From Code to Value: A Study on the Teaching Reform of Ideological and Political Education in Emerging Engineering Courses

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ABSTRACT

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| **Aims:**This study aims to explore innovative approaches for the deep integration of ideological and political education with the course *Principles of Single-Chip Microcomputers and Mechanical Engineering Applications*, guided by the fundamental task of fostering virtue and cultivating talent. The research seeks to establish an effective teaching model that synergizes professional education with ideological-political education.**Study Design:**A model curriculum for ideological and political education was constructed as a practical platform. The study employed a tripartite teaching model focusing on *value shaping, ability cultivation, and knowledge impartation*, integrating core ideological-political elements such as craftsmanship, patriotism, and innovation consciousness.**Methodology:**The teaching team implemented diverse pedagogical strategies, including collaborative lesson study, blended online-offline teaching, and case-driven instruction. The study assessed the impact of these methods on students' engineering ethics awareness and innovative practical abilities through course evaluations and performance metrics.**Results:**The findings demonstrate that the proposed teaching model significantly enhanced students' engineering ethics awareness and innovative practical skills. The integration of ideological-political elements into the technical course proved effective, fostering a balanced development of professional competence and ideological values.**Conclusion:** This study provides a replicable paradigm for ideological-political construction in engineering courses, demonstrating that a well-designed teaching model can successfully merge technical education with ideological-political education. The results highlight the potential for broader application in similar engineering disciplines. |

*Keywords: Curriculum Ideological and Political Education, Principles of Single-Chip Microcomputers, Engineering Education, Blended Learning; Outcome-Based Education*

1. INTRODUCTION

With the continuous deepening and development of higher education in China, the construction of curriculum-based ideological and political education has become an important direction for the reform of university education and teaching in the new era. Curriculum-based ideological and political education aims to organically integrate ideological and political education into professional course teaching, achieving a combination of knowledge impartation and value guidance, and cultivating high-quality talents with both moral integrity and professional competence (Shao, D., Bi, Q., Yang, Q., et al. 2025). The course "Principles of Single-Chip Microcomputers and Mechanical Engineering Applications" serves as a foundational course in engineering disciplines, primarily tasked with imparting essential professional knowledge (Shen, J., & Wang, J. 2024). Additionally, it plays a crucial role in fostering students' engineering practical abilities, innovative spirit, and sense of social responsibility (Luo, W., Xia, K., & Yuan, Q. 2024). Therefore, how to effectively integrate ideological and political elements into the single-chip microcomputer course and achieve collaborative education between professional education and ideological-political education has become a significant issue in current teaching reforms.

This paper takes the course "Principles of Single-Chip Microcomputers and Mechanical Engineering Applications" as the research object. Based on the OBE and CDIO engineering education models and centered on the training objectives of interdisciplinary engineering talents under the background of "Emerging Engineering Education," it systematically elaborates on the overall design, practical effectiveness, and innovative features of the curriculum-based ideological and political construction (Wen, H., Wang, W., Hai, R., et al. 2025). By constructing a tripartite teaching model of "value shaping, ability cultivation, and knowledge impartation," the ideological and political education is deeply integrated into the professional course teaching, achieving collaborative education between professional education and ideological-political education (Song, X., Wu, Z., Qin, H., et al. 2020). In the process of curriculum-based ideological and political construction, this course closely combines the university's positioning and professional characteristics. Through the formation of a high-level teaching team, optimized design of teaching content, and innovative improvement of teaching methods, it successfully integrates ideological and political elements such as "craftsmanship spirit" throughout the teaching process (Jiang, Z., Cai, W., & Niu, C. 2020). Through various teaching methods such as dialogic teaching, thematic discussions, and practical projects, it not only enhances students' understanding and application abilities of professional knowledge but also stimulates their patriotic sentiments, social responsibility, and innovative spirit, guiding students to establish correct values and outlooks on life (Xue, Y., Ning, Y., Zheng, L., et al. 2024; Cakir, N. K., & Guven, G. 2025; Liou, Y.-H., Brouwer, J., Daly, A. J., & Lee, Y.-S. 2025).

Since 2020, the course team at North China University of Water Resources and Electric Power has systematically reconstructed teaching content and methods, using the construction of a provincial-level curriculum-based ideological and political demonstration course as a starting point. By refining typical ideological and political mapping points, the "craftsmanship spirit" is integrated into the OBE and CDIO-based engineering education models, constructing a three-dimensional education model of "value shaping, ability cultivation, and knowledge impartation." This paper discusses the construction path, practical effectiveness, and innovative features, aiming to provide references for similar courses.

