TEACHING ROBOTICS BY BUILDING AUTONOMOUS MOBILE ROBOTS USING THE ARDUINO

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Abstract

In recent years I have been teaching a project-based Robotics course within our quarter-based Mechanical Engineering program using the Stamp microcontroller. Students work in teams to complete a number of weekly lab exercises designed to sufficiently build their robotics expertise to the level that they can complete a project to design, build, and test an autonomous mobile robot to successfully complete an assigned task of their choosing. The course was structured in such a way that course materials laid out everything explicitly for the students since time was short on a ten-week quarter schedule. They simply followed the directions given. This fall, we changed to a semester schedule, changed our microcontroller from the Stamp to the popular Arduino, and restructured the entire course. Since extensive information is available on-line and in the literature for the Arduino, the course philosophy and structure has changed. Instead of providing students with all the information they need, students are now presented with a task, and they are told to go discover how to do it. As a result, the course is more challenging and interesting for them. This is aided by the additional time available in the semester schedule and by the wealth of information available for the Arduino. The paper discusses the current structure of the course, how independent team effort is evaluated, and the problems encountered in switching from a Stamp-based ten week quarter course to an Arduino-based "self-discovery" semester course.

Background and History

Robotics has been a popular project-based professional elective in our quarter-based Mechanical Engineering program for a number of years. Initially, the course focused on industrial robotics, and students worked in teams to design, build, and test tooling and fixtures to accompany an industrial robot in a workcell. At that time, we had a lab with PUMA, Adept, and IBM/Fanuc robots generously donated from the Rochester Products Division of General Motors. Maintenance of these machines became problematic, as many came to us with extensive operational hours from production environments. Keeping these machines running fell to me and my teaching assistants. Funds were not available on a university budget to bring in a repair person, often from a considerable distance on a per diem and travel expense basis. Debugging was often accomplished by phone consultations with either manufactures or used equipment dealers, and defective parts were replaced with spare parts from machines kept around for that purpose. It was a "junkyard dog" environment, and eventually we decided we could not sustain the lab under these circumstances any longer.

My grad student at the time suggested we change our focus to building autonomous mobile robots to accomplish a specific task using the Stamp microcontroller. Stamp programming was easy to learn, especially for mechanical engineering students with little, if any, prior programming experience. Projects now focused on building autonomous mobile robots, e.g. mine retrieval and disposal robots, and robots for finding and extinguishing a lit candle in an eight foot by eight foot playing field marked off with electrical tape. Teams often competed against each other to accomplish the task in the shortest possible time. The design, build, test experience remained the central focus of the course, and only the means to accomplish this experience had changed. Eventually, we went back to projects chosen by teams, as competition seemed to take much of the fun out of the projects. One downside of using the Stamp was its cost of $100 for a Stamp Board of Education (microcontroller and attached prototyping board). This was offset, however, by splitting the cost between three team members, and not requiring a text for the course. Students worked in teams to complete a number of weekly lab exercises designed to sufficiently build their robotics expertise to the level that they could begin their project. These included basic programming, sensors, servo motors, and DC and stepper motors. The course was structured in such a way that course materials laid out everything explicitly for the students since time was short on a ten-week quarter schedule. They simply followed the directions given. In some cases, they copied and pasted sample coding which they slightly modified. This was not challenging, which was reflected in "boring" and "tedious" student course evaluations.

New Course Philosophy and Structure

This fall, we changed to a semester schedule, changed our microcontroller from the Stamp to the popular Arduino, and restructured the entire course. In the new structure, the course gets started with three one hour lectures, with examples, on the basics of Arduino programming. These three lectures can be broken down as follows:

1.) Getting Started with Arduino
- Outlines basics of Arduino hardware, software, and robotics programming.

2.) Arduino Programming Language
- Details sketch structure, programming syntax notes, and pin functionality.

3.) Starting Arduino Examples
- Demonstrates integrated analog and digital writing and reading examples

Teams of two are formed, which stay together for both the lab exercises and the project. These can be self-formed by the students or assigned as they would be in industry. Beginning week 2, each week of classes for the next 8 weeks consists of two one hour lectures along with a lab block. To reduce the chaos that often occurs with many students in the labs, teams attend one of two lab periods in which a maximum of six teams are accommodated by the work stations available. Each workstation has a computer (with interfacing cables), power supplies, and a soldering station provided. Teams are required to purchase their own soldering iron and are responsible for keeping it clean and tinned. Teams also purchase their own Arduino Uno (approximately $30).

