Unit 5 Designing a Robotics System

Overview

Purpose

The purpose of this unit is to provide students with experience designing and fabricating a robotic system. Students will develop capability with the design process for developing technical solutions by employing the fundamental processes associated with robotics systems and electronics. They will use the skills and knowledge acquired in electronics, programming/interfacing and fabrication to design and build a robotics system. This unit is organized using the following topics:

• Topic 1: Getting Organized

• Topic 2: Exploring Opportunities

• Topic 3: Writing a Design Brief

• Topic 4: Investigation and Research

• Topic 5: Generate Options

• Topic 6: Select the Best Solution

• Topic 7: Development of the Solution

• Topic 8: Evaluation and Redesign

• Topic 9: Present the Report

Profile

The design activity constitutes the major project of this course. Typical activities/processes include:

• Usage and maintenance of design portfolios.

• Application of the design process to the development and fabrication of an electronic system that uses sensing and control subsystems.

- Identification of authentic problems that students are capable of solving.

- Identification of resources, including tools and materials.

- Investigation and research of possible solutions to robotics design problems.

- Selection of the most appropriate solution to a robotics problem.

- Development of a solution through the construction of a robotics system.

- Evaluation and/or testing of a robotics system.

- Presentation of a report on the design problem, the process, and the solution.

- Participation in design teams

Implementation

Implementation

This unit should be completed in not less than 45 hours of class time. This may be expanded depending on the delivery style of Units 2, 3 and 4.

This design activity may be related directly to an activity or problem in another discipline. This is primarily a design team activity, but it is reasonable to expect individual students to maintain a design portfolio, or be responsible for specific parts of the design team portfolio and product development/production processes.

Planning for Design

Planning for design in Robotics Systems Technology 3205 needs to address the following:

- Student exposure to problem situations and sample design briefs with flexibility to accommodate the actual needs of the student.

- Student access to space that can accommodate a wide range of production activities, including fabrication and testing areas.

- Student access to tools and materials appropriate to the problems that students will be solving.

- Distribution of clear instruction concerning the design process/procedure guidelines for students.

- Distribution and explanation of appropriate evaluation criteria to the students for the course and design activity.

- Distribution of design portfolio guidelines and management strategies to students.

- Development of a plan for students to manage the design process.

- Development of design team development and maintenance strategies for students.

- Development of a clear time line for students, specifying completion dates for each phase of the process.

Appropriate Problems

One of the most important tasks for the teacher is determining what is an appropriate problem for students to solve. Students can attempt to solve many of the problems that professional designers attempt. However, high school student cannot be expected to develop a solution with the same level of sophistication as a professional designer. A student and professional designer can each attempt to solve a problem for a common client but the solutions will differ in their complexity. The main difference between each of those solutions is determined by the expectations for the solution. A number of factors may be manipulated to affect solution expectations to design problems, including:

- Statement of the Design Brief - A design brief is used to focus the efforts of the design team. It states the problem, limits that are on the solution, and what the solution must do. It can be worded to make the process very open (e.g., any solution is possible), or narrow (e.g., solutions must come from a narrow range of possibilities).

- Statement of Design Work Evaluation - Inform students so they understand how they are being evaluated. Help them understand that they are building capability with technological problem solving, and that they are being graded on this more than the actual product. Many students are accustomed to being graded on a product (e.g., essay, report, test) and may find it difficult to adjust to this type of evaluation methodology.

- Complexity of the Problem - Restrict the problem so that it is very straight forward. Don't confuse a general problem situation (e.g., there is a need to communicate directly to all students about events in the school) with a specific problem

Implementation

(e.g., the intercom is intrusive and interrupts classes). Pick a very specific problem, keep the solution simple, and ensure that there are resources to develop the chosen solution. In the case of the Robotics Systems design activity, students should be challenged to design and fabricate a robot for a specific mission using the fundamentals of sensing and control. It is up to the teacher's discretion to judge the complexity of the problem to be solved; however, students should have to draw on the skills developed in Unit 2, 3, and 4 to solve the problem.

