

Robotics-based Curriculum Development for An Immigration Course into Computer Systems Engineering

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Abstract - A robotics-based freshman immigration course into Computer Systems Engineering (CSE) was created to introduce students to the main design issues in CSE: multi-controller programming, sensor interfacing, servo actuation and serial communications. The instructional materials were designed around 3 projects: car bot in maze, GERWALK bot penalty kick, and GERWALK bot going up stair steps. Selected descriptive and prescriptive creativity tools were also incorporated into the curriculum to round out student design experience. Mid-term course assessment results are presented in this article.

I. INTRODUCTION

Starting in Fall 08, the Faculty of Engineering at The University of Georgia is offering a new Bachelor of Science degree in Computer Systems Engineering with an interdisciplinary perspective:

“The Computer Systems Engineering undergraduate program of study covers the range from scientific principles and engineering concepts to the practical application of designing and implementing products and systems requiring hardware-software integration. Graduates from this program will have a critical understanding of computer hardware and software development issues and how to use computers to automate, monitor and control various systems, industrial as well as biological. The job market needs of a computer systems engineering graduate include telecommunications (wired and wireless networks), computer-human interactions (training or role-playing), decision-making (financial and health care industries), and embedded mechatronics (industrial or biomedical), where the engineer is needed to increase the efficiency and overall effectiveness of computing and sensing systems”.

(http://www.engineering.uga.edu/academics/Comp_Sys.php)

Recognizing the importance of freshmen engineering courses in affecting students continuing interests and retention ([1],[2],[3]), we opted to create a new 1 semester-credit hour course whereas the students can obtain an overview of the

main issues that a Computer Systems Engineer would encounter in his or her work after graduation. We also wanted to showcase selected creative problem-solving approaches and tools used, thus the core instructional materials were designed around 3 robotics projects:

1. The first project involved a pre-made “car-bot” equipped with NIR sensors to help it avoid obstacles using a provided software solution and the student’s task was to extend this solution to allow this car-bot to navigate itself autonomously through a maze (see Fig. 1).



Figure 1. Car-bot traversing a maze.

2. The second project involved a GERWALK bot (for a definition of “GERWALK”, please visit this web site http://en.wikipedia.org/wiki/VF-1_Valkyrie). Essentially, it was a “box” on top of 2 legs allowing bird-like bipedal motion (see Fig. 2).

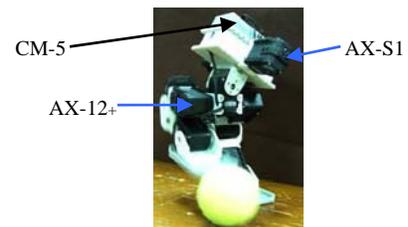


Figure 2. GERWALK bot kicking a tennis ball.

Also starting from a provided software solution, the student’s task was to extend this software solution to allow the GERWALK bot to kick a ball into a goal guarded by a car-bot controlled by the instructor.

- The third project required the student to adapt the existing GERWALK bot hardware and software design so that it can climb up stair steps in a balanced manner (see Fig. 3).



Figure 3. GERWALK bot climbing stairs.

The following demo web sites were created for the students:

- <http://www.engr.uga.edu/~thai/Bioloid/CarBotMaze/>
- <http://www.engr.uga.edu/~thai/Bioloid/KickBall/>
- http://www.engr.uga.edu/~thai/Bioloid/GerwalkStairs_2/

The secondary objectives of the course were to introduce students to the main steps of the engineering design procedure and selected creativity practices, in preparation for their first formal course in engineering design to be taken during their sophomore year.

The course specific goals were for students to learn about the basic programming of microcontrollers, the interfacing of sensors for sound and near-infrared light, the actuation of servo motors and computer serial communications concepts. These concepts and methodologies were demonstrated “synchronously” in a technology-enhanced classroom described in [4], and also “asynchronously” using narrated tutorials pod-casted from the web when students were outside the classroom. The students were also introduced to selected descriptive creativity tools such as “Empathy” [5] and “SCAMPER” [6], and a prescriptive creative design approach called TRIZ [7].

