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Using the Sony AIBOs to Increase Diversity in Undergraduate CS Programs

Maria Gini [a,1], Jan Pearce [b] and Karen Sutherland [c]
[a] *Dept of Computer Science and Engineering, University of Minnesota*
[b] *Dept of Mathematics and Computer Science, Berea College*
[c] *Dept of Computer Science, Augsburg College*

Abstract. We describe a proposed approach to increase diversity in undergraduate Computer Science programs and to encourage undergraduates majoring in fields such as health professions, business, art, and education to take more computer science courses. The approach is centered around using the Sony robot dogs AIBO in the classroom, starting at the very beginning of the computer science curriculum, as a tool to attract a diverse population of students to Computer Science, to introduce them to to fundamental concepts in computing, and to give them an appreciation of the importance of becoming competent with technology.

Keywords. Undergraduate CS curriculum, Sony AIBO, women in CS

1. Introduction

Women and minorities are underrepresented in Computer Science (CS) and related disciplines. CS departments have long had difficulties in both attracting and retaining female and minority students [5,21]. In the USA the percentage of bachelor's degrees given to women increased from 43% in 1970 to 57% in 2001, but in fields such as engineering and science, women still lag behind [28]. Females earned 13% of the bachelor's degrees in Computer Science in 1970. This increased to 37% in 1985, but has been declining ever since, to 28% in 1994 and 19% in 2001 [27].

To encourage undergraduates majoring in different areas, such as health professions, business, art, or education to consider a career in computer science or, at least, to take more computer science courses, we are developing a beginner course centered around the use of the Sony robot dog AIBO (`http://www.sonystyle.com`). We see the AIBO as a powerful tool for exposing students to concepts in Computer Science, for strengthening their programming skills and increasing their self-confidence, and for showing them how to use technology to solve real world problems. As adaptive technologies and medical devices become more pervasive, it is important that all students realize that learning more about computer technology is not only attainable but also advantageous and exciting.

[1]Correspondence to: Maria Gini, Dept of Computer Science and Engineering, 200 Union St SE. Minneapolis, MN 55455. Tel.: +1 612 625 5582; Fax: +1 612 625 0572; E-mail: gini@cs.umn.edu.

The ability of the Sony AIBO robots to interact with people [13] through voice commands, their cuteness, their ability to move graciously, to follow orders given to them via voice commands or visual cards, to communicate with each other, and to grow from a puppy stage to a fully developed personality make them ideal for our goals.

Activities we have done over the last year using AIBOs with people of different ages, from elementary school to graduate students, and of different backgrounds, from computer illiterate to expert programmers, have shown consistently that people get engaged with the AIBOs in a way that is hard to duplicate with any other technology we have tried (such as Web browsing, working with Lego-based robots, etc.)

2. Improving Recruiting and Retention of Women in CS

Studies have shown that many students stereotype computer scientists almost exclusively as "geeky white males" [31,22] and that those not identifying with this label suffer an alienation that significantly impacts their continued progress towards a degree in computer science [32]. It is a damaging cycle that reinforces the male stereotype and significantly limits the number of people trained in computer science.

In addition to the negative stereotypes associated with the field [9,14,16,21,30], factors that contribute to the difficulties associated with recruiting and retaining female students include a feeling of insufficient preparedness when starting their undergraduate degrees [6], and a feeling of isolation within the computer science community [26].

Creating a larger community of women is not simple, as observed in [22]. Carnegie-Mellon addressed the lack of "a critical mass of women, resulting in a shortage of new leaders" [12]. Their success and recommendations require much higher numbers of women in CS than many universities and colleges currently have.

We believe we can mitigate some of these problems by offering a new entry point into the CS curriculum that is more appealing to women and that, at the same time, will help them fill any real or perceived gap in knowledge.

Felder [8] reports a study of the effect of personality types on engineering student performance. Although it is known that in order to be successful in an engineering career, a student should experience learning styles other than only the one they prefer, Felder states "severe mismatches commonly occur between the teaching style of instructors and the learning style of their students." The study shows a positive correlation between students who do not learn well in a lecture-based environment and both women and first generation college students. Many engineering courses are lecture-based, so to increase women representation it is important also to adopt different teaching styles.

We will address specifically three of the major issues that affect women recruiting and retention:

1. **Increase confidence by hands-on programming experience.** Women often have little confidence in their computing ability [3]. This can result in more stress for female students, or women changing majors even when their class performance is above average. Beyer et al. state that one of the reasons for poor self-image around computing is that women are less playful than men with computers. Robotics programming, by nature, is playful. Through the class experience we hope to give students experiences that "boost their self-confidence" [3] and that improve their self-perceptions about computer science and career goals.