Course resources consist of general Word documents and Excel sheets detailing course scheduling, required lab materials, course and lab guidelines, and details on project deliverables and objectives, along with a more consistent documentation set for each lab. The first item of these sets is a “Lab Assignment” Word document that explains the purpose of the lab to be completed, the concepts being targeted in the task, equipment and components that will be available in the lab, pre-lab and write-up instructions, and some helpful hints and reminders to avoid common mistakes that could severely damage components. This is complemented by a “Research PowerPoint” which poses a series of lab-related questions for the teams to research and answer before class. These questions cover everything from concepts and code examples that may have been forgotten from the early lectures to trying to find targeted tutorials online that accomplish specific objectives similar to those in the lab. Finally, the “Discussion PowerPoints” are identical in format to the research slides, which are used in class with the lecture to facilitate solving issues students may have had with specific questions. These slides have the solutions to the questions so students can identify were they came up short and further research these areas to adequately prepare themselves for the lab. An example of slides using this structure can be seen in Figure 1.

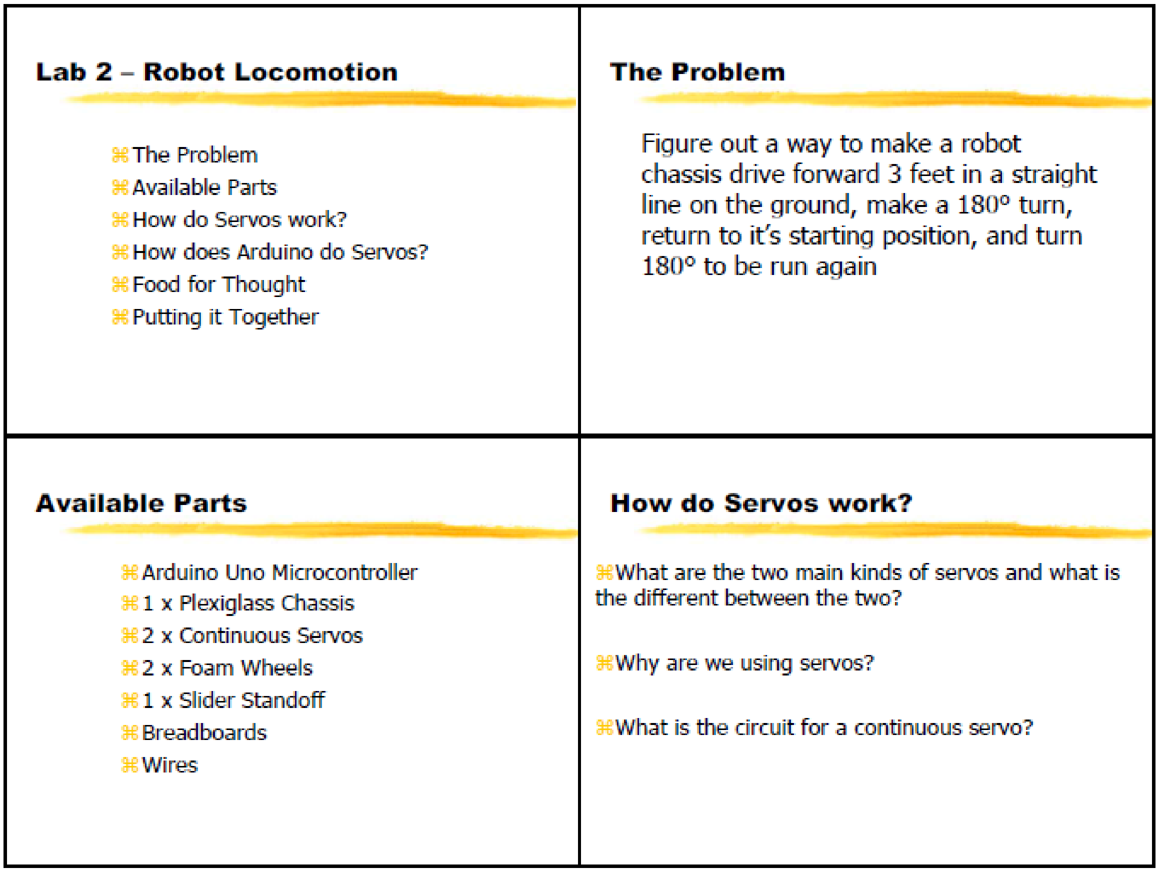


Figure 1: Research and Discussion PowerPoint Slide Format.

