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Teaching Practice of "Three-Dimensional Penetration" in Engineering Drawing Course

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Abstract: Based on the constructivist learning theory, this paper proposes a "Three-Dimensional Penetrating" teaching model, which organically integrates the knowledge, competence, and literacy dimensions into the entire teaching process. Targeting the teaching content of the Engineering Drawing course, the ideological and political teaching objectives of the course are put forward: cultivating students' adherence to drawing standards, a serious and responsible work attitude, and a rigorous and meticulous work style. The ideological and political teaching design idea of the course is proposed: without changing the original knowledge and teaching systems, and centered on the course's ideological and political objectives, ideological and political content is interwoven with specific teaching materials. Taking the Engineering Drawing (2) course as an example, the ideological and political teaching cases integrated into each week's course are listed in detail. The practical results show that this teaching model effectively improves students' ideological and political literacy and engineering practice ability, and provides a useful reference for the ideological and political construction of professional courses in engineering disciplines.

1. Introduction

According to the Guidelines for the Construction of Curriculum Ideological and Political Education in Institutions of Higher Education issued by the Ministry of Education in May 2020, integrating ideological and political education into professional course teaching has become an important way for colleges and universities to implement the fundamental task of fostering virtue through education [1]. Engineering Drawing is a core basic course for engineering majors, which not only undertakes the mission of imparting professional knowledge but also shoulders the responsibility of cultivating students' engineering literacy, professional ethics, and national sentiment. Su et al., guided by fostering virtue through education, integrated the connotations of national conditions education, science and technology education, and professional behavioural norms into course teaching [2]. Bai effectively utilized the "Great Ideological and Political Course" to cultivate excellent engineers and constructed an all-staff, whole-process, all-field, and all-round training system for outstanding engineers [3]. Xiang et al. constructed a "five-element and multi-dimensional"

ideological and political content system for the Engineering Drawing course, and established a "three-classroom coordination, four-classroom integration, and five-competence promotion" ideological and political education path for the course, continuously improving the education effect of the Engineering Drawing course [4]. Zhang et al. strengthened the construction of curriculum ideological and political education through "three combinations", "three integrations", and "three learnings", promoting the smooth integration of professional courses and ideological and political education [5]. Li et al. took the craftsman spirit as the starting point, responsibility as the grasp, and practical teaching and team cooperation projects as the basis, exploring the ideological and political reform of the Engineering Drawing course based on typical ideological and political elements such as team cooperation, sense of responsibility, and craftsman spirit [6]. Many universities have integrated curriculum ideological and political education into the Engineering Drawing course. However, the current ideological and political teaching of the Engineering Drawing course still faces many challenges, such as insufficient integration of ideological and political elements with professional content, single teaching methods, passive acceptance by students, and imperfect evaluation systems. Therefore, in-depth research into the theory and practice of ideological and political teaching in the Engineering Drawing course is of great significance. This study aims to explore an effective model for ideological and political teaching in the Engineering Drawing course. By in-depth analysing the characteristics of the course, designing teaching content integrated with ideological and political elements, innovating teaching methods, the "Three-Dimensional Penetrating" teaching model is proposed, and a collaborative education system of "knowledge and skills-professional literacy-national sentiment" is constructed. The effectiveness of the model is verified through teaching practice, providing an innovative path for ideological and political education in engineering courses.

2. Theoretical Basis of the "Three-Dimensional Penetrating" Teaching Model

2.1 Connotation of the "Three-Dimensional Penetrating" Teaching Model

The "Three-Dimensional Penetrating" teaching model proposed in this paper refers to the organic integration of three dimensions—knowledge, competence, and literacy—into the entire teaching process, rather than treating them in isolation. The knowledge dimension includes core disciplinary knowledge, interdisciplinary knowledge, and cutting-edge knowledge; the competence dimension includes problem-solving ability, communication and collaboration ability, and innovation ability; the literacy dimension includes moral character, humanistic literacy, scientific spirit, and social responsibility.

• Knowledge dimension of the Engineering Drawing course: Projection theory, various expression methods of engineering drawings, specified drawing methods and annotations for standard parts and commonly used parts, expression methods and annotation methods of various technical requirements in part drawings, and expression methods and annotation methods in assembly drawings.

• Competence dimension of the Engineering Drawing course: Spatial imagination ability, drawing expression ability, and the ability to correctly read and draw part drawings and assembly drawings.

• Literacy dimension of the Engineering Drawing course: Awareness of implementing national standards, engineering thinking of applying knowledge to practice, rigorous scientific thinking mode, serious and responsible work attitude, and the craftsman spirit of striving for excellence.

