-quality learning resources through the network platform, continuously promoting their autonomous learning ability, enhancing their innovative thinking, and broadening their professional horizons. Meanwhile, the application of the network platform, through big data analysis, enables teachers and students to keep up with cutting-edge research and professional development trends, ensuring the timeliness and relevance of teaching effects and meeting the needs for interdisciplinary talents in the digital era. (Table 2) At the same time, through process-based tracking and heterogeneous evaluation, it promotes the development of students' cognition and the connection of knowledge structures[10].

4 Implementation Path and Support System of Research-Based Teaching

The traditional teaching model can no longer meet the needs of compound talents in our era. Research-based teaching is a teaching model that takes problems as the guidance and students as the main body, and its implementation path and support system require systematic design[11].

4.1 Implementation Path

4.1.1 Reconstruction of the Curriculum System.

Application-oriented universities need more flexible and diverse courses to cultivate students' innovative awareness and practical operation abilities. This requires that the setting of the curriculum structure must combine theory with practice. In order to achieve the coordinated development of knowledge accumulation and ability improvement, Jerome Bruner proposed the "spiral curriculum theory". Spiral learning (Figure 1) is a teaching model that cyclically iterates theoretical learning and practical application and gradually deepens them. Through the cyclic process of "practice → theory → re-practice → re-theory", it strengthens learners' active construction of the knowledge system, emphasizes the key role of practice in knowledge construction, forms a cognitive closed loop of "perceptual experience, rational abstraction, and practical verification", and realizes the coordinated development of knowledge accumulation and ability improvement[12].

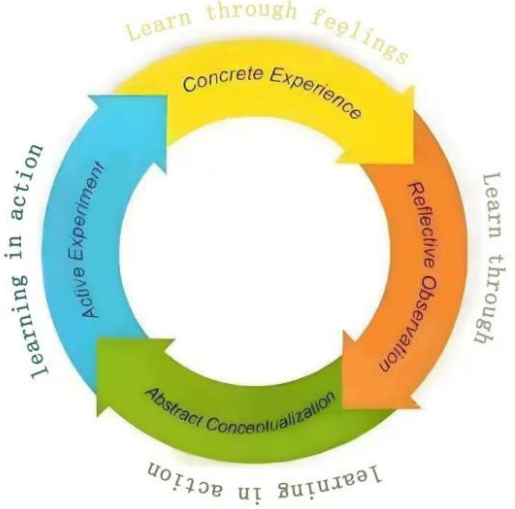

Fig. 1. Spiral learning model

The curriculum setting of architecture is a process from theory to continuously strengthening the understanding of practice and the transformation of theory. In the first year, students mainly study basic theoretical courses. In the second year, curriculum design and internships are added, through which students can obtain direct experience through practice. In the third year, the theoretical course of "Principles of Public Building Design" is added, where students can extract laws to form theories, summarize methods. At the same time, complex curriculum designs and internships are included for re-practice, and students can conduct systematic reflection on their experiences. In the fourth and fifth years, through curriculum design and graduation design, students can apply theories to solve problems in complex topics. The complexity of learning in the whole process gradually increases. The content of ideological and political education in courses is integrated into each stage. Through this repeated cycle, students' innovative abilities are strengthened, their problem-solving abilities are improved, the directionality and effectiveness of students' learning are enhanced, and students' sense of social responsibility is elevated[12].

4.1.2 Innovation of Teaching Methods.

Research-based teaching is a teaching model that takes problems as the guidance, exploration as the core, and students as the main body. In the teaching process, problem-driven and goal-oriented approaches are usually adopted. Teachers stimulate students' learning enthusiasm and interest by setting open-ended questions or real-life scenario tasks. For example, by incorporating social hot issues, frontiers of disciplines, or interdisciplinary issues, problem situations are created, enabling students to discover the interconnections among various disciplines during the learning process and broaden their horizons. The aim is to cultivate students' critical thinking, innovative abilities,

and practical abilities. It organically combines the knowledge objectives (basic theories), ability objectives (analyzing and solving problems), and innovation objectives (critical thinking and design abilities).

In the teaching process, by adding some real cases or specific projects, students can be involved in the classroom, participate in learning how to solve problems, digest, understand and absorb abstract knowledge. At the same time, it can arouse more curiosity among students, forming a complete closed loop of "raising questions → analyzing problems → designing solutions → practical verification → reflective improvement".

4.1.3 Reform of the Evaluation Mechanism.

The research-based teaching model emphasizes process evaluation and pays attention to students' performance during the exploration process, such as teamwork, problem analysis ability, and problem-solving ability. At the same time, a diversified evaluation system should be improved. By introducing teacher evaluation, peer evaluation, evaluation by off-campus experts, and student self-evaluation, students are comprehensively evaluated and examined from multiple angles and at multiple stages. Through student self-evaluation and peer evaluation, students are guided to correctly understand themselves, make self-corrections, improvements, and enhancements. While the evaluation criteria emphasize the commonalities among students and the laws of teaching, they also pay more attention to the individual differences and unique characteristics of students, enabling the evaluation results to develop in the direction of objectivity, fairness, science, and comprehensiveness. The evaluation mechanism focuses on the improvement of students' self-awareness and abilities, with the expectation of cultivating modern new engineering talents who can adapt to the development of industries, majors, and science and technology.