The weekly lab cycle begins with the "Lab Assignment" and "Research PowerPoint" being posted on-line on Wednesday. Occasionally a "clue" or helpful link is given, but teams are expected to self-discover a solution to the lab task. This is a distinct change from the old structure in which teams were given all the information they needed. This is aided by the additional time available in the semester schedule and by the wealth of information available on-line for the Arduino. On Friday, teams meet for a "Discussion Session" based on their research. Each team gets a question asked in a random order. A right answer is worth 2 points, a partially correct answer is worth 1 point, and no points are awarded for an incorrect answer. Teams are then asked to openly discuss the solutions they have found to solving the lab task, which parallels the "Discussion PowerPoint" structure. This is followed on Monday by an individual quiz of five multiple choice questions based on the lab. After this, teams prepare a "Pre-Lab" consisting of a preliminary circuit, flowchart, and software code. This is to be completed before coming to their assigned lab session to make sure that they have a starting point for getting the objective accomplished. In this lab session, teams demo a working solution to the lab TA, and write up a short report which is due by the Friday of that week, when the Discussion Session begins for the lab to be done in the next week.

The lab objectives for the class went through significant revision to orient the class more towards achieving some common robotics objectives on a chassis interface (i.e. servo usage, object detection, line following, etc.) so as to introduce students to some of the obstacles they would encounter while integrating components into their final projects. This required the improvement and duplication of robot chassis for each team to use during their lab session, which include all of the necessary components and sensors to accomplish each objective. A picture of these chassis can be seen in Figure 2. Similarly, soldering stations and additional equipment were purchased and assembled to aid in completion of the labs and fabrication of the student's project chassis. The new lab assignments that were created for the semester schedule consist of:

1.) RGB LED
- Simple PWM controlling of an LED using Arduino.

2.) Robot Locomotion
- Propelling robot chassis in a straight lines using continuous servos.

3.) 555 Timer Servo Tester
- Building a simple circuit to introduce basic electronics.

4.) How to Solder
- Soldering tested circuits to introduce permanent assembly processes.

5.) Object Detection
- Integrating distance sensors with locomotion of robot chassis.

6.) Line Following
- Integrating line following, locomotion, and distance sensors to accomplish a simple objective with robot chassis.

7.) Motor Power
- Introducing DC motor and unipolar stepper motor control using H-bridges and Darlington arrays.

8.) Accelerometer Measurement
- Introducing accelerometer usage and data capture in Microsoft Excel.

As can be seen above, the labs were carefully chosen and sequenced to gradually introduce students to robotics components, building through integration to achieve increasingly complicated objectives. At the same time, students are introduced to other critical areas of robotics like chassis construction choices, electrical circuits, soldering, and additional components that can be used to accomplish similar objectives. This structure also helps to inspire students who have more difficulty choosing a project objective or figuring out how to achieve the objective, making them more successful.

Project milestones are used to help teams stay on track as follows:

Figure 2: Robot Chassis for Class Lab Groups.

- Topic Selection
  (Week 3)
- Project Proposal Revision
  (Week 4)
- Team Roles, Norms, Scope, and Specs
  (Week 5)
- Literature Search
  (Week 6)
- Concept Selection
  (Week 7)
- After a literature search, identification of alternative concepts, as well as a feasibility assessment
- Preliminary Design
  (Week 8)
- Sketches and analysis
- Detailed Design & Drawings for Prototyping (Week 9)
- Inventory Check
  (Week 10)
- Parts in hand
- Build Completed
  (Week 15)
- Preliminary prototype pre-demonstration to professor and TA
- Final Project Demo to Class
  (Week 16)
- Project Presentations with Video
  (Finals Week)

Course Schedule

The course schedule is shown in Table 1. Notice that lab assignments are completed in Week 9 to allow teams to focus their entire efforts on their projects for the remainder of the course. Individual team meetings are then held weekly with the instructor and lab TA to insure that teams are ready for a preliminary demo in Week 15. The intention here is to demonstrate that the individual functions, modules, or sub-systems work successfully but not necessarily together in an integrated fashion. The final demo requires all functions be integrated and working successfully. Teams often overlook including sufficient de-bugging time in their scheduling, and they are reminded of this in the weekly team meetings. Here also, teams are praised for their progress as well as cautioned to catch up if they are behind the schedule they are required to set for themselves.