2. methodology

**2.1 Overall Design of Ideological and Political Construction in the Microcomputer Course**

Throughout its long-term development, the university has consistently adhered to its mission of serving regional economic and social development as well as the national water conservancy and electric power industries. It has gradually refined its educational philosophy of "cultivating talent as the foundation and applying knowledge to practice," and has developed a university spirit characterized by "dedication to water conservancy and relentless self-improvement." Furthermore, it has established a distinctive talent cultivation model marked by the traits of "being willing to work at the grassroots level, enduring hardships, staying committed, being practically competent, and performing excellently."

Based on the university's educational positioning, disciplinary characteristics, and talent cultivation objectives, the construction of this course focuses on the following aspects: First, efforts are made to build a high-quality faculty team and optimize the structure of the teaching staff. Second, the course content is scientifically designed according to the course's characteristics and positioning, with the latest disciplinary advancements and teaching reform achievements being integrated into teaching practices. Third, innovative teaching methods and evaluation systems are developed by considering the course content and the characteristics of graduate education. Through diversified teaching approaches, the course aims to enhance teaching quality, foster students' independent thinking abilities, and cultivate their research and practical skills, ultimately striving to produce high-quality innovative talents.

This course integrates ideological and political education throughout the entire teaching process. By incorporating elements such as patriotism, value orientation, research philosophy, innovative thinking, and craftsmanship spirit, the course aligns with ideological and political theory courses, creating a synergistic educational effect. Specifically, the course aims to guide students to establish a life philosophy of loving their country and family, being proactive and enterprising, while mastering professional knowledge. It also seeks to cultivate students' professional qualities of innovation and responsibility. By strengthening the education of the "Four Confidences" (confidence in the path, theory, system, and culture of socialism with Chinese characteristics), the course internalizes the core socialist values as students' behavioral guidelines, promotes the inheritance of excellent traditional Chinese culture, enhances legal awareness, and fosters engineering professionalism and ethical standards.

The course has established a tripartite teaching model of "value shaping, ability cultivation, and knowledge imparting," with the following specific implementation pathways:

In the dimension of value shaping, the spirit of craftsmanship is organically integrated into the OBE (Outcome-Based Education) and CDIO (Conceive-Design-Implement-Operate) engineering education models. Through the "Excellent Engineer Education and Training Program," the course focuses on cultivating students' sense of responsibility, innovative spirit, and meticulous professional attitude, thereby providing talent support for the high-quality development of the national manufacturing industry. Additionally, leveraging diversified platforms such as the course website and ideological-political education WeChat groups, the course promptly disseminates cutting-edge disciplinary developments and scientific advancements. This broadens students' academic horizons, inspires their sense of mission to contribute to the great rejuvenation of the Chinese nation, and enhances their enthusiasm and initiative in participating in course activities.

In the dimension of knowledge imparting, a dialogic teaching model is implemented to transform traditional teaching paradigms. As the organizer of teaching activities, the instructor guides students to actively share their understanding of knowledge. Through teacher-student interactions, students deepen their grasp of knowledge and achieve a comprehensive understanding of key concepts. During this process, the course incorporates the developmental history of China's microcontroller technology, particularly the leap from technology import to independent innovation, fostering students' national pride and sense of duty to contribute to technological advancement. Moreover, thematic seminar-style teaching is conducted by setting professional topics such as interrupt systems. Students are guided to explore technical principles and application scenarios in depth. Meanwhile, by introducing China's breakthrough achievements in related technological fields, the course inspires students to reflect on the application value of professional knowledge in addressing national strategic needs, thereby strengthening their sense of social responsibility and knowledge application capabilities.

In the dimension of ability cultivation, a mechanism for horizontal and vertical integration of knowledge points is established to guide students in systematically mastering the course knowledge system. This cultivates their independent thinking and teamwork abilities, enhancing their comprehensive competence in solving complex engineering problems. Furthermore, practical skills are emphasized through the use of professional software platforms such as Proteus and Keil C. Students are systematically trained in simulation analysis, with a focus on mastering core functions such as I/O port control, timing and counting, interrupt handling, and serial communication. This lays a solid foundation for subsequent engineering practices. In addition, major national engineering projects are integrated into practical teaching. By analyzing how engineering professionals apply specialized knowledge to solve practical problems, students gain a deeper understanding of the subject matter, while also strengthening their national confidence and patriotic sentiments.