In essence, the literacy dimension of the Engineering Drawing course is the ideological and political content of the course. Therefore, it is imperative to integrate curriculum ideological and political education while imparting drawing knowledge and cultivating students' drawing abilities, so as to construct the "Three-Dimensional Penetrating" teaching model.

2.2 Theoretical Basis of the "Three-Dimensional Penetrating" Teaching Model

The theoretical basis of the "Three-Dimensional Penetrating" teaching model originates from constructivism, which was established based on Piaget's genetic epistemology and later developed by Vygotsky and other scholars. Its theoretical connotation has been further enriched, forming a methodology that effectively improves the effect of cognitive learning [7]. The contemporary constructivist learning theory emphasizes "student-centered" learning, positing that knowledge is not derived from the teacher's one-way instruction but is acquired by learners within a certain context with the help of the teacher. It emphasizes that students actively construct knowledge, while teachers act as guides and facilitators. Therefore, the constructivist learning theory holds that "context", "collaboration", "conversation", and "meaning construction" are the four core elements or attributes of the learning environment [8]. The "Three-Dimensional Penetrating" teaching model organically integrates knowledge, competence, and literacy, while emphasizing that students actively construct knowledge and teachers serve as guides and facilitators.

Based on active processing and meaning construction in a specific context through collaboration with others and on the basis of existing knowledge and experience, constructivism advocates designing teaching from the aspects of stimulating interest, creating contexts, and organizing collaborative learning to improve students' autonomous learning effects, and has derived teaching methods such as situational teaching and cooperative learning. Constructivism holds that knowledge is not obtained through teacher instruction, but is acquired by learners in a certain context (i.e., social and cultural background) with the help of others (including teachers and learning partners) through interpersonal collaborative activities and the use of necessary learning materials, via the way of meaning construction. Since the learning environment required by constructivism has been strongly supported by the latest information technology achievements in the contemporary era, the constructivist theory has increasingly been combined with the teaching practice of teachers, thus becoming the guiding ideology for deepening teaching reform in schools at home and abroad.

3. Curriculum Ideological and Political Teaching Design

3.1 Ideological and Political Objectives of the Engineering Drawing Course

The Engineering Drawing course covers a wide range of content and is one of the first basic courses for engineering majors that freshmen come into contact with, featuring the pioneering role in education. Therefore, the construction of curriculum ideological and political education in this course is of great importance. Since 2020, our university has continuously explored the integration of curriculum ideological and political education into the teaching of Engineering Drawing course [9]. Based on the teaching tasks of Engineering Drawing course, the ideological and political objectives of the course are determined as follows: starting from the historical development of engineering drawing, introduce the brilliant achievements of China's ancient machinery manufacturing to stimulate students' national pride and cultural confidence; emphasize the importance of drawing standards and rigorous attitude, connect them with the professional ethics and sense of responsibility of engineers, guide students to develop a serious, responsible, and meticulous work style, and ultimately achieve the goal of cultivating high-quality engineering and technical talents. Through the political education function of curriculum ideological and political education, the academic objectives of the course are achieved, laying a solid foundation for subsequent courses (e.g., Mechanical Principles, Mechanical Design, and Mechanical Structure Design, etc.) and future work.

3.2 Ideological and Political Teaching Design Ideas for the Engineering Drawing Course

The ideological and political teaching design idea for the Engineering Drawing course is: on the premise of maintaining the original knowledge system and teaching system unchanged, focus on the ideological and political teaching objectives of the course, insert ideological and political content into specific teaching content, and carry out ideological and political teaching through in-class PowerPoint presentation and requiring students to watch online short videos after class. Each weekly lesson (2 class hours) involves ideological and political content, so as to achieve the effect of "moistening things silently".

The ideological and political elements mainly include: (1) Cite typical figures and cases related to drawing to broaden students' knowledge, emphasize the importance of drawing, and enhance learning interest and initiative. (2) Cite both positive and negative examples to emphasize that drawing and reading drawings must be standardized, rigorous, and meticulous, requiring a "nitpicky" attitude of being serious about details. (3) Start from the historical development of engineering drawing, introduce the brilliant achievements of ancient Chinese mechanical manufacturing to stimulate students' national pride and cultural confidence. (4) Introduce news figures to interpret the craftsman spirit, and cultivate students' craftsman spirit of being careful, meticulous, and striving for excellence.