Furthermore, it is common wisdom that students gain confidence in their scientific endeavors by hands-on manipulation, and by seeing concrete effects of their work. It is our experience that robot programming teaches and reinforces a variety of skills, and that most students (and faculty!) enjoy using robots. Our goal is not to create robotics experts but to give students an opportunity to develop programming skills in an environment that gives quick and concrete feedback, and which is also fun.

2. **Solve real world problems.**
   We believe that focusing on solving problems, rather than just learning how to program the robot, will increase female initial interest, attracting students who do not see themselves as "computer scientists."
   Men are often interested in how the computer works as an entity unto itself. They see little need to relate the computer to real-world settings or as a tool to solve other problems. This was very evident in the introduction of the AIBOs at Augsburg College. The men were looking for processor size, the memory stick, the battery, the sensors, reading the specs, while the female were interested in questions such as "If the ball was blue, would they be able to find it?", "How can they hear me?", "Do they walk down stairs?". It has been shown that female retention in CS improves when the focus is not simply on the computer itself, but on the connections between computer science and other areas [22,19].
   Finally, introducing students to research and problem solving early on is another recommendation for retaining female students [6,33]. We will addresses the need to introduce undergraduate women to computer science research by requiring them to solve in innovative ways real-world problems.
3. **Work in groups**
   Work by Carol Gilligan [15] suggested that women score differently on Piaget's scale of moral development because they do not think in the same terms as men. In particular, Gilligan claimed that women are more oriented toward cooperation than competition. Recent studies indicate that "pair programming" [34] is an effective tool for increasing the retention of women in computer science classes [33].
   The students will work together in group projects. The projects they will work on will be open-ended and may not be "solved" by the end of the class. They will be designed so that success will be measured by participating in the process and generating a workable solution to the problem.

3. Centering a Beginner's Course on the Sony AIBO

Robotics has become widely used in undergraduate programs as a way of introducing concepts in AI [25,10,7,24,20] and more in general in Computer Science [4]. We are not aware of any systematic study on the value of teaching robotics to improve learning computer science, but anecdotal evidence supports the teaching of robotics as a way to engage the students.

What makes our proposed course different from other robotics courses is that (1) we use the robots with beginner students, (2) we center the coursework on using the Sony AIBO robots, and (3) we use a problem-based learning approach (PBL).

3.1. Why a course for beginner students?

Making the students excited about their first computing course by including creative contents and building bridges to other disciplines is recommended [18] as a way to encourage more students to consider majoring in CS.

3.2. Why the AIBO?

The Sony AIBO comes with a rich set of sensors (camera, proximity, touch, microphones), a complex body (with 20 degrees of freedom), and preloaded software that allows it to interact with humans via voice and vision without the need for any programming. We believe they are specially suited for beginner courses because of their simple and intuitive use, but, at the same time, they will allow students to grow with them. As students become more knowledgeable about programming, they will reprogram the AIBOs and make them do more interesting movements and interactions.

Compared to other robots used for educational purposes, the AIBO is more expensive than Lego-based robots, but its price is comparable to the price of the Amigobot and the Khepera [17], and significantly cheaper that the popular Pioneer [1]. Given the rich set of sensors, the integrated software, and the sophisticated mechanical construction of the AIBO, we believe it is a better deal.

The AIBOs are not intimidating and are intuitive to use, yet they will allow us to expose students to sophisticated concepts in Computer Science and to develop interesting and challenging projects. An informal poll done with University of Minnesota women students suggested that they would prefer using an AIBO over using a Pioneer or other robots.

Currently, many college-level robotics courses require group robot building projects using Lego robots with Handyboard controllers or the like. Many students, particularly women, are not drawn to soldering, shrink wrapping or low level programming in C. To the contrary, the AIBO is a commercial product, designed and built to be used by a broad population. Everything is enclosed so that the robot need not be checked for loose wires or incorrect connections each time it is run. This will allow the students to go further since they won't have to spend a lot of time on finding sensors that work and tracking down faulty wires.

The AIBO is conducive to research and experimentation not just for robotics but also for human interaction, AI, and programming. We intend to utilize the AIBOs for projects which emphasize human-computer interaction, which traditionally is an area of Computer Science quite appealing to women. Projects such as developing AIBO support for persons with physical disabilities will appeal to those CS students who are not excited about the Handyboard hardware.

A unique feature of the AIBO is its autonomy. AIBO are programmed to explore their environment and to make autonomous decisions. We believe this is a very important feature for the course, since the students will understand the power of computing by understanding what it takes to make autonomous decisions, in the face of a complex and unknown real-world that can only be partially observed via sensors.

