Journal of Contemporary Educational Research, 2026, Volume 10, Issue 1
http://ojs.bbwpublisher.com/index.php/JCER
ISSN Online: 2208-8474
ISSN Print: 2208-8466

Research on Core Courses in Robotics Engineering Focusing on "Sensors and Detection Technology"

Wenqing Song, Rongping Yu*

School of Intelligent Manufacturing and Mechanical Engineering, Hunan Institute of Technology, Hengyang 421002, China

Corresponding author: Rongping Yu, 1071929951@qq.com

Abstract: This study focuses on the core curriculum of the Robotics Engineering major, specifically the course "Sensors and Detection Technology." It focuses on the foundational knowledge, instruction, and technical skill training in robotics and proposes a research-oriented learning model for the Robotics Engineering program, with an emphasis on application and innovation. It aims to establish a cross-curricular, competition-based experimental platform for the Robotics Engineering program. The goal is to develop a multi-tiered training system and advance teaching reforms that would boost students' engineering practice capabilities. By integrating curriculum development, interdisciplinary course design, and student participation in academic competitions, the model aligns learning objectives with student development needs that will foster students' innovation and entrepreneurial skills. The study also explores a hierarchical practical teaching model via "basic experiments, cross-curricular design, and academic competitions." The model would help develop integrated innovation projects across multiple themes, and establish a project- and need-driven engineering practice training system across the entire curriculum. This approach would eventually transform traditional passive learning into active learning, thereby enhancing student development in the emerging field of Robotics Engineering.

Keywords: Sensor technology; Robotics engineering; Curriculum development

Online publication: February 4, 2026

1. Introduction

Industrial automation plays a crucial role in promoting the intelligent modernization and transformation of traditional manufacturing industries at the national level. In this context, robotics technology stands as the primary force behind the shift. Robotics technology combines computer science, sensor technology, control technology, and other disciplines into a single system and enables the development of automated and intelligent robot applications. Robotics technology has been increasingly applied in design, production, operations, and service industries after it was widely used in the intelligent manufacturing sectors. As a result, China's Ministry of Education issued the *Notice on the Research and Practice of New Engineering Education* through its Higher Education Division. The purpose is to meet the demand for comprehensive knowledge, practical skills, innovation capacity, and forward-looking competencies in industrial development. Universities across China at various levels have conducted research on the theoretical framework of "New Engineering" education. They tried to explore beneficial approaches for teaching models, experimental practices, and curriculum reforms in "New Engineering." The scope of machine perception includes "Sensors and Detection Technology" as a core course, which is a cutting-edge and key discipline in the robotics engineering curriculum. It is an applied course covering sensor characteristics, fundamental principles, practical applications, and information processing techniques. Unfortunately, students at typical applied undergraduate institutions often show deficiencies in mastering the new curriculum. The problems they face include insufficient foundational knowledge, limited self-directed learning skills, and incomplete mastery of prerequisite courses. On one hand, how to effectively teach this course and apply "Sensors and Detection Technology" in engineering practice creates new pedagogical challenges for the institutions. On the other hand, how to integrate foundational knowledge with emerging technologies within limited class hours remains a critical challenge in educational reform, given that the technological advancements and the emergence of novel sensors and detection technologies are very fast. This project seeks to focus on developing core courses in robotics engineering based on sensor and detection technology. The following sections will examine the roles and competencies of applied engineering students. The goal is to integrate theoretical instruction with innovative practices and reconstruct the teaching content and methods for developing robotics engineering talent. The research takes students' learning interests and outcomes as the priority, and aims to genuinely enhance students' innovation and entrepreneurship capabilities while satisfying their thirst for knowledge, exploration, and creativity.