3.3 Ideological and Political Teaching Design Practice for the Engineering Drawing Course

Engineering Drawing is a compulsory public basic course for all engineering majors in our university, divided into Engineering Drawing (1) and Engineering Drawing (2). Engineering Drawing (1) is offered in the first semester of the freshman year, focusing on explaining projection principles and basic methods of engineering drawing expression; Engineering Drawing (2) is offered in the second semester of the freshman year, mainly covering the drawing of part drawings (standard parts and non-standard parts) and assembly drawings. Taking Engineering Drawing (2) as an example, a collection of ideological and political teaching cases has been carefully designed, and corresponding ideological and political key points have been integrated into each week's lesson (2 class hours), as shown in Table 1.

Ideological and political teaching is carried out through in-class PowerPoint explanations and requiring students to watch online short videos after class. In addition, through in-class discussions, group presentations, and other forms, students are encouraged to actively participate in ideological and political topics, enhancing the effect of ideological and political education. After years of practice, students have provided feedback that while learning professional knowledge, their values and professional literacy have been positively shaped.

Table 1 Integration of Curriculum Ideological and Political Education into the Teaching Content of Engineering Drawing (2)

Week	Class Hours	Teaching Content	Corresponding Integrated Curriculum Ideological and Political Cases
1	2	Formation and elements of threads; drawing methods of internal and external threads and their connections	Wide application of threads in daily life; promoting the "spirit of a never-rusting screw".
2	2	Prescribed drawing methods for threaded fasteners; Prescribed drawing methods for bolt, stud, and screw connections	Air crash caused by a single bolt! On August 20, 2007, the accident of China Airlines Flight HK120.

3	2	Key and pin connections; rolling bearings	Brief introduction to SKF, the world's most renowned bearing manufacturer.
4	2	Gears; springs	Brief introduction to the origin and development of gears, and their wide application; Gears on the national emblem represent the working class; gears are also printed on some coins.
5	2	Functions and content of part drawings; view selection of parts (1 class hour); First quiz	Brief history of engineering graphics: Xin Yi Xiang Fa Yao, Tiangong Kaiwu, and Monge's Descriptive Geometry.
6	2	View representation of various parts; dimension annotation of part drawings	Short videos on dimension inspection; Emphasizing that not only graphic expression is important, but also the correct and reasonable dimension annotation in drawings is crucial.
7	2	Technical requirements: Limits and fits	Short video "Luo Liangliang, a craftsman in Shanxi: Processing the most precise parts and being the happiest worker". The relentless pursuit of machining precision by frontline workers motivates designers to respect drawings.
8	2	Technical requirements: Representation of surface texture; geometric tolerances	Introducing the "self-centering expanding sleeve device", illustrating how the standardization of drawing annotations directly affects the measurement and adjustment process of geometric tolerances.
9	2	Process structures on parts; reading part drawings	Typical case: Non-compliance with national standards during construction led to a little girl falling to her death from the balcony guardrail of her 7th-floor home, illustrating the importance of following national standards (complying with laws) and that reading drawings is as important as drawing them.
10	2	Process and standards for drawing part drawings (1 class hour); Second quiz	Displaying Master Liang Sicheng's hand-drawn drawings: "Elevation of Foguang Temple Main Hall," "Section of Foguang Temple Great Buddha Hall".
11	2	Function and content of assembly drawings; representation methods of assembly drawings; drawing methods of assembly drawings; Drawing assembly drawings (Part 1)	Short video: "Machining Technology is the Soul of High-End Manufacturing," emphasizing the standardization, scientific nature, and seriousness of drawings.
12	2	Dimensions and technical requirements of assembly drawings; item numbers and parts lists of assembly drawings; Drawing assembly	Dialectical thinking of the whole and the part: overall layout comes first, followed by detailed planning and implementation; similarly, the overall design of the assembly drawing comes first, followed by the details of specific part

		drawings (Part 2)	drawings.
13	2	Assembly process structures; reading assembly drawings	Typical cases: National key projects (Three Gorges Dam, Manned Spaceflight Program, Hong Kong-Zhuhai-Macao Bridge); the rare major casualty accident caused by aluminum liquid overflow explosion in Shandong.
14	2	Reading assembly drawings; Deriving part drawings from assembly drawings (Part 1)	Typical cases: Major national projects (C919 aircraft, China's first aircraft carrier); short video: Interpreting the "Craftsman Spirit".
15	2	Detailing part drawings from assembly drawings (Part 2); Third quiz	Infusing positive energy through typical figures: British inventor James Watt; Yang Wei, Deputy Chief Engineer of AVIC.
16	2	Comprehensive review	

4. Teaching Practice of the "Three-Dimensional Penetrating" Model in the Engineering Drawing Course

Based on the "Three-Dimensional Penetrating" teaching model, the Engineering Drawing teaching team adheres to the educational philosophy of fostering virtue through education, and is committed to in-depth development in multiple dimensions, including education and teaching, curriculum ideological and political construction, learning and training, and collective teaching and research, achieving a series of remarkable results.

