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Exploration and Practice of Multi-level Big-assignment-driven Teaching Method for Specialized Courses under the New Engineering Background

Chunyan Li[1,*], Tao Meng[1], Zunbing Sheng[1]

[1]*School of Mechanical and Electrical Engineering, Heilongjiang University, Harbin, China*
lichunyan@hlju.edu.cn
**Corresponding author*

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Abstract: In order to meet the need for compound innovative talents in engineering education under the new engineering background, a multi-level big-assignment-driven teaching method is proposed. The theoretical framework of the hierarchical big-assignment-driven teaching model is studied. Taking the course Electrical Parts of Power Plants as an example, this paper explores approaches to the content design of personalized big assignments and the hierarchical design of multi-level big assignments. Practice demonstrates that this teaching method has advantages of teaching students according to their aptitude and enhancing their comprehensive ability to solve complex engineering problems, improving their self-directed learning initiative and their interdisciplinary innovation capabilities. It thus provides a replicable new model for the reform of specialized engineering courses.

1. Introduction

The construction of new engineering disciplines aims to cultivate interdisciplinary, innovative and practice-oriented talents who possess comprehensive skills to address the challenges of industrial intelligentization[1-3]. However, traditional engineering education has two major drawbacks. One is that the training of abilities is monotonous. The teaching model based on exam papers neglects the training of the ability to solve complex engineering problems. The other one is that the differences among students are ignored. Uniform assignments are difficult to match the diverse development needs of students.

Engineering specialized courses have strong theoretical knowledge and practical application characteristics, and the course content is closely integrated with practice[4-5]. Through the study of specialized courses, students of this discipline can acquire the basic knowledge and practical skills of the major. To ensure the achievement of teaching goals, within the limited class hours, it is necessary to not only convey sufficient information and knowledge to students, but also cultivate the ability to solve practical problems. Therefore, a multi-level big-assignment model was implemented as a trial in teaching practice, and it achieved positive outcomes[6-8].

Hierarchical teaching can guide students' interests and provide different levels of teaching resources and academic guidance for students with different abilities[9]. Hierarchical and individualized teaching approaches can better stimulate students' intrinsic motivation to learn and foster their creative thinking[10-11]. It not only builds a progressive growth ladder for students with weak foundations, but also provides an innovative space for students with sufficient learning ability to break through themselves. For the improvement of the quality of specialized courses and the cultivation of students' engineering practice ability and independent innovation ability, it is of great significance.

A teaching model of hierarchy and big-assignment for specialized courses is proposed. Using comprehensive big-assignments with engineering backgrounds as a pedagogical vehicle, the teaching content is divided into three levels based on cognitive complexity and engineering difficulty. They are consolidation of basic knowledge, improvement of abilities, and expansion of innovation. Students are allowed to choose tasks that match their own levels autonomously, and they can adjust the advancement path flexibly according to learning states dynamically. This is conducive to cultivating students' engineering practice ability and independent innovation ability, which meets the needs of talent cultivation in the context of new engineering background.

2. The Framework of the Multi-level Big-assignment-driven Teaching Method

2.1. Core Concept

The hierarchical big-assignment-driven teaching method is oriented towards three-level abilities. It includes the basic level, advancement level and innovation level. It systematically enhances students' cognitive and practical abilities. The three-level abilities are shown in Figure 1.

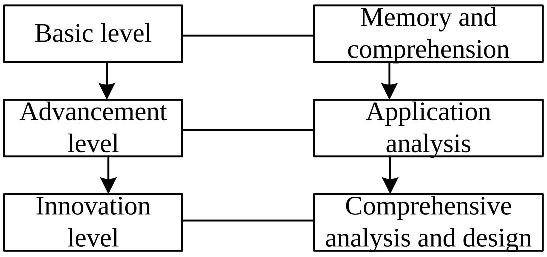

Figure 1: Three-level abilities.

The basic level focuses on the construction of the base of the knowledge system, requiring learners to master core concepts, terms, and basic principles. A knowledge repository is formed by identifying and memorizing key definitions, categorizing information, or formulas, which is laid the foundation for higher-level abilities. This stage emphasizes accuracy and completeness, and it is the starting point of the ability chain.

At the advanced level, based on the internalization of knowledge, the ability is promoted to be transferred to practice. Learners are required to apply theories to solve practical problems, with a focus on cultivating the abilities of information integration and causal reasoning, which achieves the leap from understanding to application.

The innovation level focuses on higher-order thinking and original output, requiring learners to integrate knowledge from multiple fields and complete complex system design or strategic innovation. At this stage, it emphasizes critical thinking, systematic reconfiguration, and solution, which drives knowledge to transform into value.

2.2. The Teaching Organization Process

The teaching organization process in each stage of the implementation of the multi-level big-assignment-driven teaching method is shown in Table 1.

Table 1: The teaching organization process in each stage.

