

Practical Pathways and Effectiveness Analysis of the Reform of Psychology Experimental Teaching

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Abstract: *The reform of psychology experimental teaching, which serves as a core link for cultivating methodological literacy and empirical thinking, is deeply driven by the dual forces of disciplinary paradigm evolution and technological development. This paper aims to construct an integrated analytical framework to systematically explore the theoretical foundations, model transformation, and evaluation mechanisms of experimental teaching reform. The study sorts out, at the theoretical level, the internal logic of teaching paradigms and their alignment with core competencies, and establishes design principles based on cognitive load theory and transfer theory; it then analyzes the transformation of teaching models from verification-oriented to inquiry-oriented, elaborates on the pathways of virtual simulation technology in balancing ecological validity and experimental control, and proposes a modular and dynamic process integration strategy; finally, it constructs an evaluation system encompassing multidimensional indicators, quantitative tools, and closed-loop feedback to support continuous and scientific improvement of teaching. This study provides theoretical references and practical guidance for systematically enhancing the effectiveness of experimental teaching in cultivating higher-order research capabilities.*

Keywords: *psychology experimental teaching, teaching reform, inquiry-oriented experiment, virtual simulation, evaluation system, learning transfer*

Introduction

The reform of psychology experimental teaching, which serves as a core link for cultivating methodological literacy and empirical thinking, is deeply driven by the dual forces of disciplinary paradigm evolution and technological development. This paper aims to construct an integrated analytical framework and systematically explore the theoretical foundations, model transformation, and evaluation mechanisms of experimental teaching reform. The study sorts out, at the theoretical level, the internal logic of teaching paradigms and their alignment with core competencies, and establishes design principles based on cognitive load theory and transfer theory; it then analyzes the transformation of teaching models from verification-oriented to inquiry-oriented, elaborates on the pathways of virtual simulation technology in balancing ecological validity and experimental control, and proposes a modular and dynamic process integration strategy; finally, it constructs an evaluation system encompassing multidimensional indicators, quantitative tools, and closed-loop feedback to support continuous and scientific improvement of teaching. This study provides theoretical references and practical guidance for systematically enhancing the effectiveness of experimental teaching in cultivating higher-order research capabilities.

1. Theoretical Foundations and Design Principles of Psychology Experimental Teaching

1.1 The Internal Logic of the Evolution of Psychology Experimental Teaching Paradigms

1.1.1 Paradigm Shifts Driven by Methodological Changes

The evolution of psychology experimental teaching paradigms ultimately originates from the methodological changes within the discipline. From the stimulus-response verification of behaviorism to the indirect measurement of internal processing in cognitive psychology, the paradigm shifts reflect a gradual approach to the “black box” of the mind and a continuous update of its operational definitions. This shift is not a mere accumulation of techniques but rather a deepening of the understanding of the ontology of psychological phenomena. It drives the teaching focus from training isolated behavioral

observations to cultivating students' abilities to construct psychological models and design experiments that test cognitive constructs. The internal logic of this evolution manifests as a displacement of teaching focus from “how to operate correctly” to “how to verify effectively,” thereby keeping pace with the scientific core of psychology that pursues falsifiability and precision.

1.1.2 The Expansion of Teaching Boundaries through Technological Integration

The integration of cognitive neuroscience and computer technology has profoundly shaped the development of experimental teaching paradigms. Teaching measurements have expanded from traditional reaction time and accuracy indicators to multimodal technologies such as eye tracking, electroencephalography (EEG), and virtual reality. This integration has broadened the teaching content and cognitive boundaries, making it possible to experimentally investigate complex psychological processes such as attention and emotion. The logic of this evolution lies in the fact that technology not only improves ecological validity and measurement precision but also introduces new research paradigms and problem perspectives. It prompts students to understand the methodological assumptions and limitations of different technological approaches, thereby cultivating their critical thinking in analyzing and synthesizing within a multi-method framework^[1].

1.2 The Alignment Mechanism between Experimental Teaching and Core Competencies of the Discipline of Psychology

1.2.1 The Systematic Shaping of Empirical Thinking

As a key field for shaping students' empirical thinking, experimental teaching operates through a complete cycle of “hypothesis - operationalization - testing - interpretation,” which drives students to transform abstract theories into testable research questions. This process confronts students with core methodological issues such as construct validity, control of confounding variables, and the boundaries of causal inference, thereby helping them internalize the scientific stance that “evidence outweighs intuition.” The key to teaching lies in guiding students beyond the mechanical execution of experimental procedures and toward a deep understanding of experimental logic and design philosophy, so that they can independently evaluate the validity of research designs and develop a mindset of cautious inference.