II. CURRICULUM DESCRIPTION

A. Hardware/Software Platform Chosen

The main challenge in this curriculum design was to find an appropriate hardware/software platform for freshman engineering students who may not have yet been exposed to software programming. Thus we wanted a more limited software development environment than standard tools such as BlueJ (<http://www.bluej.org>) or Alice (<http://www.alice.org>), so as to lower the necessary learning curves for students. On the other hand, we wanted a hardware-rich system so as to facilitate hands-on projects and keep students’ interests high early and throughout in the course. Thus we decided on using the Bioloid system from Robotis (<http://www.robotis.co>) which was based on Atmel’s ATmega chips (<http://www.atmel.com>). The system consisted of a main controller CM-5, based on the ATmega128, which could be interfaced with smart actuator modules called AX-12+ and smart sensor modules called AX-S1 via TTL serial protocols (see Fig. 2). The AX-12+ and AX-S1 modules were controlled by their individual ATmega8 microprocessors. The CM-5 could be programmed to tell a given set of AX-12s to

go to individual and different Goal Positions (0-1023 possible values corresponding to a physical 300° range of motion) and the AX-12s could report their Present Positions, Speeds, Loads and Temperatures back to the CM-5 during their progress towards the prescribed Goal Positions. The AX-S1s could provide active or passive NIR detection and also detect sound levels (both with 0-255 possible values for sensor data range). The Bioloid system provided students with 3 PC-based software tools: Behavior Control Programmer (BCP), Motion Editor (ME) and Robot Terminal (RT) [8]. These tools communicated with the CM-5 via the PC’s RS-232 communication port.

The Behavior Control Programmer tool is a context-sensitive line-editor (see Fig. 4) wherein students could create bot programs, check them for logic errors, download the compiled versions down to the CM-5 and run them from the PC or autonomously on the CM-5 as needed. To create a program line, the student would double-click on the left most cell to pop up a small window showing all the available commands such as IF, ELSE IF, ELSE, CONT IF, JUMP, LOAD, COMPUTE, START, END, CALL and RETURN. Once this command was selected, the student double-clicked on the next cell on the right which would display additional possible data entries that were context-sensitive based on the actual choice made for the previous cell, and so on (see Fig. 4).



Figure 4. Windows Interface of Bioloid BCP tool.

The Motion Editor tool (see Fig. 5) was used for “motion programming”, i.e. creating coordinated servo positions of a group of servos belonging to a given bot to obtain a required bot “pose”. The ME tool used graphics to help students create sequential “poses” that the bot must execute at run time in order to perform a wanted overall maneuver of the bot. The ME tool had the capacity for 127 motion pages with a maximum of 7 poses in each motion page. This tool was designed around a “teach and learn” paradigm which made the motion programming task quite easy: the student would first select a group of servos to disable the power to them so that their positions could be manually adjusted to achieve a wanted pose (“teaching” phase), then the student would reactivate power to those servos so that the ME tool could record their final positions resulting from that prescribed pose (“learning” phase). Due to the execution speed of the Bioloid system, all poses had to be statically stable by themselves to ensure successful overall maneuver execution. The BCP and ME tools were designed to be used in concert to create sophisticated and intelligent behaviors in 12 bots pre-designed by Robotis such as the GERWALK and HUMANOID models

[9]. For custom-made bots, the user would have to use the Robot Terminal tool which was beyond the scope of this report.

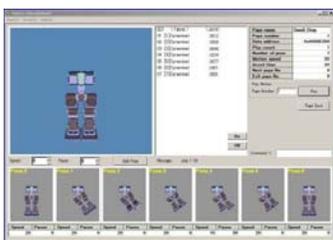


Figure 5. Windows Interface of Bioloid ME tool.

