Situated Learning-Based Robotics Education

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***Abstract*—This Innovative Practice Work-In-Progress Paper presents a situated learning-based robotics education pedagogy for computing students. Different from traditional textbook-directed robotics courses, in this work, we develop a hands-on, project-oriented robotics curriculum based on the situated learning methodology for undergraduate and graduate students. The innovative pedagogical framework and curriculum development are presented. Preliminary results and evaluations suggest that our situated learning-based pedagogy and developed robotics curriculum provide an effective solution for computing students to learn robotics.**

Keywords—Robotics, hands-on projects, situated learning, computing students

I. Introduction

Robotics technology has been playing an important role in the development of artificial intelligence (AI), intelligent transportation, and smart manufacturing [1-3]. With the increasing employment of robots to multiple applications, both undergraduate and graduate students from computing related majors such as computer science and information technology are showing a high demand of learning robotics technology to broaden their career opportunities [4-6]. Therefore, training computing students with robotics to let them possess well both science and engineering problem-solving thinking is a significant work in computing education. Education 4.0 emphasizes the learning process on students instead of instructors to achieve a steadily increasing demand for adaptive and personalized education [7, 8]. It is necessary to develop a sustainable and high-quality pedagogy to empowering computing students with proficiency in robotics.

In recent years, robotics education is experiencing a distinct rising in a variety of school communities from K-12 to graduate students [9]. Some classroom-based robotics curriculums and pedagogies have been developed to cultivate students with robotics knowledge [10-12]. In addition to offline teaching, several online training approaches were also carried out to support and motivate robotics education [13, 14]. However, fostering computing students with robotics expertise remains a challenge since most of computing students have limited pre-training in engineering subjects such as electronics and mechatronics. Additionally, although learning robotics online is an economic way, it cannot provide learners such as computing students with tangible experience to inspire creativity and self-confidence. Therefore, different from above robotics curriculums that were designed for high school basic robotics training or college-level engineering students, robotics education for computing students requires to create a unique and real-world learning environment with hands-on projects and theories.

Situated learning, which focuses on having students participate in realistic settings during their learning processes [15], has been used for professional education in multiple areas [16-18]. By taking advantage of situated learning, the classroom culture can be changed from more of knowledge supplying to an interactive and dynamic learning community. Robotics is a cross-disciplinary subject which includes software development and hardware integration [19]. Therefore, developing robotics education for computing students by leveraging situated learning is supposed as an effective solution.

In this work, we propose a robotics education framework based on the situated learning methodology [15] for computing students and implement it with effective preliminary results in real-world human-robot interaction contexts. The innovative pedagogical framework and curriculum development are presented. A survey is conducted to evaluate computing students' recognition and acceptance of the proposed pedagogy. Practice results and student evaluations indicate that the proposed pedagogy and robotics curriculum are ideal for computing students to learn robotics.

II. Curriculum Development

A. Pedagogical Framework

The framework of the proposed situated learning-based robotics education pedagogy consists of four elements, including content, context, community, and participation [20], which are integrated into the process of robotics curriculum development and implementation. In this situated learning-based robotics course, all contents are derived from real-world robot applications. For the context construction, a multi-modal collaborative robot is employed as students' classmate during the whole semester. This robot classmate is able to work with students safely for shared tasks. A classroom-based learning community is constructed for students to build the bridge between classroom situations and real-life situations outside the classroom. Hands-on projects are designed to be accomplished through teams' participation and each team contains several members. In the participation process, students can exchange their ideas with their teammates and engage in hands-on projects with effective and optimized solutions.

B. Course Introduction

The situated learning-based robotics course for computing students started from fall 2019 semester. The Computer Science Department offered this robotics class as a 3-credit course for undergraduate and graduate students from majors of computer science and information technology. In order to facilitate better student-teacher interaction, this class is limited to maximum enrollments of 10 undergraduates and 15 graduate students. This robotics course was totally run for 15 weeks.

C. Curriculum Modules

As shown in Table I, the course is composed of 4 modules with a stair-stepping structure including robotics basics, robot electronics and integration, robotics advanced applications, and hands-on projects. Each module contains several topics that are designed for the students to study and work with their robot classmate. At the end of the semester, the course has an open competition, in which each team shows off their hands-on project achievements to the University community by on-site demonstrations.

TABLE I. COURSE MODULES

Module	Weeks	Topics
Module 1: Robot basics	2	• Introduction to robotics development • Robot kinematics
Module 2: Robot electronics and integration	5	• Sensors and actuators for robotics • Signal processing for robotics • Computer vision for robotics • System controls for robotics • Mid-term exam
Module 3: Robot advanced applications	3	• Robot motion planning • Robot operating system • Robot programming • Machine learning technologies and applications in robotics
Module 4: Hands-on projects	5	• Project 1: Robot simulation system • Project 2: Object location system for robot grasping

D. Homework Assignments

The innovative practice of the proposed pedagogy is also reflected on homework assignments. Mini-project-based homework assignments are designed for our computing students in this robotics course. Every student is allocated a robotics development kit. The kits, containing several ultrasonic sensors, an Arduino board, and other robotics electronic accessories, are used by students for mini-project-based homework assignments.