1.2.2 The Integrated Cultivation of Methodological Literacy

Experimental teaching systematically cultivates students' methodological literacy through the integrated training of the entire process of research design, data collection, and statistical analysis. Its core lies in transcending the instruction of isolated techniques and emphasizing the positioning and function of each technique within the complete chain of scientific reasoning. Students need to understand the logical connections from measurement tool validity testing to data interpretation and appreciate the trade-offs among factors such as experimental control and ecological validity in method selection. This process cultivates their ability to flexibly select and comprehensively apply multiple methods according to research questions.

1.3 The Principles of Cognitive Load and Learning Transfer in Experimental Teaching Design

1.3.1 Optimization of Teaching Resources Based on Cognitive Load Theory

Experimental teaching design must scientifically manage students' cognitive resources according to cognitive load theory. It needs to distinguish between the intrinsic load inherent in the task, the extraneous load induced by poor design, and the germane load that facilitates schema construction. Optimization strategies include modularizing complex experimental procedures, minimizing extraneous load through structured task decomposition and clear guidance, and simultaneously guiding students to invest their cognitive resources in the analysis of key concepts and the understanding of principles. For example, by comparing the strengths and weaknesses of different experimental designs, teachers prompt students to actively construct cognitive schemas about control and validity, thereby deepening their learning^[2].

1.3.2 The Design of Teaching Situations to Promote Learning Transfer

Experimental teaching takes the promotion of learning transfer as its ultimate goal, enabling students to apply what they have learned to real research contexts. Teaching design must go beyond the repetition of fixed paradigms; by creating problem situations with variations, it guides students to apply

core methodological principles such as control and operationalization conditionally. For example, teachers require students to design different testing schemes for the same hypothesis or to analyze potential flaws in existing studies, thereby promoting high-road transfer. This design aims to cultivate students' methodological flexibility and adaptive expertise, enabling them to recognize the deep structure of new problems, independently mobilize and adjust their existing knowledge and skills to solve those problems.

2. Transformation and Optimization of Psychology Experimental Teaching Models

2.1 The Paradigm Shift from Traditional Confirmatory Experiments to Inquiry-Oriented Experiments

2.1.1 Restructuring of Teaching Structure: From Procedure Execution to Problem-Driven Learning

The teaching structure of traditional confirmatory experiments centers on linear procedure execution, in which students follow predetermined steps to replicate classic experiments, and their cognitive goals are limited to confirming known conclusions and becoming familiar with operational processes. The shift toward inquiry-oriented experiments is, in essence, a fundamental restructuring of the teaching structure. The new structure starts with open-ended questions and places students in the position of researchers, requiring them to independently complete the entire process from literature review and variable definition to experimental design and data interpretation. The teaching focus moves from the “correct” replication of fixed procedures to the “reasonable” design of exploratory pathways for research questions. This restructuring enhances students' active cognitive engagement, forcing them to address the inherent uncertainties and multiple possibilities in research design, thereby internalizing the core principles of experimental design through the process of problem-solving.

2.1.2 The Shift of Methodological Focus: From Verification Skills to Constructive Abilities

The paradigm shift is accompanied by a shift in the focus of methodological training. Confirmatory experiments emphasize the precision of operational skills, whereas inquiry-oriented experiments stress the adaptive and constructive abilities of methodology. In the teaching process, students not only need to master a single technique but also need to learn how to weigh and choose among different experimental paradigms, measurement tools, and control methods based on specific research hypotheses. This involves deep reflection on the tension between internal validity and ecological validity, as well as critical comparisons of the logic underlying different experimental designs. This shift in methodological training aims to cultivate students' ability to flexibly integrate and innovatively apply research methods when facing novel and complex problems, thereby realizing a role transformation from a technical operator to a junior research designer^[3].

2.2 The Application Pathway of Virtual Simulation Technology in the Construction of Experimental Situations

2.2.1 The Concretization of Complex Processes and the Integration of Multimodal Data

One of the core application pathways of virtual simulation technology lies in achieving precise concretization and multidimensional measurement of complex or abstract psychological processes. Social interactions, dangerous situations, or micro-level cognitive processes that are difficult to operationalize in traditional experiments can be constructed and rigorously manipulated through virtual environments. The technological pathway is not limited to situational presentation; more critically, it involves the synchronous acquisition and integration of multimodal data. For example, in a virtual social exclusion paradigm, researchers can simultaneously record behavioral choices, eye movement trajectories, and autonomic physiological responses, providing students with a multi-level chain of evidence for analyzing complex psychological phenomena. This pathway expands the boundaries of experimental teaching content, introducing cutting-edge topics from cognitive, emotional, and social neuroscience into the classroom, and trains students' abilities to process and analyze multidimensional, high-density data.