B. Instructional Technologies Used

Classroom instruction was done in a technology-enhanced teaching laboratory whereas each student had access to a Windows Vista PC equipped with dual displays to achieve a dual-workspace capability for in-class activities [4]. Students used one display for their own personal workspace, and the second display was configured as an “external” workspace which could be set to be “passive” and only received live transmission of all activities currently happening on the desktop of the Teacher Station (such as PowerPoint slides). Students could then optionally use their Pen Tablets to capture and annotate screen shots of this external workspace and thus could create their own electronic class notes as separate graphics files or integrate them into their own Word or OneNote documents to take home. A second option was also provided to students by the instructor’s pre-printing all PowerPoint slides (or any other Office 2007 documents) into a Windows Journal Writer file format which essentially transformed these slides into graphical backgrounds unremovable by the students but that can be annotated “on-top” by students using Pen Tablets (please note that this option is only available to those using Office 2007 with Windows Vista or Windows XP Tablet PC for operating systems). However this “external” workspace could also be used in an “active” mode allowing students to actually share into the desktop of the Teacher Station or peer student’s desktop to participate in collaborative works (see [4] for more details).

This teaching laboratory was also equipped with microphones throughout the room so that the instructor’s lecture narrations and verbal exchanges among instructor and students, along with instructor’s desktop activities, were recorded using Techsmith’s Camtasia Studio software and then processed off-line to be published on the UGA WebCT facility within 1-2 hours after the end of each class session.

The Camtasia software was also used to create custom multimedia presentations that were available 24/7 from the web (via WebCT) and served either as lead-in components to an upcoming lecture (such as showing students how to use the BCP tool, or explaining a pre-made Bioloid program that was to be used as the starting point for the next homework), or as homework feedback to clarify some discovered student misconceptions and presenting a more efficient solution, etc... The goal was to connect in-class and outside-of-class activities into a chain of learning episodes, all aimed towards student

learning of the subject matter in as many modes as possible, and as often as students would want it.

C. Pedagogical Approach in Bioloid Programming Tasks

Our overall approach was to consider “teaching as fostering learning” [10] or at least to make students aware of their strengths and weaknesses in the subject matter.

For the Fall 08 semester, this course was scheduled for one 55-minute meeting weekly and started out with the instructor going over the syllabus particulars and doing a “lab” showing students how to use the dual-workspace capabilities that they had at their disposal and enrolled students were requested to take several asynchronous surveys:

1. A WebCT survey to provide information about the current knowledge levels of enrolled students in Computer Systems Engineering.
2. A learning style survey at the University of Arizona’s site http://www.ulc.arizona.edu/learning_style.php to help students determine their dominant learning styles: visual, auditory or kinesthetic.
3. Two “creativity” surveys [11] and [12] for students to correlate their work habits with those of highly creative individuals.

The second lecture was to provide feedback over the results of the previous surveys and to lecture on general Engineering Design approaches (descriptive and prescriptive methods) and to discuss the main issues that a Computer Systems Engineer would have to consider such as: sensor interfacing, mono and multiprocessor programming, actuator control and network/multiprocessor communications.

The next series of 3 lectures were focused on using the BCP tool to program the CM-5 and the servos AX-12+ to perform the following selected tasks:

1. Program the CM-5 to declare and assign values to variables and to print outputs using the commands LOAD and COMPUTE.
2. Design selection structures to model alternate actions to undertake with IF, ELSE IF, CONT IF commands.
3. Create deterministic and conditional loops using the IF and JUMP combination and statement labels.
4. Design and use appropriately subroutines with the CALL and RETURN commands.
5. Set AX-12 Moving Speed and Goal Position.
6. Understand and use the servo Moving Flag parameter to monitor the Present Position and Present Speed of a servo while it is moving to a set Goal Position.

All lectures and assignments during this period were designed to allow the student to progress from the handling of one servo to two servos, first from a mono-processor viewpoint (i.e. CM-5 only) and then from a multi-processor viewpoint (i.e. CM-5 in a supervisory mode checking in on progress made by each AX-12’s controller in achieving a certain task assigned to them).

