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

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Abstract: *The purpose of reforming psychology experimental teaching is to develop students' methodological literacy and empirical thinking, and at present, this reform is being promoted by the dual-track development of the disciplinary paradigm and technology. The following sections will present the theoretical basis, model construction and evaluation of experimental teaching reform in an organised manner. The goals of this paper are to offer theoretical support for the internal logic of teaching paradigms and their connections with core competencies; based on the theories of cognitive load and transfer, design rules will be established; the development path of teaching models from verification-oriented to inquiry-oriented will be analyzed; the process of virtual simulation technology in balancing ecological validity and experimental control will be explained; a modular and dynamic process-integration strategy will be put forward; and finally, a multi-dimensional evaluation system with quantitative tools and a closed-loop feedback mechanism for continuous and scientific improvement of teaching will be built. Offer some theoretical support and practical suggestions in this paper to help improve the general situation of experimental teaching for fostering high-end research ability.*

Keywords: *Psychology experimental teaching, teaching reform, inquiry-based experiments, virtual simulations, evaluation system, learning transfer*

Introduction

Reforms need to be made in the teaching of psychology experiments to cultivate students' methodological literacy and empirical thinking, and this change has been promoted by modifications in the disciplinary paradigm and technological development. The goal of this paper is to construct a general analysis system and systematically study the theoretical foundation, model translation and evaluation of experimental teaching reform. Based on the theoretical foundation of this paper, we will first introduce the internal logic of teaching paradigms and their alignment with core competencies; next, we will establish design principles for teaching in line with cognitive load theory and transfer theory; then, we will analyze the transition of teaching models from verification-oriented to inquiry-oriented; after that, we will elaborate on the path of virtual simulation technology in balancing ecological validity and experimental control; then, we will propose a modular and dynamic process integration strategy; finally, we will construct an evaluation system with multiple indicators, quantitative tools and a closed-loop feedback mechanism for continuous scientific improvement in teaching. Some theoretical and practical support for improving the general situation of experimental teaching in cultivating high-end research ability is provided in this paper.

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 Arising from Methodological Revisions

With changes in how psychology has been studied experimentally, so too have the methods of experimental teaching. Behaviourism is based on the stimulus-response model, and cognitive psychology has, in an indirect way, sought to study internal states and has been striving to define "the black box of the mind" with all its might over the years. It is not only a list of methods but also an advancement in the understanding of the ontology of psychological phenomena. Training based on the observation of isolated behaviour can provide a direction for teaching behaviour observation and promote students' construction of psychological models and design of experiments to verify cognitive constructs. The basic idea of this development is to shift the focus of teaching from "how to operate correctly" to "how to verify effectively", and thus keep pace with the scientific core of psychology, which is falsifiability and precision.

1.1.2 Extending the Scope of Teaching with Technology Integration

In recent years, cognitive neuroscience and computer technology have been used to change the form of experimental teaching. Measurement of teaching has moved away from the old ways of reaction time and accuracy to many modern technologies such as eye-tracking, EEG, virtual reality, etc. Materials have been added to expand the scope of teaching aids and cognitive areas, and now we can conduct experiments on complex psychological phenomena, such as attention and emotion. Although technology has increased both the ecological validity and the measurement accuracy of the research, it has also given rise to new research models and problems. It can help students learn about the methods and deficiencies of all kinds of technology modes, and thus independently consider the advantages and disadvantages of different ways to get things done[1].

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

1.2.1 Systematising the Construction of Empirical Thinking

Experimental teaching is a basic way to train students' empirical thinking, and generally, it takes the form of a full cycle of "hypothesis - operationalisation - testing - interpretation" to motivate students to turn abstract theories into testable research problems. At this time, some basic problems in research methods will be introduced to the students, such as construct validity, control of confounding factors and the limits of causal inference, and they will learn to weigh evidence over intuition. The teacher should guide the students to go beyond merely carrying out the steps of the experiment and cultivate a sense of experimental logic and design thinking; thus, they will be able to independently evaluate the validity of the research design and develop a cautious-inferential attitude.