2. Restructuring the curriculum and consolidating the new engineering education programs

Establishing a research-based learning model that is both application-oriented and innovation-driven is essential for the robotics engineering program. To align with learning goals and students' development, the model should integrate curriculum development and interdisciplinary course design with student participation in academic competitions. The practical components should address the realistic and complex nature of engineering problems, and help students to enhance their ability to apply knowledge and develop innovation and entrepreneurial abilities. Additionally, the "Sensors and Detection Technology" course should lay the foundation for building an interdisciplinary, competition-based experimental platform for robotics engineering (as shown in **Figure 1**). This platform creates an accessible and hands-on learning environment. This platform integrates with other core courses, such as "Microcontroller Technology," "Robot Motion Control," and "Robot Drive Technology," to deliver practical teaching activities. Based on the intelligent systems, comprehensive experimental projects should also be introduced to diverse specialized courses. It would create an integrated knowledge structure and foster comprehensive professional understanding. The interdisciplinary course can be implemented over three to four semesters as a key practical component for the students. After completing a course, students should participate in a certain project segment. The participation in a hands-on project would help the students establish a comprehensive engineering practice framework for further study. Furthermore, the course should be structured around group collaboration. Each student will serve as a project leader in rotation. The arrangement will help to develop leadership and teamwork skills in the participants. Instructors will oversee the project milestones during this process. They should provide technical guidance and support if necessary. Students are expected to combine different core skills they learned from different courses, such as mechanical design, sensor installation, and measurement and control circuit construction, by forming teams to participate in academic competitions. The approach enables students to apply knowledge from "Sensors and Detection Technology," "Robot Motion Control," "Microcontroller Technology," and "Robot Drive Technology" effectively. It also provides a more intuitive understanding of common sensors and actuators and walks the students through their learning via hands-on application. Throughout the learning process, students will experience the joy of learning and gain a sense of achievement. As a result, their innovative thinking abilities will be significantly enhanced.

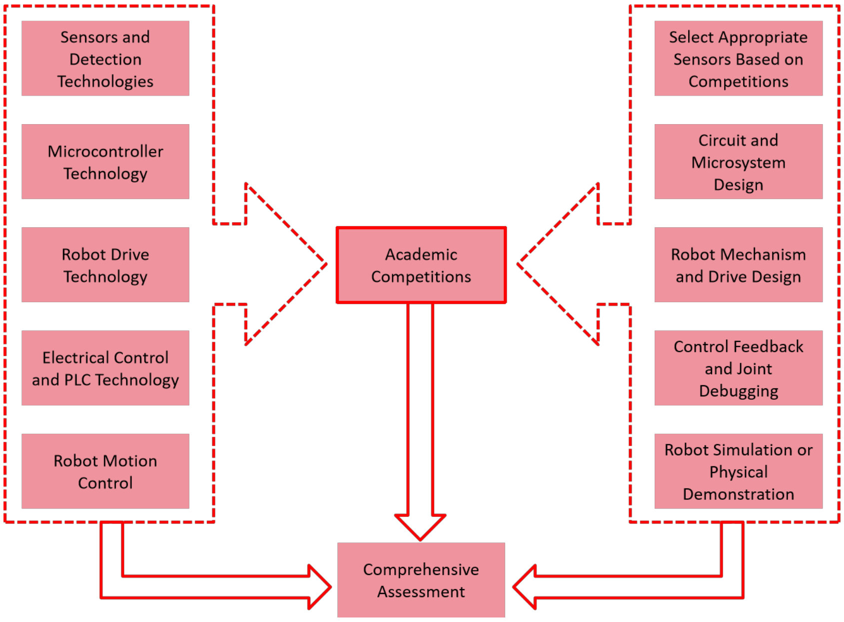

Figure 1. Cross-course competition-based experimental platform for the robotics engineering program

3. Enriching teaching resources and methods to enhance teaching effectiveness

Sensor technology is rapidly expanding the horizon of human perception. It uses physical and quantitative measures to explore the outside world. It also serves as fundamental knowledge for the fields of robotics, the Internet of Things, and artificial intelligence. They represent some of the most advanced technologies available today. Sensors enable robots to perceive and interpret their environment, and are keys to adaptive and precise control. "Sensors and Detection Technology" occupies a central role in robotics engineering. Robotics engineering integrates a broad knowledge base spanning natural sciences, engineering, and social sciences. It is also one of the most highly developed interdisciplinary subjects. Most sensors are miniaturized devices that enable digitization, intelligence, networking, and systematization. They provide essential support for automatic control and detection and are increasingly applied across industries. As a core course of the new robotics engineering major, "Sensors and Detection Technology" covers topics including electricity, magnetism, optics, and electronics. Although various local textbooks exist for the "Sensors and Detection Technology" course, the content is often fragmented. Most of them are filled with traditional knowledge and articles solely describing the internal structure, working principles, and applications of specific sensor types. Besides, the course always draws on learning materials from multiple disciplines. As a result, students often struggle to connect prerequisite and subsequent courses, making it difficult to develop a cohesive understanding of the subject. **Table 1** summarizes recent research on the development and implementation of this course in domestic universities. It highlights the common challenges in the current teaching system.