First using only one AX-12 servo, students were asked in class to program the CM-5/AX-12 system so as to move the servo back and forth between 2 Goal Positions (800 and 200

for example), which they would respond with the following **Program 1** (in pseudo code):

- Label_1:
LOAD Servo1 GOAL POSITION with 800;
- LOAD Servo1 GOAL POSITION with 200;
- JUMP to Label_1;

Although **Program 1** contained no logic error, when it was executed students could see that Servo1 just sat there and vibrated, then they realized that they did not take into account the fact that Servo1 needed a finite time period to actually travel to one Goal Position to the next. Thus they next inserted Wait loops based on the Moving Flag value (which is set to 1 by the AX-12's controller as long as the servo is in motion towards a given Goal Position) to yield **Program 2**:

- Label_1:
LOAD Servo1 GOAL POSITION with 800;
- Wait_1:
IF Servo1 MOVING FLAG is 1, THEN JUMP to Wait_1;
- LOAD Servo1 GOAL POSITION with 200;
- Wait_2:
IF Servo1 MOVING FLAG is 1, THEN JUMP to Wait_2;
- JUMP to Label_1;

Next students were asked to expand **Program 2** into a weekly homework assignment whereas 2 servos were to be moved between different Goal Positions (for example between 1000 and 300 for Servo2) and at different speeds (one high, set at 1000 and one slow, set at 200). They most invariably came up with a solution similar to the following **Program 3**:

- Set Servo1 MOVING SPEED to 1000;
- Set Servo2 MOVING SPEED to 200;
- Label_1:
LOAD Servo1 GOAL POSITION with 800;
- LOAD Servo2 GOAL POSITION with 1000;
- Wait_1_1:
IF Servo1 MOVING FLAG is 1, THEN JUMP to Wait_1_1;
- Wait_1_2:
IF Servo2 MOVING FLAG is 1, THEN JUMP to Wait_1_2;
- LOAD Servo1 GOAL POSITION with 200;
- LOAD Servo2 GOAL POSITION with 300;
- Wait_2_1:
IF Servo1 MOVING FLAG is 1, THEN JUMP to Wait_2_1;
- Wait_2_2:
IF Servo2 MOVING FLAG is 1, THEN JUMP to Wait_2_2;
- JUMP to Label_1;

Students would observe that **Program 3** did move the 2 servos back and forth as required, however they also noticed that the faster servo was waiting on the slower one to get to its intended Goal Position before they continued their motion cycles all over again. Here, when asked how to make the servos' motions independent of each other, most students

would not be able to come up with a workable solution. Thus the instructor next created a homework-feedback narrated tutorial showing first a video clip showing that the 2 servos could actually be programmed to move back and forth independently of each other, and explained that the "wait-and-see" attitude of the faster servo was due to the use of the previous Wait loops, and therefore the challenge was how to wait for the servos to get to their intended Goal Positions without using the Wait loops, which seemingly was a contradiction of ideas. This narrated tutorial next provided some hints about the "correct" solution by sharing with students the main section of the new **Program 4**:

- Label_1:
IF Servo1 MOVING FLAG is NOT 1, THEN CALL Move_1;
- IF Servo2 MOVING FLAG is NOT 1, THEN CALL Move_2;
- JUMP to Label_1;

Here **Program 4** showed a 180° turn in thinking about the problem, because now the emphasis was on what to do when the servos were found to be not moving (because they had arrived at their intended Goal Positions), instead of figuring out what to do when they were found to be moving as previously done for **Programs 1, 2 and 3**. In other words, students had to think about the parallel tasks of the other processors in the system (i.e. the ATmega8 inside each AX-12) and not just consider that only the CM-5 is doing all the "thinking" and "acting" for the whole bot assembly. The ultimate goal of these types of exercises was to convince students to be comfortable with an "Opposable Mind" [13] and to consider task scheduling when dealing with a multi-processor system such as the Bioloid system. However detailed code for subroutines Move_1 and Move_2 were not shared to students as this task became their next homework assignment.

Looking at the above programs in a different light, we could say that we introduced the students to multi-threaded programming without burdening them with too much abstraction, as a matter of fact they had learnt to associate the threads Move_1 and Move_2 with concrete objects as Servo1 and Servo2 communicating back to the CM-5 using their respective MOVING FLAG as semaphores.

