Board 97: Robots at Your Service: An Entrepreneurial and Socio-Technical ACL Course Module

Dr. Ming Z. Huang, University of San Diego

Ming Huang received his MS in University of Rhode Island and Ph.D. from the Ohio State University in Mechanical Engineering. He is currently professor and chair of mechanical engineering department at USD. His research interests are coordination and computer aided design optimization of of robotic mechanisms, theory and practices of inventive problem solving and engineering pedagogy.

Dr. Elizabeth Reddy, Colorado School of Mines

Elizabeth Reddy is a Teaching Assistant Professor in the Division of Engineering, Design & Society at Colorado School of Mines. She is a social scientist, holding a PhD in cultural anthropology from the University of California at Irvine and an MA in Social Science from the University of Chicago. She is Co-Chair of the Committee for the Anthropology of Science, Technology and Computing in the American Anthropological Association. She studies experts and their work in relation to environments, technologies, and human lives. Her current research projects deal with earthquake risk management technology in Mexico and the United States, environmental data justice in the US/Mexican borderlands, and the development and practice of engineering expertise.

Robots at Your Service:
An Entrepreneurial and Socio-Technical ACL Course Module

Abstract

The advancement of robotics technology in recent years, coupled with AI and big data, helped ushering in the era of service robotics, where robots are no longer used in factory automation only but in close proximity and interaction with humans as assistants. The significant interests in humanoid robots and driverless cars exemplify this development trend. While courses on robotics have found their way into Mechanical Engineering curriculum, they are typically offered as electives and tend to be technically centric, not much time being afforded to address the social and ethical implications inherent in its applications. A course module, named 'Robots at Your Service', was developed to engage students to critically think about the social and ethical implications while performing technical research assignments and identifying new opportunities in robotic applications. Active & collaborative learning (ACL), such as jigsaw and gallery walk, are used for effectively engaging students and promoting self-learning. Initial assessments of its first deployment in Spring 2018 showed positive outcomes for its feasibility. This module was developed for an undergraduate junior/senior robotics course; however, its generic format makes it suitable for graduate level adoption as well.

Introduction

Engineering students traditionally are trained technically, with less focus on critical examinations of assumptions within engineering practice, and less emphasis on the larger contexts in which engineering is embedded. With funding from an NSF IUSE/PFE Revolutionizing Engineering Departments (RED) grant, our School of Engineering is "revolutionizing" engineering education, with the aim of preparing students to innovate engineering solutions developed within a contextual framework that embeds humanitarian, sustainable and social justice approaches with technical engineering skills [1]. This requires an enhanced curriculum with a focus on student teamwork, a greater consideration of social and economic factors, improved communication with diverse constituents, and reflection on an ethical understanding of their decisions and solutions. One way of curriculum enhancement is to identify appropriate courses where inclusion of social contents are natural and meaningful (e.g., [2], [3]). Robotics, being multidisciplinary in nature and becoming compellingly ubiquitous in society, is a prime case in point for such an integration.

In Mechanical Engineering curriculum, courses on robotics are typically offered as electives and tend to be technically centric, not much time being afforded to address the social and ethical implications inherent in its applications. A course project module, named 'Robots at Your Service', was developed to engage students to critically think about the social and ethical implications while performing technical research assignments and identifying new opportunities in robotic applications. Active and collaborative learning (ACL) methods, such as jigsaw and gallery walk, are used for effectively engaging students and promoting self-learning. Initial assessments of its first deployment in Spring 2018 showed positive outcomes for its feasibility. Although this module was developed for an undergraduate junior/senior course at USD, MENG 445 - Introduction to Robotics, its generic format makes it suitable for graduate level course

adoption as well. The second deployment of this module is scheduled for this Spring 2019 term in March. Assessment results will be collected and presented at the ASEE meeting in June 2019.

The ACL Module Design

Research studies have shown that students learn better through guided participation facilitated by pedagogies of engagement [4] [5]. This course module, Robots at Your Service, intends to guide students to explore and learn topics of current robotic technologies, robotic applications, and concept ideation using several ACL methods (jigsaw, gallery walk). Designed as a team project assignment which involves both in- and out-of-class activities, it aims to achieve the following learning objectives.