Recent studies with adults [11] and with children [23] show that the majority of them views the AIBO as having mental states, life-like essence, and social communication skills. To the best of our knowledge, this is the first robot for which people have shown the type of psychological, cognitive, and emotional reactions they tend to have with pets [2].

What makes the AIBO special for people is one of the reasons for selecting it as the platform for our course. The fact that it has a complex body with multiple sensors and can be programmed with varying level of sophistication is another important reason. We know that our students will have different levels of programming skills. With the AIBO no one will get scared by the complexity but, at the same time, no one will get bored.

3.3. Why Problem-Based Learning?

In problem-based learning, relevant problems are introduced at the beginning of the instruction and are used to provide the context and motivation for learning. As described in [29], "While no evidence proves that problem-based learning enhances academic achievement as measured by exams, there is evidence to suggest that PBL "works" for achieving other important learning outcomes. Studies suggest PBL develops more positive student attitudes, fosters a deeper approach to learning and helps students retain knowledge longer than traditional instruction."

4. Course Material

The course material is designed to both attract students to CS and to give them the initial background they need to succeed in further CS courses.

The course will use the preloaded AIBO software and its scripting language, together with more sophisticated programming tools to program them for more complex tasks. We will start with Pyro [4], an easy to use programming system written in Python. We will then use extensions we have developed at the University of Minnesota as part of an AIBO class for advanced students. The extensions allow for additional control (such as controlling the LEDs on the robots, or controlling the ear motions), for proper execution of sequences of commands, and for read/write from sockets. The use of sockets will allow us to create clients for the AIBO in different programming languages, such a C, scheme, perl, or php. This in turn will allow the students who have already some programming experience to use their programming knowledge more effectively.

We expect the preparation and background of the students to vary substantially, from students who have no knowledge of computing, except perhaps some computer literacy, to students who have already taken programming courses.

The course will be driven by real world problems. By working on application areas where computer science is useful, we will shift the focus from teaching the technology to understanding the role of the technology in solving real problems. We believe this will help attract students who are interested in the long term results of using the technology more than in the technology itself. We will ensure that different application areas are included in the course to make it appealing to all students, including those interested in human factors, social systems, psychology, cognitive science, and animal behaviors.

We will, in particular, focus on developing functionalities in the area of speech recognition and other forms of human interaction. Beginner students do not know much programming, but are very interested in natural ways of interacting with the robots. By providing relevant software to support the interactions, we will give the students a better appreciation of the need for software and some understanding of the process by which software is created.

Topic:	Include AIBO in an evaluative game to assess Attention Deficit Hyperactive Disorder (ADHD) children. [1]
Steps:	Learn about methods to assess ADHD. Find an expert to help you.
	Design a simple game using the AIBO around an existing method used to assess ADHD.
	Evaluate the game with someone not from your group.
	Ask an expert to give you feedback.
Topic:	Include AIBO in a play activity that your grandmother would enjoy doing.
Steps:	Think about how an elderly person would like to interact with a pet. Find an expert to help you.
	Design software for the AIBO to engage in a simple interaction game.
	Evaluate the results with someone not from your group.
	Ask an expert to give you feedback.

Table 1. Sample projects.

The activities for the course will be centered around lectures and laboratory activities. The objective of the lectures is to expose students to relevant material related to the programming of the dogs and to related Computer Science concepts. The objective of the laboratory activities is to work on group projects.

Students will work in groups of 3-4 students each. The groups will be organized to mix level of skills and of academic interests in each group. The projects will be interdisciplinary to appeal to the broad background of the students. The projects will run through the semester and will be demonstrated at the end of the semester to an outside audience, such as local girl scout troops or other groups. This will put the students who attended the course in the role of outreaching out to the community and becoming role models for younger students. Table 1 provides some examples of the types of projects we will propose to the students.

5. Conclusions

We have presented a proposed curriculum for a beginner course designed to increase diversity in Computer Science undergraduate programs. The course is centered on the use of the Sony AIBO as a tool for attracting new students to study computer science and for introducing them to fundamental concepts in Computer Science. The unique features of the AIBO in terms of its ability to interact with humans makes it an attractive platform for the students we wish to reach.

The main idea is to help students to develop a deeper understanding of the Computer Science field and to appreciate the role of technology, not to make them experts in robotics. The ultimate goal is to make students more interested and better prepared for further courses by providing them with an enjoyable learning experience, by exposing

[1] Thanks to Laurel Lewis for suggesting this problem.

them to the excitement of being able to come up with solutions to real-world problems, and ultimately by helping them to take increasing responsibility for their own learning.

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