Similar instructional approaches would be applied when providing student practice in interfacing and programming the sensing modules AX-S1, specifically in active NIR sensing and sound detection.

D. Introducing Students to Selected Creativity Tools

Due to lack of time, we could only spare 4 meetings to discuss and apply selected creativity tools: 2 meetings on descriptive tools such as "Empathy" [5] and "SCAMPER" [6], and 2 meetings on a prescriptive tool called TRIZ ("Teoriya Reshentya Izobretatelskikh Zadatch" which was Cyrillic for "Theory of the Solution of Inventive Problems") [7].

"Empathy" was a technique to become one with the subject being studied such as imagining one-self being inside

various processors, actuators and sensors so as to be able to “think” as a bot.

The seven letters from “SCAMPER” stood for changes that ones could apply to an existing product to create a new one:

- S for Substitute – materials, procedures, peoples.
- C for Combine – with other assemblies or processes.
- A for Adapt – change product function, use parts from another product.
- M for Modify – attributes, materials, processes.
- P for Put – putting existing product to other uses.
- E for Eliminate – remove components, simplify systems or processes.
- R for Reverse – reverse functionality or goals.

This technique was applied in class with students to solve a design problem about driving concrete piles into the permanently frozen ground of Siberia as described in [7]. The design challenge was how to resolve a contradiction in requirements: in order to drive the pile satisfactory into the permafrost, it needed to have a pointed tip, however in order to have maximum load bearing capacity it needed a blunt tip instead.

Genrich Altshuller, a Russian engineer working in a patent office, observed that many inventive technical problems from various fields of engineering were solved using the same generic approaches. This realization led him in 1946 to introduce the Teoriya Resheniya Izobretatelskikh Zadatch (TRIZ) offering a systematic approach towards product and process innovation and development [7]. TRIZ is rich in many ideas and techniques that are beyond the scope of this course, therefore only Substance – Field relationship, and Contradiction aspects were presented. First, we discussed the Substance-Field (Sufield) aspects which evolved around energy, tool, and object as shown in Figure 6. This type of relationship was widely found in Technological Systems which existed to perform functions. A function was an intended direct action of a tool on the object. A tool was a component that directly controlled the behavior of an object. This interaction evolved into a system which could be biological, technological, societal, etc... Fey and Rivin pointed out that Technological Systems were organized as hierarchies [14]. In a hierarchy, any system contained subordinate systems and itself might serve as a component for a higher-level system.

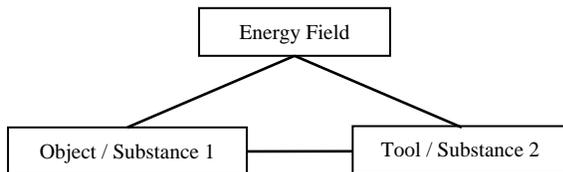


Figure 6. The Triad Relationship.

TRIZ used a Sufield modeling approach for analysis and synthesis of physical structures and processes in technological systems. This modeling technique divided a large problem into smaller pieces to simplify the work into subsystems and

their interactions. The term substance could be a material object ranging from a simple pencil to a complex aircraft system. The term field generally referred to fields in physics, such as, electrical, mechanical, optical, or gravitational.

For example, when a robot was designed to kick a ball into a goal, it could be simplified into subsystems. One subsystem could be to find the ball (see or sense) and then aligned the ball with the goal before it kicked it towards the goal with sufficient force. We realized that finding the ball would require sensors which existed in many types. The sensor or sensors that were selected must be able to detect the object and also to discriminate it from any other matter around it. For the sensor to be able to perform its mission correctly, it must be connected to a reliable and proper energy source that enabled its functions. Next would be a mechanical function to move the robot to the ball and align itself to kick the ball into the goal. This subsystem required interactions between three components: a micro-controller (Field), sensor (Tool / Substance) and mechanical movement (Object / Substance). The microcontroller supplied the intelligence and energy required, while the sensor identified the ball and informed the mechanical movement via the microcontroller to kick the ball. This was a subsystem that could be isolated and addressed as needed.