Purpose of Student Design Teams

Student design teams:

- emulate standard practices from industry.

- develop team skills.

Implementation

- develop better solutions to real world problems.

- build on strengths of individual students.

- increase chances of success for individuals.

Design Teams

There is a substantially different expectation with students-as-designers and professional designers. There are high expectations on professionals in terms of skills, strategies, knowledge and the quality of their solutions. Students are learning a methodology, while at the same time acquiring basic technical skills and know-how. They are building capability in the academic, social and technological arenas. Professionals are presumed to have advanced capabilities. Students are evaluated differently as well. The purpose of evaluation is to determine their knowledge, technical skill, and level of design capability.

Effective Operation of Student Design Teams

Student design teams require:

- collaboration and cooperation among members.

- sharing of ideas among members.

- each student to do his/her part.

- each student to assume leadership in an area of expertise or interest when called upon to do so.

- each student be able to allow another to be leader when necessary.

- willingness of each student to compromise on some issues

Key Issues for Managing Student Design Activities

Teachers should:

- ensure that the problem is well understood by the students. This is the purpose of the design brief. The design brief should state the problem clearly, state any special conditions related to solving it, state what the solution should accomplish, and what the students are expected to do (what they are accountable for).

- ensure that students understand team versus individual work. There will be individual work required of students and that individual work will be part of the overall design team work.

- ensure that students maintain a design portfolio. The design portfolio must have a record of work completed, including drafts and developmental work; a record of decisions made and the reasons for making them. The design portfolio normally uses the steps of the design process as its main headings.

- ensure that students understand the Design Process. The major steps of the design process serve to help students focus on tasks that need to be completed. Although the steps are presented below as a linear sequence, in practice students may move back and forth through the steps.

- ensure that the reporting procedure is clearly outlined and understood. Reporting is a means for students (as part of design teams) to share the results of their design problem solving activity with other students in the class.

- ensure that the importance of the solution development is addressed. A solution must be developed. No solution means that the design activity was not successful.

- ensure that the evaluation outline for the unit includes the three design components. The components are the design portfolio, the design solution, and the design report. The purpose of the design portfolio is to document what actually happened, and, as such, it offers clues as to how students thought through the process.

Evaluation

Unit 5 accounts for the largest time allotment of all five units in Robotic Systems Technology 320. It therefore, should account for the largest percentage of the courses evaluation.

Evaluation of Unit 5 should be based on the following:

Design Process	10%
(observation during each step)	
Design Portfolio	40%
Solution	30%
Report	20%
Total	100%

Outcomes and Strategies

Topic 1 - Getting Organized

Specific Curriculum Outcomes

Robotic Systems Technology 3205

Students will be expected to:

5.1.1 work cooperatively and collaboratively in design teams [1.401, 1.402, 1.403, 1.404, 1.405]

Suggested Teaching and Learning Strategies

For the Teacher

This outcome is intended to insure that the design project is a team effort. This project should be completed using cooperative project based teaching methodologies.

Points to Emphasize

- In industry, design is always done by teams of professionals who bring a variety of skills to the project. Effective collaboration is an essential employability skill.

- Design teams are most effective in groups of two or three.

- It is important that the teacher review the characteristics of a good team member and principles of good group collaboration.

For the Student

Establishment of design team structure, determination of roles and responsibilities, and development of an initial plan of action.

It is your responsibility as a member of the team to:

- share responsibilities.

- share ideas.

- participate.

- assume leadership in the area of expertise/interest when called upon to do so.

- allow others to take the lead when necessary.

- compromise on some issues.

- show respect for the opinions of other group members.

Topic 1 - Getting Organized

Suggested Assessment and Evaluation Strategies

Performance

- Organize the design team by collaboratively determining team member roles.