Table 1. Research on the construction of typical sensors and detection technology courses in domestic universities in recent years

No.	Institute	Research on the construction of courses
1	Henan Institute of Science and Technology [1]	Collaborating with different enterprises and integrating different engineering education certification standards to implement a bilingual teaching mode
2	Suzhou University of Technology (Changshu Institute of Technology) [2]	Developing and innovating its laboratory facilities
3	Guangxi Normal University [3]	Implementing a teaching model that integrates active learning with project-based assessment
4	Nanjing Normal University [4]	Strengthening theoretical teaching by integrating experimental videos; organizing student-centered group discussions; increasing design-oriented and open-ended experiments, enhancing course design in sensors and detection technology; conducting innovative practical activities for college students
5	XinZhou Normal University [5]	Implementing teaching methods that integrate theory, experiments, and course design; enabling students to learn, discuss knowledge both online and offline, analyze simulations and experiments, and engage in project-based course design.
6	Liaoning University of Technology [6]	Expanding its teaching content and supporting instructional resources
7	Taiyuan University of Technology [7]	Implementing a project-based teaching reform approach to integrate teaching, learning, and hands-on practice in courses
8	Huazhong University of Science and Technology [8]	Implementing multi-level reforms, including basic verification, comprehensive design, and research innovation; upgrading practical teaching models. Also, establishing a cross-curriculum, hierarchical research-based learning, teaching system, and exploring a hierarchical practical teaching mode encompassing basic experiments, course design, innovation competitions, and advanced research projects
9	Institute of Disaster Prevention [9]	Implementing a CDIO-based teaching model for sensors and detection technology
10	Hainan Normal University [10]	Aiming to cultivate students with applied skills by reforming the course from both theoretical and experimental perspectives. The teaching mode is updated, content optimized, and practical exercises strengthened
11	Sichuan University of Science & Engineering [11]	Emphasizing technology application as the primary driver, exploring problem-solving strategies, and conducting classroom teaching focused on essential course concepts
12	Nanjing Institute of Technology [12]	Implementing a blended online and offline teaching approach, employing diverse methods—including discussion, inquiry, task, and case-based techniques—to enhance teaching effectiveness and engage students in learning
13	Jiangsu University of Technology [13]	Integrating artificial intelligence, cognitive reasoning, and data analytics into teaching, the system includes intelligent virtual experiment platforms, smart teaching process management, student attention and engagement monitoring, and three-dimensional evaluation of learning, significantly enhancing the effectiveness of course-based practical instruction.
14	Tianjin Sino-German University of Applied Sciences [14]	Establishing a teaching philosophy emphasizing applied skills, hands-on practice, project guidance, integration of real and virtual environments, and innovation

In response to this, we aim to strengthen students' problem-analysis and problem-solving skills based on the "13th Five-Year Plan" higher education planning textbooks, the school's self-developed textbooks, experimental reports, practical reports, work task lists, and task evaluation forms aligned with the course content. The school-developed "Robot Sensor Innovation Comprehensive Practice Box" enables students to independently design and build sensor devices through creative design, hardware assembly, and software programming. By taking the course, they are expected to apply sensor technologies in engineering practice and cultivate application-oriented undergraduate competencies. We also develop augmented reality (AR) teaching resources to implement the AR-supported learning method in higher education. By integrating physical and virtual teaching methods, the program can effectively reduce equipment damage caused by student errors. It also supports online instruction for experimental and practical courses. In addition, courses are conducted in small groups. The robotics sensing laboratory is divided into a theoretical practice area and an experimental validation area. The theoretical practice area includes the Team Collaboration Learning Zone and tablet computers to support group exploration and teamwork. It is also equipped with dual electronic screens for effective teacher–student interaction, as well as school-developed instructional tools and equipment for practical teaching. Students are expected to bring their own laptops and mobile devices. It will create an integrated smart classroom that combines theory, experimentation, and competitions for those attending classes in the experimental validation area. The effort will enhance student engagement and improve teaching effectiveness. At the same time, it will help build up the overall environment for supporting ideological and political education in the laboratory. The combined effect will integrate physical infrastructure and educational activities that reflect socialist core values. This environment aims to positively shape the students' perspectives and enhance the effectiveness of ideological and political education.