2.2.2 The Integration of High Ecological Validity and High Controllability in Situational Design

Virtual simulation technology provides an effective pathway for reconciling the tension between experimental control rigor and situational ecological validity. It can construct highly realistic scenarios, such as complex traffic intersections or immersive negotiation scenes, while maintaining

millisecond-level precise control over independent variables (e.g., traffic flow, negotiation partner's facial expressions). This integration breaks through the rigid and oversimplified limitations of traditional laboratory situations, enabling students to test theories in complex systems that approximate the real world. This technological pathway requires students to deeply understand how to maintain the logical rigor of experimental design while enhancing situational realism, thereby deepening their understanding of the essence of the experimental method—that is, exploring causal relationships under controlled conditions.

2.3 The Modular and Dynamic Integration Strategy for the Experimental Teaching Process

2.3.1 The Modular Deconstruction of Teaching Content and Progressive Competence Development

The primary strategy for optimizing the experimental teaching process is the logical modular deconstruction of voluminous teaching content. Modular deconstruction is not a simple segmentation of knowledge; rather, it breaks down experimental teaching into core competence modules—such as “literature review and hypothesis formation,” “variable operationalization and design type selection,” “experimental procedure implementation and data acquisition,” and “statistical analysis and report writing” —based on the cognitive ladder of research competence formation. Each module has clear learning objectives and assessment criteria, and it is supported by micro-training units. This deconstruction allows teaching to be flexibly combined according to different specializations and student backgrounds, while ensuring that students receive clear feedback on their competence attainment in each module, thereby forming a progressive pathway for competence development^[4].

2.3.2 The Dynamic Adjustment of Learning Pathways and Personalized Adaptation

On the basis of modularization, the dynamic integration strategy aims to achieve flexibility and personalization in learning pathways. The traditional fixed teaching process is replaced by a dynamic system that can be adjusted in real time according to students' performance and feedback. For example, in the “experimental design” module, the system can dynamically push supplementary cases or design challenges of varying complexity based on students' mastery of fundamental design principles. The teaching process is no longer unidirectionally linear; instead, it forms a cycle of “learning – assessment – feedback – adjustment.” This strategy allows students with advanced abilities to explore higher-level topics in depth, while providing necessary scaffolding support for those who encounter difficulties, thereby achieving a certain degree of personalized adaptation within collective teaching, enhancing overall teaching effectiveness and students' learning autonomy.

3. Construction of an Evaluation System for the Effectiveness of Psychology Experimental Teaching

3.1 Design of Multidimensional Evaluation Indicators for Experimental Teaching Effectiveness

3.1.1 The Foundational Dimension: Assessing the Mastery of Operationalized Knowledge and Procedural Skills

The foundational dimension of the multidimensional evaluation system focuses on students' operationalized understanding of core knowledge in psychology experiments and their level of mastery of procedural skills. The design of indicators in this dimension needs to transcend traditional factual knowledge recall tests and instead assess students' ability to transform abstract concepts (e.g., “working memory load,” “implicit attitude”) into concrete, measurable experimental operations. Specific indicators include the following: whether students can precisely define independent and dependent variables and propose appropriate operational definitions; whether they can identify potential confounding variables in specific experimental designs (e.g., mixed design, within-subjects design) and propose control strategies; and whether they can accurately understand and articulate the internal logic and applicability boundaries of commonly used experimental paradigms. These indicators collectively reflect whether students have constructed a solid cognitive schema of experimental methodology, thereby laying the foundation for higher-order thinking activities^[5].

3.1.2 The Advanced Dimension: Comprehensive Assessment of Research Design and Critical Thinking

The advanced dimension of the evaluation system aims to capture students' ability to integratively

apply knowledge for innovative research and critical evaluation. The design of indicators in this dimension focuses on the examination of complex cognitive processes. Specific indicators include the following: the ability to design an experimental plan with internal validity as well as certain ecological considerations or innovative elements for a given theoretical proposition; the ability to systematically assess the methodological rigor (e.g., construct validity, statistical power) and the reasonableness of conclusions of published psychology experimental studies; and the ability, when faced with contradictory or uncertain data results, to propose multiple plausible theoretical explanations and design follow-up verification strategies. This dimension's indicators focus on the flexibility and depth of students' thinking, as well as their understanding of the “procedural” and “contestable” nature of scientific research.