Pencil and Paper

- Complete the provided peer and self evaluation forms.

- Journal (Design Portfolio)

- Name the design team

- Record the name of each person and the role that they will serve on the design team

Resources

CDLI Integrated Systems

1205 Resource:

Unit 4, Section 1, ILO 1

Topic 1 - Getting Organized

Specific Curriculum Outcomes

Robotic Systems Technology 3205

Students will be expected to:

5.1.2 maintain a complete design portfolio of the design process and design activity [1.401, 1.402, 1.403, 1.404, 1.405]

Suggested Teaching and Learning Strategies

For the Teacher

The purpose of this outcome is to have each design team document this process in the form of a portfolio.

Points to Emphasize

The design portfolio is an essential component of the design process. It will make up most of the content of the final team presentation at the end of the project. It should contain:

- an introductory page.

- a design team page.

- a daily log page.

- the design process steps as major headings.

- a prototype evaluation page.

Because of time restraints teachers may wish to provide a design portfolio template. The portfolio can be electronic using a variety of applications (website, presentation or word processing. Maintenance of the design portfolio throughout the completion of the design activity must be a priority with students.

For the Student

Design portfolios are essential to the design process. They are like diaries and need to be constantly maintained to have meaning. They should track all ideas, decisions, actions and activities. Pages may contain but are not limited to:

- photographs of members working on the various aspects of the project

- any sketches/documents related to the topic

- short videos of prototype development and testing

- notes and questions related to research and group decisions.

Topic 1 - Getting Organized

Suggested Assessment and Evaluation Strategies

Resources

Performance

A complete portfolio of the design process and design activity will be maintained as the team works through the design activity.

CDLI Integrated Systems

1205 Resource:

Unit 4, Section 1, ILO 2

Journal (Design Portfolio)

A daily log of the team progress and activities should be kept.

A personal log accounting for daily tasks should be kept.

Topic 2 - Exploring Opportunities

Specific Curriculum Outcomes

Robotic Systems Technology 3205

Students will be expected to:

5.2.1 investigate problem situations to determine opportunities to develop robotic systems. [1.301,1.305]

5.2.2 identify specific problems for the design and development of robotic systems. [1.301, 1.304, 2.301]

Suggested Teaching and Learning Strategies

For the Teacher

The purpose of this stage of design is to investigate situations that may provide opportunities to design robotic systems.

Points to Emphasize

- In this design activity students will be developing prototypes of robotic systems.

- There are two parts to this section of the process. They are:

- dentifying opportunities from which they will select a suitable project

- selecting a suitable design project.

- The extent to which students are going to be left to identify their own problem situations depends on the particular class and time allotment. Although it may not be realistic to require students to identify their own problem situations, it is not the intent of the design activity to give students everything they need to develop a solution from a given set of plans.

- Design teams should be given every opportunity to question, problem solve and troubleshoot as part of the design activity. Regardless of the method of identifying projects, it is essential that students take ownership of the problem they have chosen to solve.

For the Student

Students should brainstorm for ideas for a robotic system project as a group. Research each idea that interests the group to see if they are feasible and collaboratively select a problem to solve.

Topic 2 - Exploring Opportunities

Suggested Assessment and Evaluation Strategies

Performance

- A complete portfolio of the design process and design activity will be maintained as the team works through the design activity.

- Investigate and identify potential opportunities for a suitable design project. (Record in the appropriate place in the Design Portfolio.)

- Student design teams should develop a list of probing questions to clarify the problem being presented.

Resources

CDLI Integrated Systems

1205 Resource:

Unit 4 Section 2, ILO 1

Topic 3 - Writing a Design Brief

Specific Curriculum Outcomes

Robotic Systems Technology 3205

Students will be expected to:

5.3.1 select a specific problem for design and development of a robotic system and communicate it clearly in the form of a design brief. [1.304, 2.304]

Suggested Teaching and Learning Strategies

For the Teacher

The purpose of this outcome is to get the student design teams to select a specific problem and to communicate it clearly in the form of a design brief. The design brief is used in business as a binding contract between client and designer. In this case, the design brief will define the nature and scope of the design activity, and will be determined by the design team in collaboration with the teacher.