4. Reforming the student assessment system and enhancing their ability to apply learned knowledge

Students will be assigned similar competition projects from previous years before the course begins. It is based on the years of experience of teaching the "Sensors and Detection Technology" course. Students will complete practical tasks collaboratively in small groups using short instructional videos. Teachers will guide students in analyzing project plans and solving problems step by step using short instructional videos. Besides, flipped-classroom, active-learning, and project-based methods will also be used in classes. They will be integrated with the micro-lectures to extend the theoretical and experimental learning experience of students beyond the classroom. After completing the course, students will refine and improve their competition projects. Subsequently, they will submit the final projects as assignments. As shown in **Figure 1**, the program implements an innovative, practical teaching model centered on a cross-course competition system. The research-based curriculum spans from three to four semesters. The program aims to provide students with comprehensive engineering practice experience. It will also develop their technical skills and scientific mindset. Finally, rigorous assessment methods will be employed to evaluate students' learning outcomes. The comprehensive assessment consists of three components: individual self-evaluation (20%), group peer evaluation (20%), and project or competition-based evaluation (60%), as shown in **Table 2**. The evaluation system is comprehensive. It not only assesses students' mastery of professional knowledge, such as sensing technology, but also evaluates their ability to apply knowledge in practice and their engagement in learning.

Table 2. Assessment methods for comprehensive evaluation

Assessment type	Assessment content	Weighting (%)
Individual self-evaluation	Attendance rate	10
	Literature retrieval and research	10
Group peer evaluation	Scheme design	10
	Modular implementation	10
Competition assessment	Design report and results	20
	Competition awards	20
	Academic papers and patents	20

5. Strengthening teaching staff development and innovating student learning methods

The core curriculum should place greater emphasis on further teaching staff development in applied undergraduate institutions and robotics engineering programs. The purpose is to establish a mechanism through which universities and enterprises jointly develop and train teaching staff. Through strategies such as "external recruitment" and "outbound professional exchange," and by adopting mechanisms of "introduction, training, certification, restructuring, and motivation," the program aims to build a stable team of professional teachers. The system emphasizes a clear division of responsibilities and collaborative teaching. The ultimate goal is to develop a robotics teaching team with dual qualifications in both academic instruction and practical engineering. They are expected to be strong in teaching and applied capabilities. In addition, the program will leverage the practical innovation base and the school–enterprise cooperation platform for the robotics engineering program. They will sponsor the teachers to visit other universities and practice-oriented teaching bases. The academic exchange programs will be beneficial for teachers' professional development, experiences, and continuous improvement of both theoretical and practical instruction. In the talent development process, teachers should regard students as the central participants in the learning. During instruction, teachers should place appropriate emphasis on the systematic teaching of theoretical knowledge. At the same time, greater emphasis will be placed on instruction informed by feedback derived from data analysis. Practical feedback from big data analysis will evaluate whether the students have effectively mastered theoretical knowledge with hands-on skills. The evaluation will help the student catch up with society's diverse demands for applied technical talent. The teaching process should prioritize supporting students' individualized development. This approach simultaneously ensures that a diverse range of application-oriented graduates are prepared to fulfill societal needs. Teachers can adopt the flipped-classroom active-learning approach to increase teacher–student interaction in classroom teaching activities. They should stimulate students' initiative and enthusiasm for pre-class preparation, independent analysis, and active participation.

