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Reflections on Teaching Reform of Professional Basic Courses in the Context of Digitalization

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Abstract: In the digital context, teaching reform of professional basic courses requires balance between theoretical teaching and digital technology application. Taking the “Fluid Mechanics and Pumps" course as an example, this paper analyzes typical problems in the reform. Specifically, a deviation in course orientation results in weak theoretical instruction, excessive use of information technology intensifies students’ cognitive load, and the abuse of AI tools undermines the effectiveness of after-school tasks. The study proposes optimization paths. Firstly, it involves strengthening the theoretical system by reconstructing course orientation. Secondly, it aims to optimize knowledge presentation with AI and mind maps to reduce students’ cognitive load. Thirdly, it ensures the originality of after-school tasks through intelligent course platforms. The results provide practical references for teaching reform of professional basic courses in the context of digitalization, facilitating the transition from knowledge acquisition to ability generation.

1. Introduction

With the rapid development of human society, the demand for talent is constantly changing. Higher education teaching reform aims to adapt to this social demand by cultivating high-level talent with practical ability, innovative ability, and stronger adaptability to modern social challenges [1,2]. In this context, the teaching effect of professional basic courses, as a core link in the talent training system, directly affects the formation of students' comprehensive abilities. Current teaching still has problems such as emphasizing practice over theory, unclear knowledge presentation logic, and lack of innovation in after-school tasks, which hinder students' deep learning and the development of higher-order thinking.

In the curriculum system of talent cultivation, professional basic courses are a crucial junction that enables students to transform from general knowledge acquisition to professional competence development, playing a connecting role in the talent cultivation system. In professional basic course teaching, it is necessary not only to integrate students' general theoretical basic knowledge but also to provide them with necessary professional background knowledge and practical skills so as to facilitate students’ transition to professional course learning and enhancing their understanding of professional fields. Therefore, when reforming teaching models and methods, professional basic courses should focus on their characteristics and orientation. They should strengthen the systematicity and forward-looking nature of course content based on students' cognitive development laws and in combination with disciplinary frontier trends. Meanwhile, with the help of information-technology-based teaching platforms, teachers should optimize teaching resource allocation, precisely adjust teaching rhythm through intelligent feedback and learning situation analysis, and reduce students' cognitive load. Teachers should introduce project-based and problem-oriented learning tasks to stimulate students' inquiry enthusiasm and promote the improvement of their knowledge transfer and comprehensive application abilities.

The "Fluid Mechanics and Pumps" course taught by the author is a compulsory and core course for the oil and gas storage and transportation major, which is also a typical professional basic course. This paper primarily focuses on analyzing and reflecting upon several typical problems in the teaching reform of this course.

2. Problems in Curriculum Reform

2.1 Problem of Deviation in Professional Basic Course Orientation

Case-based teaching is a teaching method that uses typical examples in real situations as vehicles to guide students to build knowledge frameworks by analyzing problems. It has been widely applied and popularized in various engineering, management and other course teachings [3].

However, case-based teaching places excessive emphasis on engineering applications. This weakens the systematic deduction and internal logical connection of basic theories. As a result, students have inadequate comprehension of principles when transferring knowledge, resulting in the phenomenon of knowing the facts without knowing the underlying reasons. This reflects a deviation in course orientation. It fails to balance the relationship between "basic" and "professional". It also ignores the basic orientation that professional basic courses should focus on consolidating theoretical foundations and serving subsequent professional courses.

The author also discovered in the final exam paper analysis that, although students' application ability has greatly improved, there is a common phenomenon of losing marks in basic concept. This indicates that students have an insecure mastery and vague differentiation of basic concepts. These issues are often concealed by good performance in classroom interactions and exams.

After thorough discussion and analysis, the course team holds the view that the root cause of the problem lies in the deviation of course orientation. In the process of emphasizing engineering practice and application orientation, the teaching focus unconsciously shifts towards professional applications, ignoring the systematic cultivation of students' theoretical reasoning and basic abilities. As a professional basic course, it essentially aims to equip students with a solid theoretical framework and scientific thinking methods, rather than merely addressing specific engineering problems. Therefore, it is necessary to redefine the boundary between "basic" and "application" and adjust the depth and breadth of case design. Under the premise of maintaining the fidelity of engineering situations, the teaching weight of theoretical derivation, model abstraction and logical connection should be strengthened, ensuring that students can not only understand the source of knowledge but also flexibly apply it to complex situations.

2.2 Problem of Cognitive Overload in Classroom Teaching

With the rapid development of educational technology, PPT has become a mainstream tool for classroom teaching, while blackboard writing has gradually relegated to an auxiliary teaching tool [4]. The widespread adoption of multimedia technology has greatly shortened the time teachers need to display knowledge. Consequently, the classroom information capacity has increased significantly.