4.1 In-depth Exploration of Engineering Drawing Education and Teaching

The team has consistently prioritized the improvement of teaching quality and the innovation of teaching methods. In classroom teaching, teachers make full use of multimedia resources, combining the explanation of traditional 2D drawings with the demonstration of Three-Dimensional modelling software to help students more intuitively understand complex spatial structures and projection principles. For example, through real-time demonstration of the entire process from design concept to engineering drawing generation using software such as SolidWorks and AutoCAD, students' learning interest and practical operation ability have been enhanced.

At the same time, we have actively conducted online-offline blended teaching practices, established a dedicated online learning platform for the course, and uploaded abundant teaching resources such as teaching videos, case analyses, after-class assignments, and online tests. This not only facilitates students to conduct independent learning and review at any time but also enables teachers to track students' learning progress and provide feedback on learning effects more promptly. Extracurricular activities such as "drawing lectures" and "Engineering Drawing homework model exhibitions" are held irregularly to assist students in reading and drawing. In the past five years, the average assessment score of the course has steadily increased compared with previous years, and the pass rate and excellent rate of students have shown favourable growth trends.

4.2 In-depth Practice of Curriculum Ideological and Political Education in Engineering Drawing

The teaching team is well aware of the importance of curriculum ideological and political education for cultivating high-quality professional talents with both virtue and ability. Therefore, the team has in-depth explored the ideological and political elements in the "Engineering Drawing" course. On the one hand, starting from the historical development of engineering drawing, students

are introduced to the brilliant achievements of ancient Chinese mechanical manufacturing, such as Lu Ban's mortise and tenon structures, to stimulate their national pride and cultural confidence. On the other hand, teachers set an example by preparing each class carefully, teaching each lesson well, and carefully correcting each assignment, allowing students to personally experience the teachers' professional dedication and rigorous academic attitude through their actions. Teachers' worldviews, values, and outlooks on life subtly influence students. By disseminating positive energy, teachers better realize the perfect combination of teaching and education, and truly achieve the educational goal of integrating knowledge impartation, ability cultivation, and value guidance.

4.3 Collective Teaching and Research to Ensure the Advancement of Engineering Drawing Teaching

Collective teaching and research is an important guarantee for the team to maintain teaching vitality and continuously improve teaching methods. We hold regular teaching and research activities at least once every two weeks, engaging in in-depth discussions on topics such as the revision of the teaching syllabus, the update of teaching content, the exploration of teaching methods, and the analysis of student feedback.

In the revision of the teaching syllabus, according to the industry development trends and new talent cultivation requirements, the teaching objectives, key and difficult points, and the proportion of practical teaching of the course are adjusted in a timely manner to ensure that the course is closely aligned with practical needs. For example, comprehensive assignments, assessment links for part and assembly drawing, and three in-class quizzes have been added to implement the whole-process and process-oriented assessment. The proportion of the final exam score was 70% before year 2018, 60% from year 2019 to year 2022, and has been reduced to 50% since year 2023. A combination of formative and summative evaluation is used to assess student performance, effectively increasing the "challenge level" of learning.

In terms of teaching methods, team members often share new methods and technologies they have tried in the classroom and discuss their feasibility and promotion value together. Some teachers have tried to introduce project-based teaching methods, allowing students to work in groups to complete a small mechanical product drawing project, and cultivate their teamwork and complex problem-solving abilities through practical operations. In teaching and research activities, enthusiastic discussions are held on project topic selection, guidance during the implementation process, and evaluation and assessment criteria. These insights have been gradually promoted and applied in practical teaching processes, which has yielded positive teaching feedback.

5. Conclusion

The Engineering Drawing course is a traditional compulsory course, and it will surely develop in line with the times. The Engineering Drawing teaching team of our university has smoothly integrated the knowledge, competence, and literacy dimensions into the entire teaching process based on the constructivist learning theory, effectively improving students' comprehensive drawing ability. Targeting the teaching objectives and tasks of Engineering Drawing, a curriculum ideological and political teaching system has been constructed, and teaching content integrated with ideological and political elements has been designed, which has effectively improved students' ideological and political literacy and engineering ethics awareness, while promoting the mastery of professional knowledge and skills. While in-depth exploring the "Three-Dimensional Penetrating" teaching model, teachers' teaching ability has been significantly improved, and many teachers have won national and provincial-level awards on numerous occasions. However, the research on curriculum ideological and political education has a long way to go. In the future, we will explore the application of new

technologies such as artificial intelligence and big data in curriculum ideological and political teaching to improve the personalization and precision of teaching.

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