1.2.2 The Integrated Cultivation of Methodological Literacy

Experimental teaching can promote students' methodological literacy by having them participate in all the stages of research design, data collection and statistical analysis. The general idea is not to list all the ways, but rather to specify where and why each way should be employed in the entire process of scientific research. Students should know why a validity test of a measurement tool is to be conducted and how to balance the demand for experimental control with that of ecological validity in selecting a way to analyse the data. Thus, they will learn to select and use many different ways to solve the problems in their studies.

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

1.3.1 Optimisation of Teaching Materials in light of Cognitive Load Theory

The Design of experimental teaching should be in line with the theory of cognitive load. It should be possible to distinguish among the necessary load of the task, the unnecessary load caused by a poor design, and the helpful load for learning. Optimisation Strategies include modularisation of the complex experimental process, reduction of extraneous load through organisation of division of labour and provision of clear instructions, and simultaneous steering of students' cognitive resources to analyse important ideas and learn basic knowledge. Teachers can compare the strengths and weaknesses of the various experimental designs, and through this process of learning, students will be able to construct their own knowledge systems based on control and validity[2].

1.3.2 Design of Teaching Situations to Promote Learning Transfer

The goal of experimental teaching is to promote learning transfer; that is, students can apply what they have learned in real research situations. Teaching Design should not be limited to repeating the same model; instead, by creating various problem situations, it can help students apply the basic ideas of control and operationalisation in different circumstances. Teachers can have students design all sorts of tests based on the same hypothesis or point out problems in previous studies to promote high-order transfer. The purpose of this Design is to cultivate students' methodological flexibility and adaptability; thus, they will be able to understand the basic structure of new problems and independently use and modify their existing knowledge and skills to solve them.

2. Transformation and Optimisation of Psychology Experimental Teaching Models

2.1 The Change in Paradigm from Traditional Confirmatory Experiments to Inquiry-Oriented Experiments

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

The teaching structure of traditional confirmatory experiments has students follow a fixed procedure and replicate classic experiments; their cognitive goals are to confirm known conclusions and learn about the operation of experiments. In fact, the goal of the new inquiry-based teaching is to reform the teaching system. The new structure starts with open-ended questions, puts students in the role of researchers, and has them independently complete all the steps of literature review and variable definition, experimental design and data analysis, etc. The aim of teaching is no longer to have students learn the correct way; instead, we hope they will explore by posing research questions. Rearranging the order of the course materials can motivate students to study more actively, have them face problems and uncertainties in research design firsthand, and help them grasp the basic ideas of experimental design through problem-solving.

2.1.2 A Shift in the Focus of Methods: From Verification Skills to Constructive Abilities

At the same time, there has also been a change in the direction of training methods. The first is to confirm that the operation skills are correct, and the latter is to examine the flexibility and construction ability of the methods. In the course of teaching, students need to learn a certain way of studying and also be able to weigh and select among many experimental models, measuring instruments, and control devices according to the requirements of their own studies. Determine how much internal validity needs to be reduced for the sake of ecological validity and evaluate the reasons for various experimental designs. The goal of changing how students are taught is to enable them to freely combine all kinds of research methods and create new ones in the face of new and complex problems; thus, they will become junior research designers rather than simple technical operators[3].

2.2 Application Path of Virtual Simulation Technology in the Construction of Experimental Situations

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

The first reason for employing virtual simulation technology is to create an actual space and collect all sorts of data on difficult-to-observe or abstract psychological phenomena. Social interaction, dangerous situations, micro-level cognition and other phenomena that are difficult to observe in traditional experiments can be created and organised in virtual environments. The technology road is not only about presenting the situation; at the same time, one should collect and organise all kinds of data. For example, a virtual social exclusion model can collect all kinds of data on the study of complex psychological phenomena in students at the same time, such as behaviour choices, eye-movement data, changes in autonomic physiology, etc. Therefore, the range of experimental teaching content has been expanded, new topics from cognitive, emotional and social neuroscience have been added to the classroom, and students' ability to process and analyse all kinds of high-density data has been developed.