Through the systematic implementation of the above teaching model, this course is committed to cultivating high-quality engineering talents with solid professional knowledge, outstanding practical abilities, and profound patriotic sentiments, thereby providing talent support for serving national strategic needs and regional economic and social development.

**2.2 Ideological and Political Innovation Features in the Microcontroller Course**

The microcontroller course, with the fundamental mission of "fostering virtue through education," has established a tripartite teaching model that integrates value shaping, ability cultivation, and knowledge imparting. This model organically incorporates ideological and political education into the professional curriculum. Through systematic instructional design, the course not only emphasizes the acquisition of professional knowledge but also prioritizes the establishment of ideals and beliefs, the enhancement of moral cultivation, and the development of healthy personality traits, thereby achieving a deep integration of professional education and ideological-political education.



**Figure 1. Highlights and Implementation Process of the Course**

In terms of the tripartite teaching model, the course centers on value shaping, supported by ability cultivation and grounded in knowledge imparting, forming a systematic instructional framework (as shown in Figure 1). In the dimension of value shaping, the course integrates ideological and political elements such as patriotism, craftsmanship spirit, and innovation awareness into the teaching content through case studies and thematic discussions, guiding students to establish correct values and professional ethics. In the dimension of ability cultivation, the course focuses on developing students' practical skills and innovative thinking. Through project-based learning and experimental exercises, students' ability to solve complex engineering problems is enhanced. In the dimension of knowledge imparting, the course optimizes the design of teaching content by incorporating the latest disciplinary advancements, ensuring that students acquire a solid theoretical foundation in their field.

Regarding the design and implementation of ideological-political teaching cases, the course meticulously designs teaching cases through collective lesson preparation and teaching seminars, seamlessly integrating ideological-political elements with professional knowledge. For example, when explaining the development history of microcontroller technology, the course incorporates China's journey from technology import to independent innovation in related fields, inspiring students' national pride and sense of duty to contribute to technological advancement. During teaching activities, instructors employ heuristic questioning and group discussions to encourage students to actively reflect on the application value of professional knowledge in addressing national strategic needs, thereby cultivating their sense of social responsibility and mission.

To comprehensively evaluate student learning outcomes, the course has established a multi-dimensional assessment system. Building on traditional evaluation methods, this system innovatively incorporates "ideological-political unit" evaluation metrics. Specifically, dimensions related to ideological and political education are integrated into various assessment components, including classroom performance, group discussions, innovative experiments, online quizzes, and offline examinations. This approach comprehensively evaluates students' ideological performance, learning capabilities, innovative thinking, and practical skills. For instance, in group discussions, not only is students' mastery of professional knowledge assessed, but their teamwork spirit and sense of social responsibility are also emphasized. In innovative experiments, students' hands-on abilities are evaluated alongside their innovative thinking and engineering ethics.

The distinctive features of the course's ideological-political construction are vividly illustrated in Figure 1, showcasing a well-rounded approach to education. At its core, the course focuses on value shaping, guiding students to establish correct values and professional ethics through education on ideals, beliefs, moral cultivation, and personality development. Building on this foundation, the course places significant emphasis on ability cultivation, fostering students' practical skills, innovative thinking, and teamwork abilities, which collectively prepare them for future career challenges. Complementing these efforts, the course ensures robust knowledge imparting by integrating the latest disciplinary advancements into the teaching content, thereby equipping students with a strong professional knowledge base. To holistically assess student development, a comprehensive, objective, and effective evaluation system has been established, which not only measures academic abilities but also evaluates ideological qualities, ensuring a balanced and thorough assessment of student progress. In terms of implementation outcomes and significance, the adoption of the above teaching model has not only enhanced students' professional competencies but also significantly strengthened their ideological and political qualities. Throughout the learning process, students gradually develop a life philosophy centered on patriotism, innovation, and responsibility, demonstrating a strong sense of social responsibility and professional ethics in practice. This teaching model, which deeply integrates professional education with ideological-political education, provides valuable insights for the construction of ideological-political education in engineering courses and explores effective pathways for cultivating high-quality engineering talents with both moral integrity and professional excellence.