Grading

By nature, grading design projects is a difficult task due to the subjectivity involved. To try to address that subjectivity, an overall grading rubric was developed, shown below in Table 2, and the final demonstration (class demonstration) was further broken down in Table 3 and shown with typical results.

Teams are asked to give a 10 minute presentation on their project during exam week. The following slides are suggested, but each team is free to vary this as they feel appropriate:

- Problem Description
- Alternatives Considered
- Final Design (CAD Model and S/W Flowchart)
- Video of Working Prototype (Approx. 2 Min)
- Results
- Problems Encountered/Overcome
- Lessons Learned

Teams are asked to dress in business attire, as they would for an interview, and to make their slides on a CAD system or on PowerPoint. The rubric used for the presentation is shown in Table 4 with typical results.

Each student is asked to keep a bound logbook of their individual contributions to their project, which should include: their concepts for accomplishing the project functions, any ideas and sketches, feasibility calculations, results of bench tests, etc. This is evaluated by the instructor and TA as shown on the schedule in Table 1. In class, some discussion occurs about the importance of the logbook, and how it can be a legal document in industry IP issues. However, as a general conclusion it seems that many students struggle with this as documentation is not high on their list of things they like to do. Students are also asked to complete a peer evaluation/percent participation form listing individual perception of the percentage of the total effort put forth by each team member in reaching the final design (including a self-assessment). If a student feels that there was a disproportionate sharing of the work, or that a teammate did not do his/her share, disclosure is requested, and most do. The roster of projects just completed are shown in Table 5.

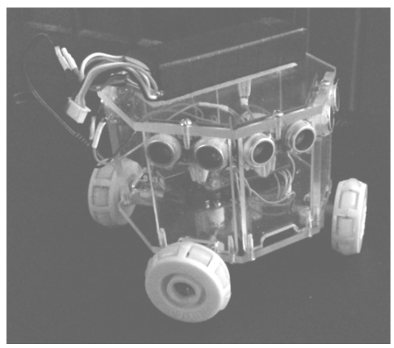
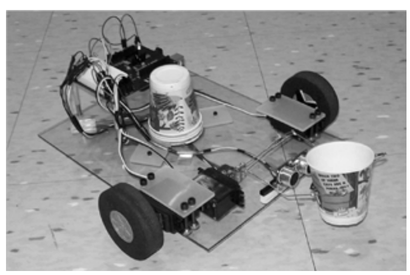
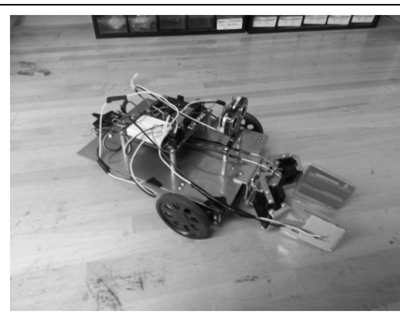
Table 1: Robotics Schedule 2131