E. Hands-on Course Projects

Two final hands-on projects are designed to for computing students in this course. In project 1, the students are required to use the state-of-the-art robot programming approaches including ROS [21] and MoveIt [22] to build a robot simulation system. The robot classmate in the classroom-based learning community can be driven by the simulation system to do some picking and delivery tasks. In project 2, students employ ultrasonic sensors and Arduino platform [23] as well as the fundamental knowledge of robotics delivered in classes to develop an object location system for the robot classmate to correctly grasp objects from the workspace and deliver them to its human partner in realistic human-robot collaboration situations [24, 25].

III. RESULTS AND EVALUATIONS

A. Implementation of Final Course Projects

The hands-on project implementation results of one of the teams are shown in Fig. 1. As presented in Fig. 1 (a), one of the students randomly putted the object in the robot's workspace. The ultrasonic sensors detected the object position and sent the raw data to Arduino for future processing. After receiving the raw sensor data, the Arduino evaluated the object exact position in the robot coordinate system through the team's object location algorithms, then sent the position to the workstation. As shown in Fig. 1 (b), the workstation gave the position commands to the robot controller to have the robot grasp the object in the workspace. Then the robot handed-over the object to its human partner, as presented in Fig. 1 (c). The on-site showcases of course projects suggested that the proposed situated learning-based pedagogy worked well for computing students to learn robotics.

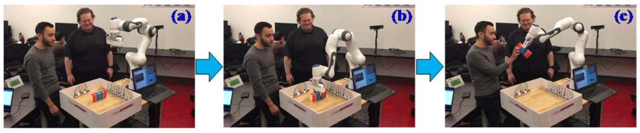

Fig. 1. Implementation of hand-on projects in human-robot collaboration.

B. Course Evaluation from Students

The feedback from students is helpful for us to identify their satisfaction in the course and to improve the course quality. As shown in Table II, a voluntary survey with anonymity was conducted in the robotics class at the end of fall 2019 to evaluate students' experience and expectations of this robotics course.

TABLE II. QUESTIONS OF THE SURVEY

No.	Do you think that
Q1	this course has clearly defined the concepts and skills to be obtained?
Q2	this course is well prepared and organized in each class?
Q3	the proposed pedagogy framework is interesting and meaningful?
Q4	this course is approachable and has a positive attitude toward progress?

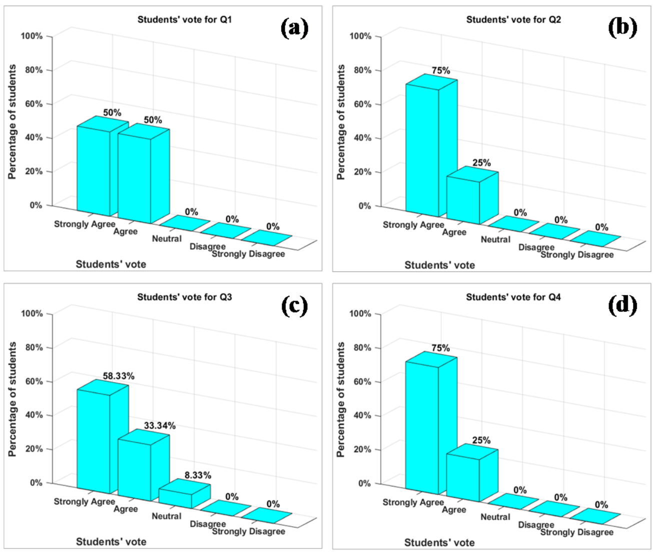

Fig. 2. Evaluation results of the proposed pedagogy.

As shown in Fig. 2 (a), 50% of students strongly agreed and 50% of students agreed that the course had clearly defined concepts and skills in their learning processes, respectively. Fig. 2 (b) indicated that 75% of students were strongly satisfied with the course preparation and organization in each class. When the participants were asked to rate if the proposed pedagogy framework was interesting and meaningful, as presented in Fig. 2 (c), 58.33% of them were strongly satisfied with this point, 33.34% of them agreed it, and 8.33% of them held neutralizing attitude, separately. It indicated that some more measures should be taken to make the robotics education pedagogy more interesting. It can be observed from Fig. 2 (d) that all the participants considered that this course was approachable and had a positive attitude toward progress. Of the respondents, 75% of students strongly agreed and 25% of students agreed this point. The evaluation results from computing students suggested that most of the students agreed that the proposed situated learning-based pedagogy was effective for them to learn robotics knowledge.

IV. Conclusion and Future Work

We have presented a hands-on, project-oriented robotics curriculum based on the situated learning methodology for undergraduate and graduate students from computing related majors. The pedagogical framework and curriculum development have been introduced. Preliminary results and evaluations suggested that our situated learning-based pedagogy and developed robotics curriculum provide an effective solution for computing students to learn robotics. In order to improve the course quality and students' recognition, we will design some new teaching strategies like brainstorm [26] in the class to increase students' engagement. In addition, more evaluation questions will be developed to get students' feedback comprehensively.

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