In summary, through its tripartite teaching model, systematic design of ideological-political teaching cases, and diversified evaluation system, the microcontroller course has achieved synergistic development of professional education and ideological-political education, offering an innovative example for the construction of ideological-political education in engineering courses in the new era.

3. results and discussion

The course has updated its assessment methods to align with its educational objectives by setting group learning goals and incorporating implicit ideological and political elements into typical case studies. Students collaborate on project designs through leaderless group discussions and research reports, while a phased evaluation system integrates ideological and political education into the existing assessment framework. This approach not only evaluates students' mastery of professional knowledge through solving engineering problems but also incorporates their moral performance into the course assessment, placing greater emphasis on the learning process.

Through the integration of ideological and political education, the course guides students to establish correct outlooks on life and values, fostering a sense of social responsibility encapsulated by the belief that "the rise and fall of the nation is the concern of every citizen." This motivates students to actively engage in learning professional knowledge and participate in various innovation and entrepreneurship competitions, achieving notable results. By utilizing methods such as questionnaires, students are encouraged to participate in teaching evaluations, leading to a shift in their attitudes toward learning. They no longer question the purpose of their studies but instead adopt a positive approach, clarify their goals, and strengthen their commitment to academic excellence. The course content, which is both rich and engaging, fosters active participation and a genuine enjoyment of the learning process.

The course has achieved significant progress by emphasizing scientific research and the study of ideological and political education reforms, applying research findings to teaching activities. A shared resource library of ideological and political teaching cases has been established, providing valuable materials for both teachers and students. This initiative not only enhances the course's effectiveness but also sets a strong example for others to follow, demonstrating the broader impact of its innovative approach.

**Table 1. Case Studies of Knowledge Points and Innovative Methods**

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| **Teaching Key Points** | **Teaching Methods** |
| Instruction Set | Extended Method |
| C51 Language Fundamentals | Comparative Method |
| Microcontroller Serial Communication | Seminar Method |
| A/D Conversion | Introduction Method |
| Microcontroller Experiments and Course Design | Self-Practice Method |

This study adopts the "parallel lesson preparation" teaching research model. During the pre-class preparation phase, the teaching team conducts in-depth teaching research activities through collective lesson preparation seminars. They systematically organize textbook content by chapter, thoroughly analyze key and difficult teaching points, and emphasize the organic integration of teaching objectives and implementation pathways. The study highlights the synergistic innovation of teaching content and methods, striving to enhance the theoretical depth and practical value of the curriculum while balancing its ideological, theoretical, and approachable aspects. This approach provides a practical implementation pathway for professional course teachers to develop ideological and political elements in their courses.

In the classroom teaching implementation phase, the research team innovatively employs a "group discussion" teaching model. Through diversified teacher-student interaction methods such as questionnaires and assignment design, the model actively engages students' participatory awareness and promotes their deep internalization of ideological and political elements. This teaching model effectively achieves the organic integration of knowledge impartation and value guidance, offering a practical example for integrating ideological and political elements into professional course teaching.

Based on the aforementioned teaching innovation practices, the research team has achieved significant results. In terms of teacher professional development, a replicable curriculum ideological and political construction plan has been formulated. In student cultivation, the team has guided students to achieve outstanding results in national innovation competitions, fully validating the practical effectiveness of this teaching model. This research outcome holds important theoretical value and practical guidance significance for advancing ideological and political construction in higher education curricula.

**Table 2. Achievements of the Teaching Team in Applying New Teaching Methods**

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| **Competition Name** | **Award Level** | **Date** |
| National "Internet Plus" College Student Innovation and Entrepreneurship Competition | Bronze Award | 2021 |
| Henan Division of the National 3D Digital Innovation Design Competition - "Intelligent Planetary Wheel City Explosive Disposal Robot" | Grand Prize | 2021 |
| Henan Division of the National 3D Digital Innovation Design Competition - "Underactuated Pneumatic Manipulator for Automatic Handling" | Grand Prize | 2021 |

4. Conclusion

This paper takes the course "Principles of Single-Chip Microcomputers and Mechanical Engineering Applications" as the research subject, focusing on the cultivation objectives of interdisciplinary engineering talents under the context of the "Emerging Engineering Education" initiative. It systematically elaborates on the overall design, practical outcomes, and innovative features of the ideological and political construction within the curriculum. By establishing a tripartite teaching model that integrates "value shaping, ability cultivation, and knowledge impartation," the course deeply embeds ideological and political education into the professional curriculum, achieving a synergistic educational effect that combines professional training with ideological and political education.