Points to Emphasize

The Design Brief should contain the following components:

- Description of the problem situation.

- Statement of a specific problem.

- Criteria (conditions and limitations) affecting the solution.

- Expectations for the solution.

- Information about the tasks the designers are expected to do or deliver.

For the Student

- Identify and clearly state the robotic system problem.

- Specify conditions and criteria that determine the design and development of a solution to the problem.

- Generate a design brief for this problem.

Topic 3 - Writing a Design Brief

Suggested Assessment and Evaluation Strategies

Journal (Design Portfolio)

- A daily log of the team progress and activities should be kept.

- A personal log accounting for daily tasks should be kept.

Resources

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1205 Resource:

Unit 4, Section 3, ILO 1

Topic 4 - Investigation and Research

Specific Curriculum Outcomes

Robotic Systems Technology 3205

Students will be expected to:

5.4.1 investigate problems similar to the robotic systems problem selected and assess their solutions. [1.302, 1.304, 5.301, 5.303]

5.4.2 identify technological resources available to resolve the design brief. [1.302, 3.305]

Suggested Teaching and Learning Strategies

For the Teacher

The purpose of these outcomes is to investigate similar problems to the ones students have chosen to solve and identify technological resources available to solve the problems.

Points to Emphasize

• Reference Materials may include books, magazines, catalogs (showing ready-made products), CD-ROM's, or the Internet.

• Students will need to be made aware of the two components of this step. They are: researching similar problems or related solutions and identifying available resources to solve their own design problem.

• Strict timelines will have to be applied to keep this step of the design activity from becoming too extensive. Teachers should ensure student design team members understand the importance of the information they gather.

• Teachers should demonstrate how the information obtained needs to be documented in the design portfolio.

• An initial review of the student design portfolios could be completed at this point in the design process to ensure students are properly maintaining them.

• The design portfolios should be assessed early to allow students opportunity to correct any procedural issues.

For the Student

Students should complete the following tasks:

• Design teams meet and assess the design task.

• Design project responsibilities are distributed equitably among design team members.

• Design team members conduct research as required.

• Research acquired is recorded in the design portfolio.

Topic 4 - Investigation and Research

Suggested Assessment and Evaluation Strategies

Performance

Select a suitable design problem and communicate it clearly in the form of a design brief. (Record in the appropriate place in the Design Portfolio.)

Journal (Design Portfolio)

Students could include photograps and all documentation in their team log.

A personal log should account for the activities that each student completed during class time.

Resources

CDLI Integrated Systems

1205 Resource:

Unit 4, Section 3, ILO 2

Topic 5 - Generate Options

Specific Curriculum Outcomes

Robotic Systems Technology 3205

Students will be expected to:

5.5.1 engage in idea generating strategies to identify a range of alternative solutions to solve the robotic systems problem. [1.302]

Suggested Teaching and Learning Strategies

For the Teacher

The purpose of this outcome is to have students generate ideas for the possible solution of their team's problem.

Points to Emphasize

- Typically, this step can be accomplished by a brainstorming exercise. It may be useful to ask students to think about solutions in advance and share their ideas with other design team members.

- Teachers could ensure that all students have an opportunity to express their ideas - all ideas should be given equal weight.

- They could try for a minimum of 6-8 different ideas, not just variations on the same idea. Variations on the same idea could be listed but not included in the 6-8 count.

- Teachers should encourage students to resist the urge to qualify or judge the ideas as they identify them.

- The brainstorming activity should be student led within their design team.

- This should be a 20-25 minute exercise.