Stage	Teacher Role	Student activities
Assignment of tasks	The content design and the hierarchical design of the big assignment	Free choice of difficulty level of the big assignment
Process Guidance	Consultant	Learning research and scheme design
Outcome Evaluation	Multidimensional evaluator	Report

In the implementation of the differentiated instruction for the big-assignment teaching, teachers mainly assume the roles of designers for the project tasks and content stratification, consultants throughout the course, and multi-dimensional evaluators. Students' activities mainly include freely selecting difficulty levels, conducting research and designing solutions, and finally submitting a report.

2.3. Hierarchical Dynamic System Design

The problem of student ability matching and challenge motivation is addressed by combining the design of a hierarchical dynamic evaluation system with the mechanism of adding difficulty coefficients. The design of the hierarchical dynamic evaluation system refers to the hierarchical weighting model and dynamic difficulty adjustment principle in educational evaluation. It can be combined with specific subjects to refine the weight of indicators. The advantage of the hierarchical dynamic evaluation system is that it not only ensures fairness but also provides growth guidance. Students at the basic level can obtain stable scores through high completion rates, which avoids direct competition with higher-level tasks. The additional scoring mechanism quantifies the willingness to challenge into explicit benefits, which promotes the improvement of autonomous ability.

2.3.1. Differentiation Level Scoring Standard

Students with weak foundations are avoided to choose high-level tasks blindly, which may lead to frustration. At the same time, the scoring standard strictly matches the ability goals at each level should be ensured. Three levels of tasks are designed with students' cognitive abilities. They are the basic level, the advancement level and the innovation level. For each level, an independent scoring standard is adopted as follows.

1) The basic level focus on task completion and basic skill attainment. The main focus lies in the completeness of the steps, such as the coverage of basic knowledge points.

2) The advancement level increases the weight of comprehensive application ability, such as data analysis.

3) The innovation level emphasizes innovation and in-depth exploration, such as originality of solutions, and demonstration of high-level thinking.

2.3.2. Difficulty Coefficient Bonus Mechanism

On the basis of completing the tasks at the current level, a stepwise bonus can be obtained if a higher difficulty challenge is chosen. For example, an additional 5% for the transition from the basic level to the advancement level, and 8% for the transition from the advancement level to the innovation level. The bonus is calculated independently and it does not occupy the weight of the basic score. This ensures that students prioritize completing the core tasks at the appropriate level. The bonus mechanism allows students to attempt breakthroughs without sacrificing the basic score.

3. Taking the Course of Electrical Part of Power Plant as Example for Teaching Implementation Case

3.1. Personalized Content Design of Multi-level Big Assignment

Taking the course on the electrical part of power plants as an example, the personalized three-level task content design for the multi-level big-assignment is shown in Figure 2.

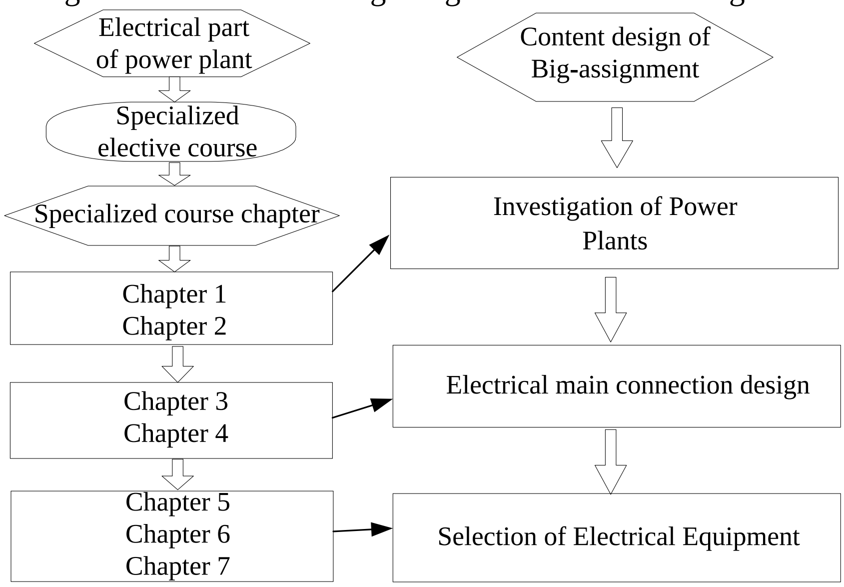

Figure 2: The personalized three-level task content design for the multi-level big assignment.

The teaching content of the course for electrical part of power plant consists of seven chapters. They are overview, heating and Electrodynamics of conductors, arc extinguishing principle and main switch equipment, main electrical connection design, plant power supply connection design, selection of electrical equipment, and distribution device. The personalized big-assignment content is divided into three parts, including power plant investigation, main electrical connection design of power plant, and selection of electrical equipment in power plant. The content of the personalized big- assignment involves all chapters of the teaching content, runs through the entire course. It is a comprehensive design.

3.2. Hierarchical Design of Big-assignment

Take the course on the electrical part of power plants as an example. For each sub-task of the core content of the course, three levels are designed as shown in Table 2.