At the end of this project, students will be able to

1. Describe basic elements of robotic systems and current technologies
2. Identify new opportunities of robotic application
3. Specify functional requirements of a robotic system for a chosen application
4. Communicate benefits of a chosen robotic application
5. Recognize social, ethical and technical implications of robotics applications
6. Develop team skills by completing this activity

Note that, besides skillset development, outcomes 2 and 3 are related to the 3C's (curiosity, connections, and creating value) of the entrepreneurial mindset [5]. The following presents a detailed outline of the project module including teaming, deliverables and student assessment, as well as deployment and staging schedule. Two sample assignment handouts are included in the appendix. Of course these are suggestions based on a 3-day 55 minutes each session class schedule; modification is expected to fit needs of individual school setting.

<u>Teaming</u>

- Team size: 3 to 4 students
- Method of assigning teams: by instructor based on students availability and preference

<u>Deliverables and student assessment</u>

- Deliverables:
  - Individual - 2 memos
  - Team – poster, presentation, and a written tech brief (2 pages)
- Student assessment:
  - Memos – graded according to level of engagement
  - Poster and presentation – group vote (most votes earn bonus)
  - Tech Brief – graded according to rubric
  - Teamwork Evaluation (rubric, peer evaluation)

<u>Deployment and staging schedule</u>

- Three stages to deploy the module for a duration of 1.5 week, spread out in 3 in-class sessions (55 min) and 3 out-of-class assignments (6 to 8 hours)
- Stage I: *Pre-assignment ('hook')*
  - Select a film featuring robots, watch it, and produce a short memo on the technical and legal and/or ethical implications of the robotics story. *(*deliverable: memo 1)*
- Stage II: *To learn state of robotic technologies*

- 1st class – 1) discuss/share pre-assignment, 2) review basic elements of robotic system, 3) form team, 4) assign 'expert' role (*jigsaw*), 5) assign each expert to research state of technologies in the assigned area *(*deliverable: memo 2)*

– Stage III: *To generate/propose/specify new robotic application*
  - 2nd class – 1) expert group sharing (20 min), 2) home team debriefing (20 min), 3) brainstorming (10 min), 4) assign team to meet out of class to continue ideating to identify an opportunity application and to generate contents for poster
  - 3rd class – 1) team to set up poster (3 min), 2) team to view/study posters (8 min) *(gallery walk)*, 3) presentation (3 min – one representative each team) with Q&A (3 min), 4) voting (2 min), 5) debriefing/reflection *(*deliverable: poster)*
  - Team to submit a tech brief (a week) *(*deliverable: tech brief)*

Pilot Implementation Assessment

The module was first implemented in Spring 2018 term in the Introduction to Robotics course. The class comprised 12 students (1 woman, 12 men), all juniors and seniors MEs. Overall, the 3-stage deployment structure as well as in-class activities worked out as envisioned.

To assess the efficacy of the module, the following methods of assessment were employed.

1. Review of preliminary memo assignments about robots in film
2. In-class participant observation during discussion about the effects of robotics in society
3. In-class observation during presentation/gallery walk about student designs for robots
4. Survey after intervention.

Assessment Results of the pilot implementation are presented below. Each area of assessments is addressed in turn with a summary remark of observation and followed by some contextual comments.

1. *Preliminary memos: students seemed to be asking big questions based on their Sci-Fi exposures to robots.*

Students engaged with a wide variety of media. Some wrote about film, some TV, and some even described video games. They engaged with ample, unexpectedly robust responses and discussed their assignment animatedly in class shortly after. They demonstrated sensitivity to big-picture considerations about how a robot might be integrated into a broader social context.

2. *In class discussion: students were active in class, and had observations and/or speculations that they were excited to share.*

After writing a short memo on life with robots, students had a discussion in class about the advantages and disadvantages that robots could have in society. They were highly engaged. They discussed many of the issues and questions that address the way in which engineering topics connect to social justice: who feels the impact of technology changes, who benefits and who doesn't, how technology impacts jobs, who gets to make decisions about technology, and what social and legal structures are required. They did not substantially consider environmental impacts, though.