- Note that this activity is not focused on how a solution might or might not get developed, and may result in lots of nonsensical ideas.

- Often times, even the most frivolous ideas may lead to a useful solution if it is used to spark other ideas.

For the Student

Complete a brainstorming exercise to identify means of solving the problem. One student can be the recorder and write all ideas in the portfolio. Another can moderate the activity and ensure that all ideas are treated equally, Complete a preliminary analysis of the results of the brainstorming activity and categorize the possible solutions.

Topic 5 - Generate Options

Suggested Assessment and Evaluation Strategies	Resources
Performance	**CDLI Integrated Systems**
• Investigate problems similar to the robotic systems problem selected and assess their solutions. (Record in the appropriate place in the Design Portfolio.)	**1205 Resource:** Unit 4 Section 3, ILO 3
• Identify technological resources available to resolve the design brief. (Record in the appropriate place in the Design Portfolio.)	

Topic 6 - Select Best Option

Specific Curriculum Outcomes

Robotic Systems Technology 3205

Students will be expected to:

5.6.1 develop criteria for assessing robotic systems solution options. [1.302,3.303, 5.303]

5.6.2 using established criteria, examine the robotic systems solution options

Suggested Teaching and Learning Strategies

For the Teacher

The purpose of these outcomes is for students to learn the importance of creating and using a systematic approach to the evaluation of potential solutions to a design problem.

Points to Emphasize

Teachers should prepare a sample evaluation of one solution idea (if time permits this can involve the entire class).

- A solution evaluation checklist should be required from each design team.

- Criteria from the design brief and any other relevant criteria discovered during research should be included in this checklist. Evaluation of solutions should be treated as a team activity. Each member of the group should have input into the evaluation of each solution.

- Teachers should ensure that students understand the importance of selecting the best solution at this stage of the design process.

- Students should be able to justify their decision.

For the Student

- Students should develop a method to effectively evaluate the possible design solutions.

- Team members should insure accurate recording of this selection process in the design portfolio.

Topic 6 - Select Best Option

Suggested Assessment and Evaluation Strategies

Resources

Performance

Create a criteria table and rate each of the alternative solutions on each of these criteria. Select the best solution (s) based on this rating. Write a rationale explaining which of the alternate solutions your team selected explaining why it was selected.

Journal (Design Portfolio)

- The team log should reflect the assessment criteria for the solution.

- A personal log accounting for daily tasks should be kept.

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1205 Resource:

Unit 4 Section 2, ILO 5 and 6

Topic 7 - Develop the Solution

Specific Curriculum Outcomes

Robotic Systems Technology 3205

Students will be expected to:

5.7.1 identify specific tools/ machines and resources that are required to effectively develop the robotic systems solution. [1.303, 4.303]

5.7.2 determine new skills that will need to be acquired to effectively develop the robotic systems solution. [1.303, 4.303]

5.7.3 create a plan of action that will guide the implementation of the robotic systems solution. [1.302]

5.7.4 use safe practices to develop the robotic systems solution, redesigning as necessary. [5.302, 5.303, 1.303, 1.305]

Suggested Teaching and Learning Strategies

For the Teacher

The purpose of these outcomes is for students to develop the solution to the chosen problem including identifying tools, resources, and skills required.

Points to Emphasize

This step is the most time consuming step of the design process. Preparation should include:

*   identification and preparation of appropriate work spaces and tools for the design teams

*   the collection of resources, including consumable items, for the design activity

*   development of a strategy that ensures design work is shared equitably among the design team membership.

*   assurance that students understand and are following the safety rules presented in Unit 4.

*   Each design team must finish the product during this phase. Modeling and prototyping of the solution are required.

For the Student

*   At this stage students should have:

*   developed a fully functional prototype of the design solution.

*   followed all appropriate safety precautions for the tools and processes used.