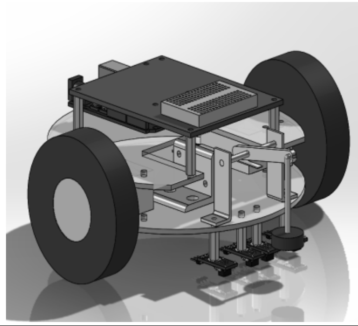
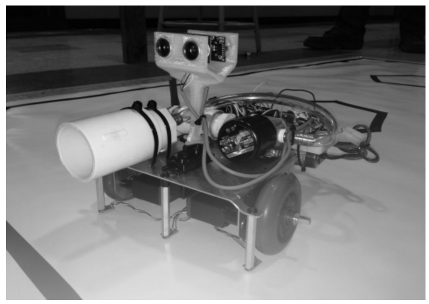
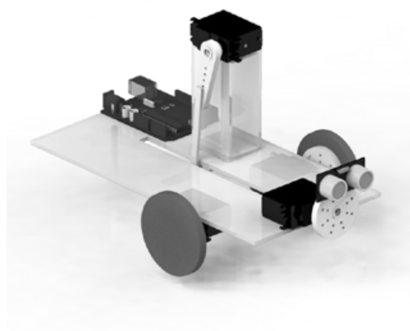
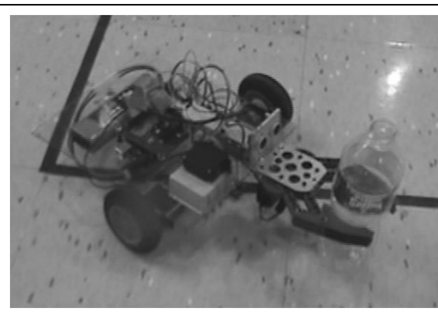
Week	Day	Material	Homework Due*	
1	M 8/26	Intro, Syllabus, Project, Robotics at RIT		Intro
	W 8/28	Getting Started with Arduino, Arduino Program Language		
	F 30-Aug	Starting Arduino Examples, Lab 1 Prep		
2	M 9/2	Labor Day – no class	Quiz 1	Lab 1
	W 4-Sep	Recitation		
	T,R	Lab		
3	M 9/9	Discussion	Quiz 2	Lab 2
	W 9/11	Recitation		
	T,R	Lab	Lab 1, Project Proposal	
4	M 9/16	Discussion	Quiz 3	Lab 3
	W 9/18	Recitation		
	T,R	Lab	Lab 2, Project Revision	
5	M 9/23	Discussion	Quiz 4	Lab 4
	W 9/25	Recitation		
	T,R	Lab	Lab 3, Team Norms & Va	
6	M 9/30	Discussion	Quiz 5	Lab 5
	W 10/2	Recitation		
	T,R	Lab	Lab 4, Literature Search	
7	M 10/7	Discussion	Quiz 6	Lab 6
	W 10/9	Recitation		
	T,R	Lab	Lab 5, Concept Selection	
8	M 10/14	Discussion	Quiz 7	Lab 7
	W 10/16	Recitation		
	T,R	Lab	Lab 6, Preliminary Desig	
9	M 10/21	Discussion	Quiz 8	Lab 8
	W 10/23	Recitation		
	T,R	Lab	Lab 7, Detailed Design	
10	M 10/28	Lecture - Boolean Logic		Lect.
	W 10/30	Lecture - Smart Materials		
	T,R		Lab 8, Inventory Check	Project
11	M 11/4			
	W 11/6			
	F 11/8			
12	M 11/11		Logbook	
	W 11/13	Team Meetings		
	F 11/15			
13	M 11/18		Logbook	
	W 11/20			
	F 11/22			
14	M 11/25		Logbook	
15	M 12/2	Preliminary Demo	Preliminary Demo	
	W 12/4	Team Meetings		
	F 12/6	Team Meetings		
16	M 12/9	Final Demo	Final Demo	
	W 12/11	---		
Finals	TBD	Presentation	Presentation	