4.2 Support System

4.2.1 Support from the Teaching Staff.

Research-based teaching cannot be separated from the professionalism, collaboration, and innovation of the teaching staff. Starting from the top-level design, application-oriented universities continuously cultivate teachers' scientific research abilities, teaching abilities, reflective abilities, and the ability of lifelong learning, stimulate teachers' initiative and creativity, and ultimately achieve the educational goal with the development of students as the core. Teachers are no longer just transmitters of single knowledge, but have transformed into guides for learning. Application-oriented universities continuously encourage teachers to participate in scientific research projects. By guiding students to participate in subject research, organizing students to participate in social research and other activities, students' initiative is stimulated, and their autonomous exploration abilities and all-round development are cultivated, with scientific research feeding back into teaching[14].

Through the joint participation of teachers and students in the exploration, integration, application, and communication of knowledge, the gap between college students

and professors is gradually eliminated. In universities, the relationship between students and teachers begins to become equal, forming a genuine community of scholars.

4.2.2 Support from Resources and Platforms.

Since architecture is a highly practical discipline, real cases and specific operation processes are indispensable in the teaching process. Through school-enterprise cooperation, 在校学生 (students at school) are given more opportunities to practice in real situations, enabling them to firmly grasp the latest industry demands and development trends. This kind of school-enterprise cooperation is beneficial for both parties to give full play to their respective strengths and jointly promote the development of the architecture discipline. Through exchanges and interactions with other countries, advanced concepts and experiences are absorbed, and various regulations on research-based teaching in architecture are continuously improved. By utilizing the favorable platforms and resources of external cooperation, the best growth environment and development opportunities are provided for students, enabling them to receive the best education in a good international environment, thus improving their language communication abilities and comprehensive qualities and laying a foundation for their future life paths.

In addition, more and more real-life examples are introduced in the teaching process, allowing students to experience the operation process of knowledge firsthand. Or modern scientific and technological information technologies such as VR/AR are used to achieve learning, making learning three-dimensional, intuitive, and full of passion, thus promoting the all-round development of students.

Through a relatively complete and more efficient research-based teaching system and methods, more innovative talents and professionals with compound skills are cultivated.

5 Challenges and Countermeasures

How to strike a balance between the cutting-edge development of the discipline and meeting the needs of regional education is where the contradiction lies. On the one hand, with the increasingly rapid development of science and technology and social progress, new technologies, new knowledge, etc. that come with it cannot be ignored. However, the traditional education system often has a certain degree of lag, so some courses will become obsolete. On the other hand, since application-oriented universities generally attach more importance to teaching than scientific research, some universities are even unable to provide necessary resources. Secondly, in the process of transforming the teaching staff, there are a series of problems such as the difficulty in changing the old teaching ideas, the imperfect teacher training mechanism, and the lack of a good career development plan [12].

Corresponding measures are taken to solve these problems: Firstly, strengthen the timely update and improvement of the curriculum content. Regularly invite authoritative experts to give lectures or participate in the design process of relevant courses throughout the whole process, so as to ensure compliance with the comprehensive development of the discipline. Secondly, with the help of distance education and online

learning platforms, get rid of regional restrictions and break information barriers, so that more students can benefit from high-quality teaching resources. Improve the infrastructure construction level of local schools and offer higher salaries to excellent teaching staff to attract more outstanding teachers to join[14].

Additionally, teaching supports scholarship. Without the support of teaching, the development of scholarship would be unsustainable. Donald Schon of the Massachusetts Institute of Technology proposed a new epistemology of practice in his book *The Reflective Practitioner*. According to this theory, in the process of practice, scholars not only move from theory to practice but also return from practice to theory. Increasing evidence suggests that the best way to form a theory is to apply it, as practice can test and refine theories. Scholarship not only involves exploring, integrating, and applying knowledge but also disseminating it. We refer to the scholarship of disseminating knowledge as the "scholarship of teaching" [1]. Therefore, to better understand and fulfill the role of scholars, universities should grant new dignity and status to applied scholarship.

Finally, conducting quality inspections of teaching and surveying students' satisfaction can keep teaching in a state of continuous improvement in the process of constantly discovering and solving problems.

6 Conclusions and Prospects

The educational reform in universities against the backdrop of digitalization represents a technology-driven educational revolution. Its core lies in discussing the value of the research-based teaching model in talent cultivation through systematic changes: empirical and case studies show that the research-based teaching model can enhance students' learning interest and strengthen their critical thinking, innovative concepts, and cross-disciplinary collaboration. This model emphasizes the integration of theoretical knowledge and practice, encouraging students to actively engage in real-world design problems to better tackle future challenges.

The research-based teaching model has a positive impact on improving the allocation of educational resources and promoting educational reform. The network of shared resources and the connection between schools and enterprises can make up for the limitations of the traditional model, which is conducive to improving students' comprehensive qualities and employment prospects, and promoting the improvement of the overall level of universities. In the face of the new situation where information technology is advancing rapidly and people's ideological concepts are changing rapidly, the research-based teaching model will surely have a greater positive impact on students' entire architecture major[16].

In the future, artificial intelligence will be increasingly integrated into our architectural education, assisting in teaching design and complementing the research-based teaching model to continuously improve teaching quality and research capabilities. Driven by continuous innovations in digital technologies, the future will present a more intelligent, personalized, and globalized educational landscape.

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