*   documented all aspects of the design solution development in the design portfolio. All steps of the design process, including tests of ideas, things that worked and things that did not work, all sketches and plans, all problems that arose and had to be solved, and new tools/skills that had to be learned must be included.

Topic 7 - Develop the Solution

Suggested Assessment and Evaluation Strategies

Performance

As a team, develop a plan of action for developing the solution.

Journal (Design Portfolio)

Develop resources necessary for project completion this should include:

- tools

- time

- specialized skills

- safety issues

This list should be recorded in the design portfolio

Resources

CDLI Integrated Systems

1205 Resource:

Unit 4 Section 4, ILO 1 – 6

Topic 8 - Evaluate and Redesign

Specific Curriculum Outcomes

Robotic Systems Technology 3205

Students will be expected to:

5.8.1 establish criteria for evaluating the robotic systems solution. [1.304]

5.8.2 evaluate the robotic systems solution, based on established criteria. [1.304]

Suggested Teaching and Learning Strategies

For the Teacher

The purpose of these outcomes is to evaluate the solution to the design problem using criteria established by the design team.

Points to Emphasize

- Evaluating the solution depends on the problem and the solution.

- In some instances, this simply means determining if the solution meets the conditions stipulated in the design brief. Evaluation of the solution will require analysis and a reasoned judgment by the students.

- Evaluating the solution could also mean using the solution (the product) for its intended purpose and determining if it actually works. This would apply if the prototype was a full scale working model.

- Teachers could provide samples of evaluation criteria and allow students to choose the best qualities of each sample and then design their own evaluation criteria.

- This is also a good time to get students to reflect on what they could have done better to meet the technical requirements of the design challenge.

For the Student

Design teams should evaluate their solution by applying appropriate criteria to assess it. Ideally testing the solution under actual working conditions would be beneficial. Design team members will record the results and the decisions made in their design portfolios.

Topic 8 - Evaluate and Redesign

Suggested Assessment and Evaluation Strategies

Resources

Paper and Pencil

Design teams should complete a reflection activity where they discuss:

- How they would have done things differently

- Challenges encountered during the project and how they overcame them.

- Challenges in working as a team

- Technical challenges with their solution

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1205 Resource:

Unit 4 Section 5, ILO 1, 2 and 6

Topic 9 - Present the Solution

Specific Curriculum Outcomes

Robotic Systems Technology 3205

Students will be expected to:

5.9.1 develop a presentation plan that is based on information recorded in the design portfolio. [1.305]

5.9.2 develop a presentation that uses appropriate presentation tools and strategies, demonstrates how the design model was implemented, and identifies the implications of the robotic systems solution. [1.305, 3.305]

5.9.3 present the design portfolio, the design solution and the design activity report to the class. [1.305]

Suggested Teaching and Learning Strategies

For the Teacher

The purpose of these outcomes is to have students develop and deliver a presentation using appropriate tools and strategies which demonstrates their understanding and use of the design process in the solution of the design problem.

Points to Emphasize

Teachers should ensure that:

- everyone is attentive to and respectful of others.

- the necessary equipment and space are available and ready.

- all members of the design team participate in the presentation.

For the Student

Presentation of the design team report. When presenting the report students should use appropriate language and terminology. The report should include:

- a summary of the design brief.

- a summary of how the design process enabled the design team to achieve the solution, including successes and challenges encountered.

- a demonstration/exhibition of the solution.

- an evaluation of the solution, including evidence of any improvements made to the design based on the evaluation.

- evidence of shared responsibility among the design team members.

The presentation structure should be based on the structure of the design team's design portfolio. The portfolio will contain evidence of all aspects of the design activity and will prove to be both informative and comprehensive.

Topic 9 - Present the Solution

Suggested Assessment and Evaluation Strategies

Resources

Performance

Each team member should have an active role in the presentation of the Design Project.

Presentation

Plan, develop and deliver the team's presentation of the Design Project.

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1205 Resource:

Unit 4 Section 6, ILO 1,2