Students drew on fiction and on their own experiences and observations in classroom discussion, and speculated creatively on the issues at hand. They seemed ready to engage and speculate. For example, one student had lived near a town where 20% of people (he estimated) lost their agricultural jobs when a new, highly roboticized dairy company moved in. We talked about how those jobs hadn't been bad, even if a lot of ambitious students graduating high school didn't want them, and how these people, who may have had generations of family living in this town and doing these jobs, had to move. It wasn't just that it was hard, the student said, but that they might not have wanted to. This was a really thoughtful description of how shifting economic and technological realities can have consequences for people. Another student reflected on the legal implications of robots taking over jobs currently done by humans. He said that if a robot was doing surgery, it might cause a death in the same way that a human doing surgery could cause a death. This would require new approaches to legal accountability.

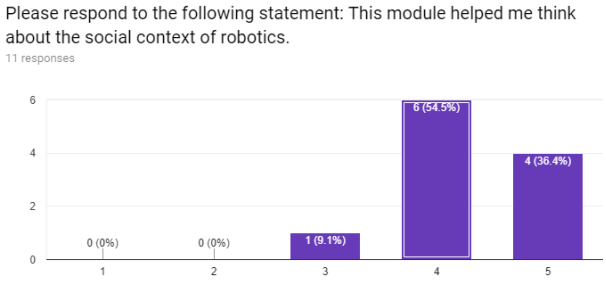
3. *Robot presentation and gallery walk: students were creative and engaged, but focused in formal discussion on technical aspects of their projects.*

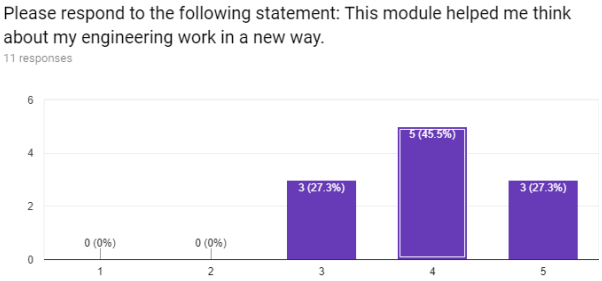
Students presented proposals that were more or less technically detailed, but while they discussed some issues of social context in their gallery walk, their presentations and most of the questions they asked each other in the formal discussion portion of the class focused on technical details to the exclusion of social ones. Examples of student proposals for new opportunities of robotic application developments are provided in the table below.

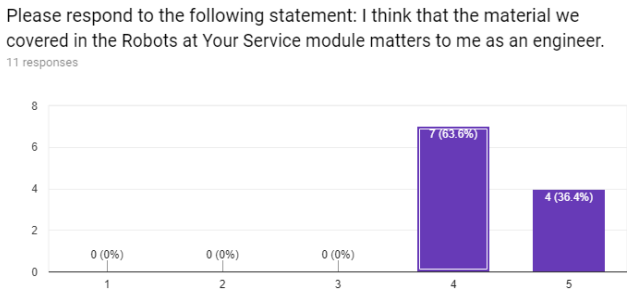
Proposal	**Description**
"Rock'em Sock'em Rehab Robot"	A robot attached to a ceiling, designed to aid a physical trainer with precision rehab issues and be calibrated to keep recovery standard across different sites.
"Orderly Robot"	A robot designed to monitor patients in a hospital and take care of some very basic patient services needs.
"Robot Rehab"	A sort of external scaffolding support suit that can brace a patient in an adjustable and supportive system.
"The Nibbler"	Wearable set of light-weight mechanical arms.

4. *Survey: students enjoyed the module and found it helpful.*

Results of survey indicated that students generally found the module useful for thinking about the social context of robotics (average response was 4.27, between somewhat and very helpful) and somewhat helpful for thinking about engineering in new ways (average response was 4, somewhat helpful). They found it clearly relevant to their work (average response was 4.36, between somewhat and very helpful).