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

We can increase the range of experimental control and improve the ecological validity of the experiment at the same time. It is very realistic to create a situation, such as a busy traffic intersection or an immersive negotiation, and observe all kinds of independent variables at the millisecond level independently (e.g., traffic flow, facial expressions of negotiation partners). It is no longer an old, fixed laboratory; now, students will learn about complex systems in their daily lives. Although the technology has made the learning materials more situation-specific, students have forgotten how to carry out an organised experiment and are thus unable to learn about cause and effect in a controlled environment.

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

2.3.1 Modular Deconstruction of Teaching Content and Progressive Development of Competence

To improve the way teachers are trained, some divisions will be made of this large volume of material. Modular deconstruction is not the division of knowledge into modules; rather, it is an organisation of the experimental teaching according to the cognitive ladder of building research competence, such as "literature review and hypothesis formation", "variable operationalisation and design type selection", "experimental procedure implementation and data acquisition", and "statistical analysis and report writing". All the modules have different learning goals and assessment criteria, and some micro-training materials can help the students learn. Deconstruction of teaching can be applied flexibly to all kinds of specialisations and students' backgrounds, and at the same time, specific feedback will be given to let students know whether they have grasped the learning content in each part so that they can improve gradually[4].

2.3.2 Dynamic Adjustment of Learning Pathways and Individualised Adaptation

Modules can be added according to the actual needs of personalised learning and customised according to your circumstances. The old fixed-schedule teaching mode will be changed to a flexible one that can be adjusted according to how the students learn and what they tell us. For example, in the "experimental Design" module, based on how well the students have learned the basic design rules, more cases or design problems at various levels of difficulty can be added dynamically. The old way of teaching is gone; now it is more like a perpetual cycle of "learning - evaluation - feedback - adjustment". Therefore, high-achieving students can learn the advanced materials independently, and help will be provided for students with difficulties. Therefore, both the teaching team and the students will be improved, and the overall quality of teaching and student interest will rise.

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 Foundation Dimension: Assessing Mastery of Operationalised Knowledge and Procedural Skills

The first level of the general evaluation system is the students' actual knowledge of the main ideas in the psychology experiments and how well they have learned about the experimental process. Although the Design of indicators in this area should be based on the traditional retrieval of factual knowledge, it is also necessary to consider students' ability to translate abstract concepts, such as "working memory load" and "implicit attitude", into concrete, observable experimental operations. That is to say, can students independently define the concepts of independent and dependent variables, propose corresponding operational definitions for them; can they identify potential confounding variables in all kinds of experimental designs (such as mixed designs and within-subjects designs) and put forward control strategies; and can they learn about and explain the basic logic and application scope of typical experimental paradigms correctly? The above indicators show that students have formed a good cognitive system for experimental methods and are ready to participate in high-level thinking activities[5].

3.1.2 High Dimension: General Assessment of Research Design and Critical Thinking

The first purpose of the assessment system is to know how well students can use all kinds of knowledge in new research and think critically. The Design of the indicators in this dimension is to explore all types of cognition. Specifically, this refers to: the construction of an experimental Design with internal validity; the addition of some ecological factors or new ideas to support a given theoretical proposition; the systematic investigation of the methodological strength (e.g., construct validity, statistical power) and the reasonableness of conclusions in published psychology experimental studies; and the presentation of multiple reasonable theoretical explanations and design follow-up verification plans for contradictory or uncertain data results. The index of this dimension is the flexibility and depth of students' thinking, as well as their understanding of the "procedural" and "contestable" attributes of scientific research.