Secondly, we discussed about the TRIZ contradiction matrix. TRIZ heuristics involved criteria, methods, or principles for deciding which among several alternative courses of action promised to be the most effective in order to achieve some goal [15]. The contradiction matrix offered an evaluative method for more than 1200 types of Technical Contradictions formulated from 40 Inventive Principles. A general form of the contradiction matrix included identifying the following:

State design attribute 1

- 1a. trade-off design attribute
 - 1.a.1 Design Principle (1) to consider
- idea or ideas emerging
 - 1.a.2 Design Principle (2) to consider
-idea emerging (if no idea....say so)
- 1b. 2nd trade-off design

For example, we used the TRIZ Contradiction Matrix to Innovate Valves in the Valve Train system of an Internal Combustion Engine as follows:

Identified design attributes for valves are:

- Speed (9)
- Shape (12)
- Strength (14)
- Reliability (27)
- Complexity of control (37)

1. Speed (9)

- 1a. Force (10)
- The other way round (13)

Provide electromagnetic solenoid to actuate and de-actuate the valve. Also an electromagnet would be placed at the other end (position valve assumes at de-actuation state [closed]) to provide added holding power. This innovation would change

the current vertical up and down movement into a horizontal configuration. The current valve with a stem will be replaced with one without a stem, etc...

For lack of space, we did not report herein the complete Contradiction Matrix for this valve redesign exercise, but as inferred from the example above, a designer weighed actions and consequences that resulted from the choices made. In this way, a deliberate systematic decision was made for the new innovation.

III. PRELIMINARY COURSE ASSESSMENTS

At the time of writing of this manuscript, we are about half way into the Fall 08 semester, thus we can only report on the earlier results from our assessment process. The class started out with 10 students, but now has 8 students.

A. Student Learning Styles

Results from our learning styles survey showed that students were mostly visual and kinesthetic learners, with only 2 students predominantly auditory (see Table I).

TABLE I
Visual, Auditory and Kinesthetic Learning Style Scores
for students in ENGR-1120-F08

Student	1	2	3	4	5	6	7	8
Visual	27	37	41	37	23	35	31	33
Auditory	21	31	33	25	29	19	33	33
Kinesthetic	41	39	21	29	35	23	33	23

Although the data showed that 4 students might be kinesthetic learners, during class only 1-2 students were actively taking notes via the Pen Tablets or on paper, while the majority of students would just watch the "show".

B. Creativity Surveys

8 students took the creativity surveys from Gillis and Raudsepp and the results are listed in Table II. Please note that there was not a 1 to 1 correspondence between Table I and Table II regarding any individual student, but that there was a 1 to 1 correspondence between Gillis score and Raudsepp score for any given student in Table II.

TABLE II
Student Scores from Gillis and Raudsepp creativity surveys
(ENGR-1120-F08)

Student	1	2	3	4	5	6	7	8
Gillis	6	8	5	7	8	8	8	6
Raudsepp	39	20	13	16	42	21	-13	5

In Gillis' survey, the scores were to be interpreted as follows:

- 7 to 10 – Creative thinker.
- 3 to 6 – Average creative ability.
- 0 to 2 – Need to follow a pre-set plan.

In Raudsepp's survey, the scores were to be interpreted as follows:

- 80 to 100 – Very Creative.
- 60 to 79 – Above Average.
- 40 to 59 – Average.

- 20 to 39 – Below Average.
- -100 to 19 – Noncreative.

C. Mid-Term Course Survey

On October 8th 2008, the current 8 students were given a mid-term survey and 7 students responded.

Students were asked to respond to the following 7 questions using a 6-point Likert scale where "StD" meant "Strongly Disagree", "D" meant "Disagree", "SID" meant slightly disagree, "SIA" meant "Slightly Agree", "A" meant "Agree" and "StA" meant "Strongly Agree":

1. In-class course materials delivery methods were effective.
2. I understood the materials presented during in-class lectures.
3. In-class materials presented via the second display were effective.
4. Recorded classroom lectures were useful.
5. Pre-recorded narrated tutorials were useful.
6. I felt comfortable going through multi-media presentations on WebCT.
7. I understood the materials presented in recorded lectures and narrated tutorials.