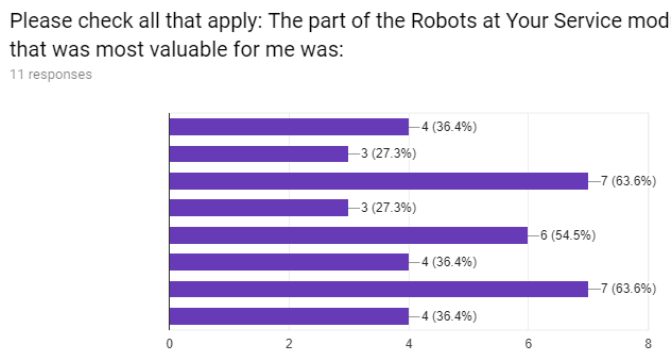




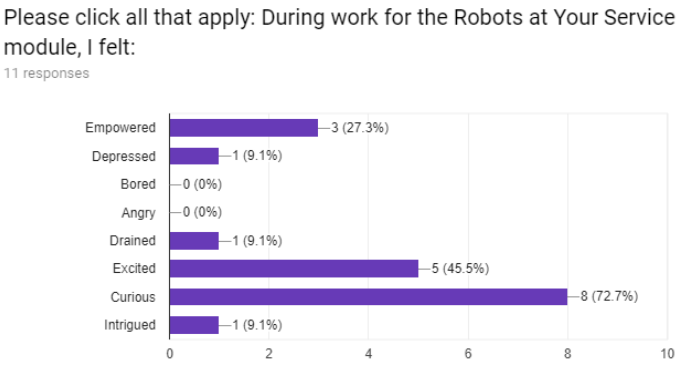


Student responses regarding the most valuable part of the module varied. Students picked as few as 1 part of the module and as many as 6 (average: about 3; modes: 5 and 1). Most liked Discussing the implications of robotics for society in class (7/11 students) Developing the poster as a team (6/11) and Sharing findings in class (7/11). The least popular parts were Pre-assignment memo on life with robots (3/11) and Writing a memo individually (3/11).

There was no trends among students who were only willing to name one part of the module as the most valuable-- they all liked different kinds of things.



Students had good feelings coming out of the module. They tended to only describe a few feelings (5 just listed 1, another 4 listed 2). Only one described having negative feelings (depressed, drained). This was, however, a student who identified three aspects of the module as "valuable" (the memos and class discussion) and commented that "It was interesting to see that designing a robot requires much more than just a frame." Perhaps he didn't enjoy working in his group.



Discussion

Students were engaged and ready to participate and they found the module rewarding.
The diversity of the elements that students reported as useful indicates that there's something for everyone-- that the different components may be great ways to engage a diverse class.

Most substantive engagement with social context happened speculatively rather than based on real cases, experiences, or data. Most of it happened in informal discussions (for example, during the gallery walk) rather than the formal parts of the independent module (posters/presentations did not show research into social issues).

Challenge for students isn't imagining how a human might interact with a robot, or speculating about sociotechnical changes, but instead about grounding that speculation in real data. This suggests that they might benefit from 1) models of collecting and presenting evidence, and 2) a requirement that students present information on their posters about social context related to, for example: users/social groups who could be impacted by a robot, a stated need for a robot, laws that the robot they have designed might be impacted or constrained by.

Conclusions

The rationale, design and development of a course module, named 'Robots at Your Service', has been presented in this paper. The goal was to engage students to critically think about the social and ethical implications while practicing to perform technical conceptual design as well as entrepreneurial tasks. The module incorporates active & collaborative learning practices, e.g., jigsaw and gallery walk, to engaging students and promoting self-learning. Feasibility of its deployment structure was validated first in Spring 2018 and recently again in Spring 2019. Assessment results from its first deployment have shown to be positive and met the learning objectives. This module was developed for an undergraduate junior/senior robotics course; however, it is believed that its generic format makes it suitable for graduate level course adoption as well. The deployment schedule may extend to allow for more time of discussions as seen fit by the instructor.

References

[1] C. Roberts, R. Olson, S. Lord, M. Camacho, M. Huang, and L. Perry, "WIP: Developing Changemaking Engineers (Year 2)," *Proceedings of the 2017 ASEE Conference and Exposition*, Columbus, OH, June 2017.