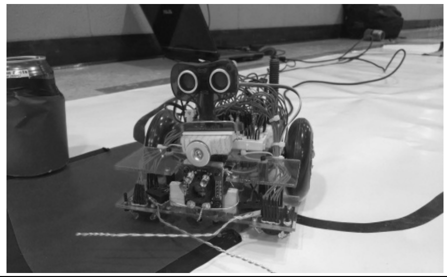
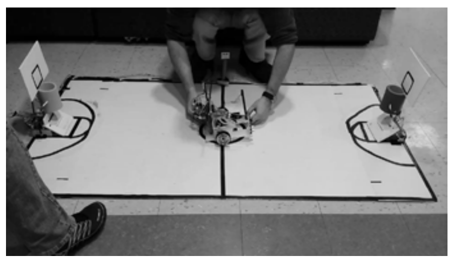
Table 2: Robotics Grading Rubric 2131					
	Parent Item	%	Breakdown	% of Parent	Notes
	Labs	35	Prelab	10	Eight total labs experiments.
			Demo	40	
			Report (including abstract, wiring diagram, software code, & flowchart)	50	
	Discussions	10	Quality of response	Equal Breakdown	Ten discussions total, 0 - 2 point scale
	Quizzes	10	NA	Equal Breakdown	Eight quizzes total, based on lab prep material
Project	Project Milestones	15	Project Scope, and Engineering Specifications	10	Overview of project goals. Description of engineering specifications for robot tasks (quantifiable measurements).
			Literature Search	15	Consult at least 5 articles from robotics journals
			Concept Selection	20	Include a sketch and description for each concept, and a Pugh chart and conclusion to encompass all concepts.
			Preliminary Design	20	Include assembly sketch, parts sketches, tentative BOM, and a description of how to complete each competition task.
			Detailed Design	25	Include an assembly drawing, CAD drawings of parts to be machined, flow charts, and BOM. Engineering specs must be finalized.
			Inventory Check	10	Parts for project should be in hand and ready for construction/assembly.
	Logbook / Participation	5	NA	NA	Checked occasionally by Dr. Walter. Used to assess contribution to project, and final grade.
	Demonstration to Prof & TA	5	Functionality (individual sub systems)	NA	Demo can show each "breakdown" item separately with some user help.
	Class Demonstration	15	Functionality (complete system)	Equal Breakdown	Demo to class must show all steps in sequence without help.
			Meets engineering specs		
			Repeatability		
			Quality of work		
			Robustness		
	Presentation	5	Problem Description and Design Specifications	Equal Breakdown	10-15 minutes each. Formal work attire required. Everyone must speak.
			Concept Development - Alternatives Considered		
			Final Design		
			Video		
			Results Discussion		
			Problems/Lessons Learned		
			Speaking Skills		
			Length		
			Quality of Work		
	Total	100			
LATE PENALTY ON ALL SUBMITTALS: 10% PER DAY; ASSIGNMENT NOT ACCEPTED AFTER 7 DAYS LATE!					

Table 3: Final Demonstration Rubric						
	Complexity	Repeatability	Perceived Effort	On Schedule	Quality / Robustness	Overall Average
Team 1	9	10	10	10	10	98%
Team 2	8	10	10	9	10	94%
Team 3	10	9	10	9	10	96%
Team 4	10	10	10	9	10	98%
Team 5	9	9	10	10	9	94%
Team 6	10	9	8	10	9	92%
Team 7	8	8	8	9	8	82%
Team 8	10	10	10	10	9	98%
Team 9	10	9	8	9	8	88%
Team 10	10	10	10	10	10	100%
Team 11	10	9	10	9	10	96%

Table 4: Presentation Rubric							
	Time (min)	Time Score	Content	Adaptability to Project Issues	Perceived Learning	Professional Appearance	Overall Average:
Team 1	12	8	10	8	10	10	92%
Team 2	10	10	10	9	10	9	96%
Team 3	6	10	10	9	9	10	96%
Team 4	12	8	10	9	10	10	94%
Team 5	7	9	10	7	10	9	90%
Team 6	7	9	10	9	9	8	90%
Team 7	5	8	9	7	9	8	82%
Team 8	10	10	9	10	10	9	96%
Team 9	9	10	10	8	10	8	92%
Team 10	14	7	10	10	10	10	94%
Team 11	8	10	10	10	10	10	100%

Table 5: Project Roster 2131			
	Title	Photo	Comments
Team 1	Trespasser Detector		Detects intruder within taped playing field and follows them until it leaves field; Uses omni-like wheels
Team 2	Object Retrieval		Finds a cup within taped playing field and stacks cup on-board chassis
Team 3	Beverage Fetcher		Finds and picks up cold can; Uses sensor in gripper to detect cold temperature

Team 4	Maze Learning Robot		Navigates a maze until it finds an object, and then returns to the start point by the shortest path; Uses magnet to retrieve object
Team 5	Search & Destroy Robot		Autonomously roams within arena boundaries to locate target object; Discerns between decoy and target to launch ping pong ball on target object, and then returns to home base
Team 6	Golf Putting Robot		Locates and positions itself over golf ball, strikes the ball at the flag, and then determines if ball is in the hole
Team 7	Sentry Gun Robot		Patrols enclosed area and fires projectile at target outside boundary
Team 8	Bottle & Can Retriever Sorter		Collects bottles and cans within an area and sorts them into piles outside the area

