# Experiences in Developing an Experimental Robotics Course Program for Undergraduate Education

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***Abstract*—An interdisciplinary undergraduate-level robotics course offers students the chance to integrate their engineering knowledge learned throughout their college years by building a robotic system. Robotics is thus a core course in system and control-related engineering education. This paper summarizes the experience of developing robotics courses presented in the literature and shares the author's experiences through many years of teaching and developing robotics courses with other educators in the Department of Mechatronics, Chungnam National University (CNU), Daejeon, Korea. First, the CNU robotics course described here has classroom and laboratory sections. In class, students learn the theories behind robotics and practice them by performing simulation studies. In parallel, students perform robotics exercises in the laboratory. Second, the lab exercises are focused on hands-on experiments on robot systems; these include an experimental kit, LEGO robots, humanoid robots, industrial robots, and home service robots. Third, competition-based learning is explored by assigning a class project to develop a boxing robot, which covers both manipulation and mobility. Finally, the course introduces robotics-associated outreach activities. The analysis of several years of student evaluation is presented.**

***Index Terms*—Competition-based learning, hands-on experience, outreach activities, robotics experiments, robotics theory.**

## I. Introduction

ENGINEERING education at the university level has always required educators to decide the appropriate balance between the theoretical and experimental aspects, both of which are necessary to satisfy the needs of industry. Recently, the ability to design and integrate creative systems has become enormously demanded by industry and research institutions.

The many educational kits in the market offer an easy and efficient paradigm that can act as a supplement for a robotics class. Robots, being interdisciplinary systems that integrate all engineering knowledge, prove an excellent tool for teaching engineering technologies to students of all ages, from children to college students.

Many university engineering departments provide robotics courses as an indispensable part of engineering education, emphasizing hands-on experience, creativity, and teamwork. Table I lists various examples from the literature of robotics education in Electronic/Electrical, Information/Computer Science, and Mechanical/Mechatronics Engineering departments dealing with dynamical systems, computer systems, and artificial intelligence.

Accordingly, upper-level robotics courses can be closely connected with capstone design programs in the engineering curriculum to satisfy current industrial needs. The intention of capstone design classes is that seniors should integrate all their previously learned knowledge to build creative systems to satisfy specific goals.

The literature offers valuable comments about curricula, projects, and contests in robotics courses offered in universities. An introduction to some low-cost robots for research and teaching activities is given in [1]. The three-course robotics track at the United States Naval Academy is introduced in [2] to explain three basic principles of modern robotics education.

In the area of manipulation, [3] presents laboratory exercises to give students hands-on experience in robotic manipulation, computer vision, artificial intelligence, and mechatronics. Multimedia practices for controlling mobile robots by audio and visual information for engineering education were presented in [4]. Internet-based programming tools were used to generate three-dimensional models of robot manipulators based on kinematics derived from Denavit–Hartenberg (D-H) parameters [5]. A practical robotics education program was developed by Ritsumeikan University, Kyoto, Japan [6]. Internet-based control of robot arms has been implemented for teaching an online control engineering course [7].

There are many case studies of mobile robots. Integration of robotics research with undergraduate courses was demonstrated by developing a robot called Rusty [8]. LEGO-based robots have been used in lab exercises and projects, in basic to advanced courses covering operating systems, networks, and artificial intelligence [9]. A class project of developing personal robots has been used to motivate computer science students [10].

A mobile robot design class taught engineering students to build their own robots as a team [11]. An autonomous fire-fighting robot design competition was held to inculcate in undergraduates the abilities to use interdisciplinary concepts and to engage in interdisciplinary teamwork [12]. Robot-based courses in computer science curricula that built on the experience of computer science and artificial intelligence educators and researchers were described in [13]. Other authors describe outreach activities for high school teachers and children that used

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4) Robotics courses can be used for outreach to children and teachers from local schools.

This paper has described the experience of developing a robotics class based on these strategies. Over the last 15 years of developing the robotics course, the most important concern has been how to attract students, despite limited budgets. Experience suggests that there are many ways to develop exciting robotics projects, for example the design of robots requiring a single actuator. It is also suggested that, even with low budgets, a variety of robot systems can be prepared if this is done over several years.

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