[2] E. Reddy, B. Przestrzelski, S. M. Lord, and I. Khalil, "Introducing Social Relevance and Global Context into the Introduction to Heat Transfer Course," *Proceedings of 2018 ASEE Annual Conference and Exposition*, Salt Lake City, UT, June 2018.
[3] S. M. Lord, B. Przestrzelski, and E. Reddy, "Engineering in the "real world": Teaching social responsibility in a 2nd Year Circuits course," *2018 WEEF-GEDC Conference*, Albuquerque, NM, November 2018.
[4] M. Prince, "Does Active Learning Work? A Review of the Research, *Journal of Engineering Education*, Vol. 93, No. 3, 2004, pp. 223-246.
[5] K. Smith, S. Sheppard, D. Johnson, and R. Johnson, "Pedagogies of Engagements: Class Room-Based Practices," *Journal of Engineering Education*, pp. 3-15, January 2005.
[6] D. Melton, "Stacking Entrepreneurial Minded Learning alongside Other Pedagogies," *KEEN'zine – Intrapreneurship edition*, Issue 3, pp. 6-9.

Appendix:

HW Assignment – Robotics and Beyond

Robotics is advancing every day, and we can only speculate what the coming years will bring. In this assignment, please select a film featuring fictional robots, watch it, and produce a short memo on the practical technical and legal implications of the robotics you see.

This memo will be one page or approx. 500 words (regardless of the length of the film you select). Make sure to put your name and the name of the film you watched on the memo. Then, using full sentences and either bullet points or full paragraphs, please do the following:

1) *Briefly*, in no more than one sentence, describe the robots in the film you have selected and what they can do.
2) What technical elements are necessary for these robots to work the way that they do? List at least 5 components of the robots and the practical challenges that each pose.
3) What are kinds of legal considerations would be required if these robots were in common use? List at least 5 issues that such robots might bring up and the practical concerns that would need to be confronted by the US legal system.

You are free to select films you enjoy. Some good options include:

Film	*TV*
Terminator (and sequels)	Humans
ExMachina	Almost Human
Star Wars (and sequels)	WestWorld
Blade Runner (and sequels)	Star Trek: The Next Generation
Big Hero 6	
Metropolis	
Wall-E	
CHAPPIE	
Robot and Frank	
Iron Giant	
Ghost in the Shell	
Living with Robots (documentary)	

Project – *Robots at Your Service*

Robotics is advancing every day, and we can only speculate what the coming years will bring. A venture capitalist looking to invest has just contracted your consulting firm to identify a novel and promising opportunity for service robotics. Customer expressed particular interests in **specific area** (e.g., medical and paramedical care) related novel applications.

Your team is assigned the following tasks:

- Research the state of art robotics technology
- Identify a promising application to be robotized
- Specify functional requirements for the chosen application
- Present to sell your chosen application to customer and competing peers

The project is to be carried out through in-class activities and out-of-class assignments involving individual as well as team work. The in-class project activities will be held on **date1**, **date2**, and **date3**. Attendance and participation in the in-class activities are mandatory to receive project grade. The project tasks/activities and deliverables are scheduled as follows.

Date 1: *To learn state of robotic technologies*

- 1) discuss/share pre-assignment
  - Do we want to give robots a real place in our society?
  - Are we ready to rub elbows so intimately with machines?
  - Will it limit our relationship with our fellow human; or worse, isolate us even further from one another?
  - Can robots' arrival be a danger to our society?
- 2) review basic elements of robotic system
- 3) form team and assign 'expert' role
- 4) research state of technologies in each expert's assigned area
- *Deliverable: Individual memo on findings for task 4 (due date)*

Date 2: *To generate/propose/specify new robotic application*

- 1) expert group sharing (20 min)
- 2) home team debriefing (20 min)
- 3) brainstorming (10 min)
- 4) team to meet out of class to continue ideating to identify an opportunity application
- *Deliverable: Poster contents of your robotic application proposal with functional specs (due date)*

Date 3: *To report/present new robotic application*

- 1) team to set up poster (3 min)
- 2) team to view/study posters (8 min) *(gallery walk)*
- 3) presentation (3 min – one rep) with Q&A (3 min)
- 4) voting (2 min)
- 5) debriefing/reflection
- *Deliverable: Team to submit a tech brief (4 pages or less, due date)*