Team 9	Color Sorting		Finds red and blue objects, picks them up, and deposits the object in the corresponding colored area
Team 10	ShotBot		Mixes pre-programmed or custom drinks; Uses a LCD user interface
Team 11	Basketball Shooting Robot		Locates, picks up, and shoots a ball at a basket; Colored ball goes into correctly colored basket

Feedback from Student Evaluations

Question: What did this instructor do well?
"Let the learning happen in the labs, which the TA oversaw, and redesigned as needed."
"Gave us good insight to the lab and the components used. Gave good demos."
"Material was presented in an organized fashion. Quizzes relevant to course material. Encouraged thought of future applications in robotics."
"The instructor provided good labs for us to work through robotics problems with wiring and programming."
"Lots of information provided on the different techniques robotics engineers use."
"Would sometimes refer to his experience in the field."
"Everything."
"Everything."
"Good demos and real world examples, though I would like to see less demos with Stamp boards. Class format of lecture, then in class discussion, then quiz, then lab felt effective."
"Labs provided clear understanding of basic programming/robotics concepts."
"Instructor covered an extensive amount of material pertaining to robotics from basic to advanced knowledge. Very supportive in aiding students develop their robot projects."
"Helping us with refining our projects, and not pressuring us to do too much, knowing that all of us have lots of classes and MSD. It was nice to be able to have some breathing room."
"Dr. Walter had many open office hours to discuss issues with his students. He is a great mentor to

have on the RIT team. Provides a lot of recommendations to make your project better."
"The instructor was obviously very interested in our work in this course and did a very good job about giving us free reign while still taking a supervisory role. He let us be as creative as we wanted and always gave helpful feedback. He is a wonderful professor teaching a great class."
Question: How can this instructor improve?
"Lectures were disorganized, with no clear goal at times."
"Lecture content seemed a little weak from weeks 4-8ish. I remember in particular going to lab and needing to have the lab TA explain how to use functions in Arduino which are very basic concepts that should have been covered in class."
"Nothing."
"He went over topics that had little to no relation to the projects in the class. Also went over only the top level of topics, which we could have done with a simple Google search."
"More correlation between the lab material and what is discussed in class. Having the three meeting times a week may have been helpful to this end."
"The project work (design review, detailed design review, etc.) may have been overkill for the project. Required a lot of work done with not much added value to the overall project."
"I would've liked more than a 1.5 day notice of a major milestone being due."
"The schedule for completion of the project didn't always make sense. Students were required to choose a project before learning about all of the robotic components. The time window to complete the project is reasonable, but hopefully some adjustment can be made to help students solidify a project choice."
"More clear layout of what is wanted for write-ups and papers. Length designation and grading rubric of how the paper is graded would help a lot."
"No critiques."
"The only thing I would do is remove the soldering lab. By doing this, we can gain an extra week for the design project in the course which most groups will need."
"The course material felt rushed in the first 9 weeks of the semester due to the extent of the material. Some topics were more extensively covered than others, while some ideas were just briefly introduced then skipped."

Conclusions

The range of comments from students above covers the spectrum, as you can see. Overall, the reviews were favorable and above the college average. That said, some improvements can certainly be made. Some students felt they were being asked to choose a project topic without knowing enough about the field of robotics. That may be helped by giving them a stronger message to look on-line in weeks 1-3 to help them make that choice. Removing the soldering lab would advance the semester schedule by a week and leave an extra week for project debugging, which is something that would improve the robustness of the projects and help relieve some of the pressure of the final demo deadline. The TA and I did develop rubrics for the final demo and presentation, but not in time to make them adequately known by the students. This will be done next time. I tried to give students an overview of the field of robotics but that message needs to come through better to them since some did not see the connection of these general topics to their specific lab assignments and project work. However, when considering all of the changes made to the curriculum during a significant institution-wide scheduling transition, it can be concluded that the course has experienced significant improvement. Small issues such as those mentioned are to be expected and can be easily remedied. To summarize these improvement areas, in the future we will:

- Help and encourage students find project ideas earlier in the coursework.
- Remove the soldering lab completely and leave this skill acquisition optional.
- Post final grading rubrics with course materials at the start of class.
- Target lecture conversations on lab and project work and verify with students that the connection is being made.