However, students' cognitive abilities have not developed in tandem over time, and this discrepancy between information transmission and students' cognitive abilities may have adverse impacts on teaching effects.

The excessively rapid flow of information deprives students of sufficient time for thinking and digestion. Knowledge remains at a superficial memory level, which makes it difficult for students to build an internal logical system. Especially when deriving complex formulas or analyzing key concepts, an excessively rapid PPT page-flipping rate leads to frequent interruptions in students' thought processes and frequent imbalances in cognitive load. In the early stage of teaching reform, the author devoted considerable effort to courseware design and classroom activity organization, yielding remarkable outcomes. The classroom atmosphere became more vibrant, and students' learning interest increased significantly. However, a classroom power outage incident triggered the author’s in-depth thinking. The teaching content at that time was the equilibrium differential equation of fluid statics. It involved a lot of formula derivation and theoretical analysis, making it relatively tedious. The author had meticulously designed and refined this content, and the feedbacks from previous students were positive. The power outage incident occurred right during the class. The author had to temporarily switch from the original PPT demonstration to blackboard-based derivation. Due to the minor disruption to the teaching progress, the author streamlined the explanation of some mathematical formulas and finally completed the scheduled teaching task.

Although the class was less lively with reduced interaction and the derivation process was less visually appealing than PPT demonstration, the students’ feedback after class was extremely enthusiastic. To the author’s surprise, the post-test results significantly outperformed those of the previous PPT teaching. Students generally reported that during the step-by-step blackboard writing derivation, they could keep up with the teacher, which made it easier for them to grasp logical clues and form a complete knowledge schema. This "accidental" event reveals the unique advantages of slow, linear, and persistent blackboard writing in theoretical teaching, especially in higher-order cognitive processes, which are irreplaceable. The optimization of technical means should not only pursue the efficiency of information presentation but also serve the essential goal of thinking cultivation. This prompted the author to re-evaluate the balance between technology and teaching and begin to explore how to reconstruct the "cognitive space" art in information-based teaching, so that knowledge presentation is no longer a speed competition but an effective guide for thinking growth.
The reason may be that the extensive adoption of information-based teaching methods in current higher education has inadvertently sped up the teaching pace, making the volume of teaching content surpass students' cognitive load [5,6]. This leads to students' selective acquisition of knowledge – neglecting the process of derivation and only remembering the results. Moreover, they often engage in rote application of formulas in exercises, ultimately resulting in a feeble theoretical grounding among them.

2.3 Problem of Ineffective After-class Open-ended Tasks

In the traditional teaching model, after-class assignments are mainly exercise-based training, the core purpose of which is to consolidate classroom knowledge through exercises. Students need approximately sixty minutes to complete each assignment. However, after introducing case-based teaching, the form of assignments has changed. Students not only have to complete regular practice assignments but also take on open-ended project tasks.

According to the task design goal, completing such assignments requires students to consult a large amount of literature, analyze, organize, and then form a task research report after group discussion. This process intends to effectively enhance students' comprehensive analysis and problem-solving abilities. However, the teaching practices indicate that, since students’ professional literacy has not yet been formed at this stage, their understanding of the professional field is superficial, and they can solely gain a basic understanding of it. Moreover, there exists content overlap between open-ended project tasks and professional course teaching, and the actual teaching effect is not ideal.

Many students often feel bewildered when facing open-ended problems. They have inadequate literature retrieval ability and lack a logical framework for information integration. Ultimately, tasks become a mere formality, consuming a lot of time with low efficiency. This exposes a major problem in current teaching design which ignores the characteristics of students' cognitive development stage. The premature introduction of high-order tasks not only increases students' learning burden but also occupies their time and energy for basic construction.

3. Reflections on Curriculum Reform

In response to these issues, the author holds that improvement and optimization can be conducted from the following aspects:

3.1 Reposition the Course and Return to the Essence of the Course

The basis of application ability lies in the in-depth understanding of principles, not just skillful operation. Therefore, the course must return to the teaching logic of "theory-oriented", strengthen the explanation of both the physical meaning behind formulas and conditional constraints. Meanwhile, it should avoid simplifying complex problems into black-box operations, enabling students to understand not only what is involved but also why it is so.

Based on the above reflections, the teaching reform of professional basic courses can be optimized from the following three key dimensions:

Firstly, it is necessary to re-examine the course orientation and prioritize the teaching of theoretical knowledge. A solid understanding of necessary theoretical knowledge serves as the foundation for students to subsequently develop their application abilities. In the teaching process, it should be avoided to introduce complex engineering projects too early. This can prevent the weakening of in-depth explanation of basic principles due to an over-emphasis on practical aspects, thus resulting in both the situation of reversing the proper sequence and the problem of redundant teaching. Classic theories should be taken as the core, and engineering cases should be integrated in a step-by-step manner.