6. Conclusion

The reform and development of robotics engineering education has entered a critical stage. As a result, it is necessary to further enhance the scientific rigor, standardization, and innovation of the discipline. However, the content and structure of current discipline-specific courses still lack sufficient standardization. In addition, instructional implementation within teaching units still lacks sufficient systematization, coherence, and clear instructional focus. Based on the instructional characteristics of the "Sensors and Detection Technology" course, this study explores and develops a multi-level training system. It seeks to offer a pedagogical framework for cultivating engineering competencies in robotics engineering. The program allows students to select projects aligned with their abilities by categorizing practical projects according to levels of difficulty. It also supports differentiated instruction and personalized learning. This study proposes a three-level progressive practical teaching model encompassing "basic verification, comprehensive design, and research-oriented innovation." The teaching model will merge the instructional goals of foundational knowledge acquisition with robotic technical skill development. Eventually, it will establish a research-based, cross-course teaching framework based on project competition. Moreover, this study develops a comprehensive machine perception experimental platform using the application of sensor and detection technologies as a foundation. It will establish a practical hierarchical-teaching pathway comprising "basic experiments, cross-course design projects, and discipline-related competitions." This approach establishes a project- and needs-driven mechanism for developing engineering practice competencies throughout the entire learning process. It also develops a multi-theme competition framework that combines innovative project manipulation. Positioning students as active explorers rather than passive recipients, this framework aligns with the core tenets of new engineering education. This pedagogical shift is fundamental to cultivating the higher-order competencies required for advanced robotics engineering.

Funding

This work was supported by the General Project of Teaching Reform Research at Hunan Institute of Technology (No. JY202413) and the Open Project of Provincial Applied Characteristic Discipline at Hunan Institute of Technology (No. KF24007).

Disclosure statement

The authors declare no conflict of interest.

References

[1] Zhang P, Bai Q, Gao G, et al., 2018, Exploration of Teaching Reform in IoT Engineering under the Background of "New Engineering"—Taking the Course of Sensor Principles and Detection Technology as an Example. Western Quality Education, 4(1): 147–149.

[2] Meng X, Xie Q, Li X, 2016, Exploration of Teaching Reform Practice in the Course of Sensor Principles and Detection Technology. Journal of Higher Education, (17): 79–80.

[3] Peng H, Liu L, Li H, 2019, Teaching Reform and Practice of "Sensor Principles and Detection Technology" Course. Education and Teaching Forum, (51): 95–96.

[4] Dou A, Wang J, 2022, Research on Theoretical and Practical Teaching Reform of Sensor Principles and Detection Technology. China Science and Technology Economic News Database Education, (6): 87–90.

[5] Zhang Q, Guo H, 2021, Exploration and Practice of Teaching Reform in Sensors and Detection Technology Course. Computer Knowledge and Technology, 17(27): 228–229.

[6] Wang Y, Cao H, 2023, Teaching Reform and Practice of "Sensor Principles and Applications" Course under the Background of Engineering Education Certification. Chinese Science and Technology Journal Database (Citation

Edition) Education Science, (2): 34–37.
[7] Wang F, 2018, Research on Teaching Reform of “Sensor Principles and Applications” Course Based on Project-Driven Approach. Science and Technology Innovation and Productivity, (06): 119–120.
[8] Xu Q, Liu J, Zhou K, et al., 2024, Cross-Course Hierarchical Practical Teaching Reform of Automation Majors Based on Intelligent Systems: Taking the “Sensing Technology” Course as an Example. Industrial and Information Technology Education, (1): 11–16.
[9] Qiu Z, Cai J, Yao Z, et al., 2022, Exploration of Teaching Reform in Sensors and Detection Technology Practice Based on CDIO Concept. University Education, 24(02): 2095–3437.
[10] Qu C, 2021, Research on Teaching Reform of the Sensor and Detection Technology Course Based on Applied Talent Training Model. Education Reform and Development, 4(3): 68–70.
[11] Zhang S, Tan G, Shi R, et al., 2021, Teaching Exploration of Sensor and Detection Technology Course Based on Intelligent Science Discipline Construction: Taking Sichuan University of Science & Engineering as an Example. University Education, 1(12): 86–88, 104.
[12] Du Y, Liu D, Qiao G, et al., 2023, Exploration of Connotative Development Strategies for Teaching Detection and Robotic Sensor Technology Courses. China Educational Technology Equipment, (22): 75–78.
[13] Yao K, Yu Y, Luo Y, et al., 2023, Application of Artificial Intelligence in Teaching “Sensor and Detection Technology” for Emerging Engineering Education. Science and Technology Information, 21(7): 176–179.
[14] Zhang P, 2023, Exploration and Practice of Teaching Mode for “Sensor and Detection Technology” Course in Application-Oriented Universities. Educational Teaching Forum, (26): 128–131.