During the process of curriculum ideological and political construction, this course closely aligns with the university's educational positioning and disciplinary characteristics. Through the formation of a high-caliber teaching team, the optimization of instructional content design, and the innovative improvement of teaching methods, the course successfully incorporates ideological and political elements such as the "craftsman spirit" throughout the entire teaching process. Utilizing various pedagogical approaches, including dialogic teaching, thematic discussions, and practical projects, the course not only enhances students' understanding and application of professional knowledge but also fosters their patriotic sentiments, sense of social responsibility, and innovative spirit. This approach guides students to establish correct values and outlooks on life. Positive feedback from both internal and external peers and students indicates that the ideological and political construction of the course has effectively increased students' learning motivation and classroom engagement, cultivated their innovative practical abilities, and provided valuable insights for similar courses in their ideological and political construction.

In the future, this course will continue to deepen its ideological and political construction, further optimize the design of teaching cases, enrich teaching resources, and refine the evaluation system. It will persistently explore new pathways for the deep integration of ideological and political education with professional education. Additionally, the course will strengthen intercollegiate exchanges and collaborations, promote the experience of ideological and political construction, and contribute to the cultivation of more high-quality engineering talents who possess both professional skills and a sense of national responsibility.

COMPETING INTERESTS DISCLAIMER:

Authors have declared that they have no known competing financial interests OR non-financial interests OR personal relationships that could have appeared to influence the work reported in this paper.

DEFINITIONS, ACRONYMS, ABBREVIATIONS

OBE: Outcome-Based Education

CDIO：Conceive-Design-Implement-Operate

References

Cakir, N. K., & Guven, G. (2025). Enhancing engineering design, scientific creativity, and decision-making skills in prospective science teachers through engineering design-based robotics coding applications. Research in Science & Technological Education. Advance online publication. <https://doi.org/10.1080/02635143.2025.2456778>

Jiang, Z., Cai, W., & Niu, C. (2020). Research on teaching mode and ideological-political reform of the course "Principles and Applications of Single-Chip Microcomputers." \*Journal of Higher Education, (09), 129–131. <https://doi.org/10.19980/j.cn23-1593/g4.2020.09.041>

Liou, Y.-H., Brouwer, J., Daly, A. J., & Lee, Y.-S. (2025). Relational rhythms: Investigating longitudinal advice networks of a leadership team during reform. AERA Open, 11, 23328584251316469. <https://doi.org/10.1177/23328584251316469>

Luo, W., Xia, K., & Yuan, Q. (2024). Exploration of teaching reform in the "Principles of Single-Chip Microcomputers" course under the background of curriculum ideology and politics. Education Teaching Forum, (17), 101-104.

Shen, J., & Wang, J. (2024). Exploration of ideological and political construction in the course of single-chip application technology under the background of emerging engineering education. Agricultural Engineering and Equipment, 51(3), 47-48, 60.

Shao, D., Bi, Q., Yang, Q., et al. (2025). Exploration on the course reform of "Principles and Applications of Single-Chip Microcomputers" under the background of "Emerging Engineering Education." Industry and Information Technology Education, (02), 46–50.

Song, X., Wu, Z., Qin, H., et al. (2020). Exploration and practice of a trinity project-based teaching model integrating "knowledge, ability, and literacy." \*Science & Technology Vision, (32), 65–67. <https://doi.org/10.19694/j.cnki.issn2095-2457.2020.32.025>

Tang, W. (2010). Practical teaching reform of single-chip microcomputer courses based on "project-driven" approach. Research and Exploration in Laboratory, 29(5), 130–132, 154.

Wen, H., Wang, W., Hai, R., et al. (2025). Teaching reform of single-chip microcomputer courses in application-oriented undergraduate education based on the OBE-CDIO model. Computer Knowledge and Technology, 21(3), 165–167. <https://doi.org/10.14004/j.cnki.ckt.2025.0146>

Xue, Y., Ning, Y., Zheng, L., et al. (2024). Blended teaching practice of the course "Principles and Applications of Single-Chip Microcomputers." Electronic Technology, 53(12), 80–82.