The levels are divided into foundation level, advancement level, and innovation level. The design of the content ensures that each adjacent level is a continuation of the previous one, with increasing difficulty and correspondingly higher requirements for comprehensive analysis and design capabilities.

Table 2: Setting of the three level of the sub-task.

Task content	Basic level	Advancement level	Innovation level
(1) Investigation of Power Plants	Collect parameters such as single-unit capacity and voltage level	Analyse the load characteristics and the bottlenecks of the equipment operation bottlenecks	propose improvement suggestions according to performance of different generator sets
(2) Electrical main connection design	Reproduce the electrical connection diagram of the investigation power plant	Design independently a feasible electrical main connection design scheme	Propose 2-3 solutions of feasible electrical main connection design schemes and justify the optimal one.
(3) Selection of Electrical Equipment	Identify physical objects of electrical equipment such as circuit breakers and transformers	Master the working principles of electrical equipment	Complete electrical equipment selection and perform dynamic and thermal stability verification

3.3. Single-blind Dynamic Hierarchical Selection Mechanism

Teachers assign differentiated assignment tasks, and the content of these tasks runs throughout the entire course. Tasks are designed with hidden level labels, which are only distinguished by I/II/III type learning modules. Students can choose the content of the assignment to complete based on their own situations, that is, they can select different levels. During the entire course of teaching, students can dynamically adjust the level when they do the tasks. Teachers customize the feedback language based on the students' self-selected levels. The assignment collaboration mechanism adopts a hierarchical group discussion approach. For example, students at the basic level are responsible for collecting equipment parameters, while those at the innovative level lead the integration of the plan.

3.3.1. Protection of Students' Confidence in Learning by the Unlabelled Choice mechanism Design

The core focus of this mechanism lies in eliminating hierarchical labels, replacing them with Task Packages Type I/II/III to distinguish between different tasks. What students see is merely different types of tasks, rather than terms like basic level or advancement level which can easily cause psychological stress. Teachers do not disclose the students' levels. They do not directly assign specific types of homework to students. Instead, it is up to them to choose by themselves. This unlabelled choice mechanism avoids categorization and allows each student to feel they are making a normal task selection, rather than being sorted into a certain level. It protects students' learning confidence and enthusiasm for completing homework.

3.3.2. Truly Serving the Students through Self-selection and Dynamic Adjustment of the Hierarchical Selection Mechanism

Allowing students to choose their own learning pathways and giving them an opportunity to gain self-awareness and challenge themselves. This choice is dynamic. Students can adjust their pathways discreetly as the situation requires during the task process. In this framework, throughout the entire course, students' pathways are not fixed but are managed dynamically based on their learning performance, homework completion, and personal progress.

3.3.3. Allowing Students of Different Abilities to Mutually Inspire and Support Each Other by Cross-level Group Discussions

The cross-level group discussions have avoided the isolation that might result from hierarchical grouping, which allows students of different ability levels to learn from each other in collaboration. Students at the basic level gain a sense of achievement by participating in specific tasks, while those at the advancement level develop their integration and leadership skills.

3.4. Course Reform of the Assessment and Evaluation Method

The reform involves adjusting the weight of the performance indicators to emphasize the process value of the multi-level big-assignments. The assessment methods before and after the reform are shown in Table 3.

Table 3: Comparison of course assessment methods.

	Original weights	New weights	Evaluation Focus
Final exam	60%	50%	Core concepts and analytical computing capabilities
Regular performance	20%	15%	Classroom interaction and tests
Experimental operation	20%	20%	Switching Operations in Power Plants and Other Field Operations
Big-assignment		15%	Comprehensive analysis and design capabilities

The introduction of multi-level big-assignments and adjustment of weight distribution have constructed a three-dimensional evaluation system of theory, practice and comprehensive application. The multi-level big- assignment is accounting for 15%. It not only retains the 20% experimental assessment of practical operation ability but also reduces the proportion of final exam from 60% to 50%, which weakens the limitations of single theoretical assessment. This adjustment strengthens the evaluation of students' knowledge integration, engineering design and problem-solving abilities. At the same time, it guides students to shift from passive exam-oriented learning to active exploration, and effectively improves the comprehensiveness and scientificity of the evaluation system.

4. Conclusions

Under the background of new Engineering Education, engineering education is accelerating its transformation from knowledge imparting to ability cultivation. The demand for interdisciplinary innovative talents is more urgent than ever before. To address these challenges, a hierarchical big-assignment-driven teaching method is proposed. With personalized big-assignments as the carrier, we design hierarchical tasks to meet different student needs. This model realizes the transformation from uniform teaching to tailored teaching, which effectively solves the problems of large differences in students' foundations and varying levels of engagement in traditional classrooms. Practice has shown that this method not only significantly enhances students' comprehensive ability to solve complex engineering problems, but also effectively improves their autonomous learning initiative and interdisciplinary innovation consciousness.

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