Being as the course is now structured for self-discovery, it is worth delving into possible methods for dealing with students who may require additional assistance in realizing the teaching objectives through independent work. The current class format is designed to help students who may be in this position by providing the answers to the Research PowerPoints through the Discussion PowerPoints, which are available online directly before the lab for any students who may have had issues with the assignment. Additionally, the class discussions are structured toward allowing peer-collaboration for thinking through the discussion topics, allowing the students who may have been weaker in understanding one area to learn from others constructively.

Possibly due to good fortune in the transition noted here, the students in the class did not have any issue with the assignments past this point, so no further action was necessary. However, if it is determined that a student is having significant trouble with researching the topics on his/her own and is not responding well to the in-class discussions, it may be worthwhile to set up individual meetings with either the lab TA or the instructor outside of class to determine the extent of the issue and tailor his/her learning experience accordingly. The most straight forward method that comes to mind is to provide this student with the Discussion PowerPoint slides from the start of each lab sequence, giving him/her ample time to thoroughly review the answers before the discussion portion of the class. This also allows the instructor to explain how the Discussion answers were established through using internet search engines and to track progress in this way so the student can be slowly transitioned from the Discussion PowerPoints to something closer to the Research PowerPoints once he/she better understands the self-discovery process.

Due to a lack of survey data for both the old course structure and the new format, no quantitative comparisons can easily be made as to the course improvements. Based on the success of all student teams at achieving some form of project objective that utilized the course content (an improvement over previous years), we can qualitatively conclude that the change in course structure has increased the effectiveness of the course materials through targeting and evaluating a more limited set of core concepts than previous course structures. This was universal across all teams, which were predominately self-formed with the exception of one or two groups. However, these teams did just as well as the self-formed teams, and the differences in quality of the project and lab output seemed to stem more notably from individual students having attention to detail, design project mindsets, and previous experiences with fabrication and programming.

A general conclusion that has been noted through this course transition is the need for some way of measuring the effectiveness of teaching styles and course formats. Being as multiple components of the class were changed in this transition, it is impossible to determine which aspects increased or decreased the effectiveness of presenting the material. Additionally, even student feedback from the course supplies little in the way of comparison, being as all students only took one form of the class or the other. Now that the new course is established, however, it is possible to track changes in the effectiveness of the teaching when small modifications are made to the course. Besides utilizing the grading criteria for the class assignments, the best way that has been established for determining this effectiveness is to evaluate the quality of the design projects and the percentage of completed projects that successfully accomplished all of the original design objectives. By statistically comparing the average class grade and the percentage of successful projects while no modifications are done to the course for two semesters with each subsequent year and modification, it seems feasible to establish an effectiveness tracking system. Yet doing so would require more strict constraints on the project objectives to make sure the students use components consistent with those taught in the lab portion, as significant deviation from this happens frequently and could skew the statistical criteria. It is an interesting issue and will be investigated in the future.

In conclusion, since extensive information is available on-line and in the literature for the Arduino, the course philosophy and structure changed. Instead of providing students with all the information they need, as was the case in the old format, students are now presented with a task, and they are told to go discover how to do it. As a result, students seem to perceive the course as more engaging and interesting. Although progress has been made, there is always room for improvement!

References

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Biographical Information

Dr. Wayne Walter is a Professor of Mechanical Engineering at the Rochester Institute of Technology (RIT). He received his BS in Marine Engineering from SUNY Maritime College, his MS in Mechanical Engineering from Clarkson University, and his Ph.D. in Mechanics from Rensselaer Polytechnic Institute. Dr. Walter has worked for the U.S. Army, Rochester Products and Delco Products Divisions of General Motors, and Xerox, and is a registered professional engineer (P.E.) in New York State. He has forty years experience teaching design related and solid mechanics courses and has developed expertise in the areas of robotics systems and micro-robotics. He is an ASEE and ASME member.

Tim Southerton is currently a fifth year mechanical engineering student at RIT in the BS/MEng Dual Degree program. As a student who enjoyed the Stamp-based Robotics class as an undergraduate, he was very interested in an opportunity to restructure the curriculum for Arduino compatibility. Once involved in the project, he decided to see it through as the teaching assistant for the lab portion of the revamped course, which proved to be an enriching experience. After graduating in the spring of 2014 he plans on pursuing a career in mechanical engineering with a strong focus on consumer electronics and new product design to help make the world that much more entertaining.