Student responses are shown in Table III. Although results from Questions 1 and 2 showed that in-class materials and delivery methods were mostly effective, one student did not see any benefit of using the second display or the utility of recorded classroom lectures. This student also commented that he or she preferred to take note with pen and paper, as this would not require a computer to review notes and never used the provided pen tablet. This student also listened to only 1 recorded classroom lecture but found the narrated tutorials useful to help doing homework.

TABLE III
In-class & Off-class materials effectiveness survey results
(ENGR-1120-F08 – 7 responses out of 8 students)

Question #	"StD"	"SID"	"D"	"SIA"	"A"	"StA"
1				2	3	2
2			1		5	1
3		1		1	3	2
4		1			2	4
5				1	1	5
6					4	3
7				2	5	

The results for Questions 2 and 7 showed that the effectiveness of the in-class and outside-of-class materials were about the same. The student answering a "Disagree" on Question 2 answered an "Agree" on Question 7. The main author had seen this pattern repeated in his other courses. The interesting fact to point out was that the recorded lectures were just straight unedited recordings of the classroom activities, but somehow the students felt that they understood the materials in the recorded versions better, perhaps because it would be the 2nd time that they would see and hear the materials, and perhaps the "timing" of the review was more conducive to their learning processes as they were "ready" to deal with the materials, and also they could pick out only the

needed information as many times as needed, all of which not possible to achieve during the actual lectures. The new thing this year was the narrated tutorials specifically designed to guide students in their homework and term projects (Question 5 had 4 “Strongly Agree” responses). Lastly all students felt comfortable in using WebCT to review recorded lectures and narrated tutorials.

Students were also asked to describe how they had used the various instructional technologies provided to them inside and outside the classroom:

1. The dual-display setup seemed to be accepted by the students as shown in these representative comments:
“I use the dual displays most of the time because I have trouble switching focus from close to far; the show on screen helps a lot”.
“Dual displays and projection screen help me see the material better and help me understand faster. I use them every week”.
“Dual displays are nice since the lecture is right next to me. Pen tablets are hard to use so I don’t really use them”.
“The dual display is very useful. I do not look up at the projection screen that often. I like to use the pen tablet to take notes, and sometimes I use screen captures. I also use the pre-made notes to write on”.
2. Recorded lectures and narrated tutorials were also found useful by the students as shown below:
“I use the recorded lectures and narrated tutorials weekly to help with homework. These also make it easier to learn the presented material over the week instead of cramming it into 50 minutes”.
“Online lectures and the tutorials are good for labs or for preparing for quizzes”.
“I use recorded lecture to refresh myself on the day of my classes. Narrated tools help a lot for my assignments”.
“The narrated tutorials and recorded lectures are very helpful. It is good to be able to go back and listen to the lecture in case you miss something in your notes”.

IV. CONCLUSIONS

In this report, we had described the curriculum for a robotics-based immigration course into the Computer Systems Engineering BS degree and also a specific mix of instructional technologies to facilitate in-class and outside-of-class learning. When asked this question “What have you liked about the course this semester?” selected responses were:

- “Learning about something completely new and different. Robotics is something I never thought I would have experience with”.
- “The interactive nature and integrated technology”.
- “Very interactive class time with helpful online videos”.
- “I have liked learning something interesting but dislikes the difficulty of it”.
- “I like learning how to write programs that make real objects do things! I look forward to the robot projects”.

In short, we could say that so far our goals for the course and for the students were met (except for the pen tablets). Some students were without any programming background and thus were quite “stretched” to stay in the course so far. In future offerings of this course, we will ask for a 75 minute weekly time slot instead on the current 55 minute session so that we can have more time for hands-on in class activities for the students and also for instructors to administer regular assessments such as weekly quizzes. As these students are currently freshmen, they will need to be surveyed after graduation about the effectiveness of the skills learned here.

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