3.2 Quantitative Analysis Methods for Experimental Operation Skills and Critical Thinking

3.2.1 Analysis of Operation Skills Based on Structured Rubrics and Process Data

The quantitative analysis of experimental operation skills must abandon a single outcome-oriented evaluation and instead adopt a comprehensive method that combines structured behavioral rubrics with process data. The structured rubric predefines key behavioral standards and proficiency levels for each stage of the experiment (e.g., equipment calibration, instruction delivery, data recording). Through direct observation or video playback, researchers code and score students' operations, achieving a fine-grained decomposition of skills. At the same time, process data (e.g., software operation logs, eye-tracker calibration time, error rate curves across experimental trials) serve as objective supplements, revealing the fluency, stability, and problem-solving strategies of students' operations. This analytical method deconstructs the vague concept of “operation skills” into a sequence of observable and comparable quantitative indicators, making teaching feedback more precise.

3.2.2 The Assessment of Critical Thinking through Cognitive Task Analysis and Concept Mapping

The quantification of critical thinking needs to rely on cognitive task analysis tools and semantic assessment techniques. Cognitive task analysis requires students to engage in think-aloud protocols while conducting experimental design or literature evaluation, and researchers then transcribe and code their reasoning processes. By analyzing the frequency and organizational logic of key cognitive elements such as “hypothesis testing,” “alternative explanations,” “identification of validity threats,” and “conditional restrictions” in the discourse, researchers can quantify the depth and structure of students' critical thinking. In addition, concept mapping assessment techniques can be used to measure students' understanding structure of experimental methodology. By comparing the changes in the number of concept nodes, hierarchical relationships, and the complexity of cross-links in students' “experimental design methods” concept maps before and after instruction, researchers can objectively evaluate the development of students' knowledge integration and systematic critical ability.

3.3 The Mechanism of the Teaching Feedback Loop in the Continuous Improvement of Experimental Courses

3.3.1 The Structure of the Closed-Loop Feedback System and Dynamic Data Flow

The effectiveness of the teaching feedback loop depends on a structured closed-loop system, in which a dynamic data flow consists of three core components: multi-source data collection, integrated analysis, and targeted intervention. Data collection relies not only on summative assessments but also systematically incorporates formative assessment data, such as the performance sequence of modular exercises, the quality of questions raised in online discussion forums, and the degree of consensus in peer evaluations. These multi-source and heterogeneous data are processed by an integrated analysis platform, with the aim of identifying common weaknesses among students in specific competence dimensions, as well as potential “breakpoints” or “gray areas” in the teaching process itself. The core mechanism of this data flow lies in transforming the analysis results from a mere judgment of individual students into concrete grounds for iteratively optimizing the course design, content presentation methods, or teaching support resources.

3.3.2 The Evidence-Based Dynamic Adjustment Mechanism of Course Elements

The ultimate mechanism of the feedback loop is to drive the continuous and dynamic adjustment of course elements. When assessment data reveal that students generally encounter difficulties in the “variable operationalization” stage, the triggering mechanism initiates a review and revision of the

corresponding teaching module, such as adding comparative cases or introducing visual design tools. When process data indicate that a specific technical interface of a virtual simulation experiment causes a high level of extraneous cognitive load, the mechanism guides a redesign of the way that technology is embedded. This adjustment mechanism emphasizes a tight coupling of “assessment and improvement,” turning the course into an adaptive system that can self-correct based on real-time evidence of effectiveness. It ensures that teaching reform is not a one-time activity but a continuously evolving professional process grounded in empirical data and aimed at enhancing students' core methodological literacy.

Conclusion

This study has systematically outlined a coherent pathway for the reform of psychology experimental teaching by integrating theoretical analysis, model construction, and evaluation design. The analysis shows that effective reform must be rooted in a deep understanding of the disciplinary methodology's evolutionary logic and shift the teaching focus from procedural skill training to the cultivation of empirical thinking and methodological construction abilities. The inquiry-oriented teaching model, the integrated application of virtual simulation technology, and the modular dynamic process together constitute the key operational carriers for realizing this shift. Furthermore, an evaluation system based on multidimensional indicators, quantitative analysis tools, and a closed-loop feedback mechanism is a necessary mechanism for safeguarding the direction of reform and driving continuous course optimization.

These elements support one another, forming a complete cycle from concept renewal to practical implementation, and then to effectiveness testing and iteration. Future directions may involve further exploring the application of artificial intelligence in personalized learning pathway recommendation and automated formative assessment, deepening the development of experimental teaching paradigms for complex issues such as cross-cultural and developmental topics, and establishing broader inter-institutional collaborative networks to share high-quality experimental teaching resources and evaluation data. Such efforts will continuously strengthen the core role of psychology experimental teaching in cultivating innovative research talents within the context of dynamically evolving disciplines and technologies.

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