3.2 Quantitative Analysis Methods for Experimental Operation Skills and Critical Thinking

3.2.1 Analysis of Operation Skills According to Structured Rubrics and Process Data

The quantity statistics of experimental operation skills do not need to aim for a single result; rather, all the collected data should be organised according to a behavioural rubric system. A fixed rubric will set out the required behaviour and the corresponding levels of achievement at different times in the experiment (e.g., equipment calibration, instruction delivery, data collection). Researchers observe and record all the skills that students demonstrate directly, and then systematically assign scores to them. At the same time, the processed data of operation (such as software operation logs, eye-tracker calibration time, error rate curves in different experimental rounds) can also be used to objectively show the fluency, stability and problem-solving strategies of students during operation. The above method is used to break down the general idea of "operation skills" into various observable and quantifiable indicators for more specific teaching feedback.

3.2.2 Assessment of Critical Thinking Based on Cognitive Task Analysis and Concept Mapping

Based on cognitive task analysis and semantic evaluation, quantify the critical thinking ability in the following way. Cognitive task analysis has been used to have students think aloud during the design of experiments or the study of literature, and researchers have recorded and coded these thoughts. By counting how often and in what way the key cognitive elements in the speech appear, such as "hypothesis testing", "alternative explanations", "identification of validity threats" and "conditional restrictions", one can determine the extent and organisation of students' critical thinking. A concept map can be used to determine the structure of students' knowledge of the experimental method. By comparing the changes in the number of concept nodes, hierarchical structure and complexity of cross-links in students' concept maps of "experimental design methods" before and after class, one can objectively determine how well students have integrated knowledge and developed systematic critical thinking.

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

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

The first is that the good effect of the teaching feedback loop is to form a closed-loop system with three links: collecting data from all sides, analysing the collected data, and then using the results of the analysis to improve teaching. The collection of data will be based on both summative evaluation and formative assessment, and other types of data will also be gathered, such as the results of modular exercise sequences, the quality of questions in online discussion forums, and the degree of peer agreement. The integrated analysis platform will collect all this data from all places and all kinds of sources, and it is hoped that it can find common weaknesses among students in certain areas of ability, as well as potential "breakpoints" or "grey areas" in the teaching process. The first kind of data flow is to change the analysis results of individual students from a simple assessment into practical support for continuous improvement in course design, presentation methods of course content, teaching aids, etc.

3.3.2 The Evidence-Based Dynamic Adjustment Mechanism of Course Elements

The purpose of the feedback loop is to constantly and flexibly change all parts of the course. If the assessment data show that there are problems with the students at the stage of "variable operationalisation", then the trigger mechanism will start to revise and adjust the corresponding teaching module, such as adding comparative cases or employing visual Design Tools. If the process data show that a certain technical interface of the virtual simulation experiment has caused a high degree of extraneous cognitive load, then this paper will propose a redesign of technology integration. The above mechanism promotes the idea of "assessment and improvement", and the course is an adaptive system that can be changed dynamically according to how effective it is. It will continue to be a process of professional development for teachers in light of the reforms to teaching, based on actual conditions, and focus on strengthening students' basic methodological literacy.

Conclusion

Organize the logical order of reforming psychology experimental teaching according to theoretical analysis, model construction and evaluation design systematically in this paper. Based on the above analysis, good reform should be based on a deep understanding of the evolutionary logic and changes in teaching methods, and the focus of teaching should be shifted from training procedural skills to cultivating empirical thinking and methodological construction abilities. First, there will be an inquirying teaching model; second, virtual simulation technology will be used; and finally, the two will be combined flexibly in modules. A system of many indicators and quantitative analysis tools should be set up to track the progress of the reform, and at the same time, a closed-loop feedback mechanism for continuous improvement needs to be established.

The above items work together to form a whole process, and then this process can be tested and optimised based on the results. In the future, we will continue to study how artificial intelligence can be used to customise students' study plans and automate formative assessment, strengthen the construction of experimental teaching models for complex issues such as cross-cultural and developmental topics, build an extended network of inter-institutional cooperation to share high-quality experimental teaching resources and evaluation data, etc. Therefore, the above efforts will continue to strengthen the foundation for psychology experimental teaching of new-type research talents in light of changes in all aspects of life and technology.

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