Secondly, it is vital to optimize the connection mechanism between teaching content and practical application. By selecting typical cases as supplements to the teaching content, we can achieve a seamless integration of theory and application, thereby effectively enhancing students' professional competence and holistic skills. Through cases, students can be guided to delve into the fundamental nature of formula derivation and encouraged to engage in independent modelling and verification across diverse situations, rather than relying on ready-made templates. In practical application, open-ended questions should be posed to stimulate students' curiosity and reinforce the training of coherent logical reasoning.

Finally, appropriately adjusting the structure of after-class tasks is an important means to guide students' deep-level learning. Teachers should reduce redundant exercises and increase thought-provoking questions to encourage students to actively explore theoretical underpinnings and guide them in independently constructing the framework of the course knowledge system. By using well-designed question chains, teachers can help students sort out the logical connections between core concepts and enhance their knowledge integration ability. Teachers should combine periodic assessments and group discussions to provide timely feedback on students' knowledge gaps and reinforce their process of independent construction.

3.2 AI-Empowered Precision Teaching Design

To address the problem of cognitive overload in classroom teaching, visual mind maps and structured knowledge graphs can be fully utilized. By combining them with students' cognitive traits and course characteristics, teachers can optimize the design of course teaching. This optimization can be carried out from the following three aspects:

Regarding course content, mind maps, knowledge graphs and other similar tools can be used to optimize the structure of the course knowledge system. This can make the learning of course knowledge more in line with human cognitive logic, thereby reducing students' inherent cognitive load and improving learning effectiveness. With the aid of AI technology, we can dynamically generate personalized learning paths. This can help students clearly clarify the hierarchical relationships between concepts and strengthen their understanding, transfer and application of key nodes.

With regard to teaching implementation, the course rhythm should be appropriately slowed down to leave sufficient thinking time for students, ensuring that knowledge points can be thoroughly comprehended and internalized by students. By analyzing the issues identified in pre- and post-tests, teachers can help students promptly discover and address their knowledge gaps. Regarding classroom teaching activities, attention should be paid to the conciseness and effectiveness of forms to avoid the interference that formalized design exerts on core knowledge. Teachers should focus on key concepts, thereby designing a limited number of well-crafted investigative tasks and adaptively modifying activity difficulty and guidance strategies.

3.3 Optimizing Open Assignments via Intelligent Course Platforms

In the teaching system of professional basic courses, open assignments possess distinctive and significant value. Their purpose is to overcome the limitation that traditional exercises solely concentrate on the simple application of formulas. They aim to construct a complete learning chain of "problem-oriented - independent exploration- academic output". This, in turn, promotes students to shift from simple knowledge mastery to comprehensive ability development. However, ensuring students’ active and meaningful engagement is key to achieving this anticipated outcome.

To achieve this goal, teachers can use intelligent course platforms to establish hierarchical task modules. They can assign personalized research topics to different students. Students can conduct in-depth inquiry according to their own interests and proficiency levels. Through semantic analysis technology, teachers can provide timely feedback on divergences in students' thinking paths. Moreover, they can offer dynamic resource provision to help students successfully complete assignments. In this way, students are better supported in their learning process.

4. Conclusion

This paper analyzes the characteristics and orientation of professional basic courses. It studies the typical issues in course construction and reform, including deviation in the orientation of professional basic course, cognitive overload in classroom teaching, and ineffective after-class open-ended tasks, as well as their underlying causes. Based on these analyses, the paper proposes solutions:

By re-evaluating course orientation, enhancing theoretical knowledge instruction, optimizing the integration mechanism between teaching content and practical application, and appropriately adjusting the structure of after-class tasks, teachers can ensure that students acquire necessary theoretical knowledge before developing their application abilities. These measures collectively avoid reversing the proper sequence and redundant teaching.

By utilizing AI tools to optimize the course knowledge system, slowing down the course rhythm for sufficient thinking time, focusing on the conciseness and effectiveness of forms, and implementing formative assessment and assessment of higher-order thinking skills, teachers alleviate students’ cognitive overload and prioritize the cultivation of theoretical knowledge and thinking ability.

By leveraging the features of intelligent course platforms and optimizing open-project design, teachers enhance the effectiveness of open-ended assignments. In addition, through peer evaluation, teachers facilitate idea-sharing and interactive feedback among students to strengthen their comprehension of knowledge points.

In conclusion, the teaching reform of professional basic courses should be based on theoretical construction. By redefining course orientation to strike a balance between theory and practice, refining the logic of knowledge transmission to coordinate technology empowerment teaching with cognitive laws, and strengthening task originality to ensure the quality of ability development, teachers are able to achieve the in-depth transformation from knowledge-centered instruction to ability generation.

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