INTEGRATION OF MATH AND SCIENCE WITH SHERIDAN ENGINEERING PROGRAM USING CDIO TOOLS

Farzad Rayegani, Ramin Ghalati

School of Mechanical and Electrical Engineering & Technology,
Sheridan College, Ontario, Canada

ABSTRACT

The (on-going) transition of Sheridan College to Sheridan University has provided with an excellent opportunity to integrate the CDIO standards and attributes in Sheridan's engineering programs from the outset. We provide examples to show the integration of math and science curricula with engineering curriculum through active integrated learning strategies, such as project based learning and design-implement experiences, making it possible to further enhance the attainment of technical knowledge and reasoning and CDIO skills and attributes, including engineering reasoning and problem solving, experimentation and knowledge discovery, system thinking, personal skills and attitudes, team work and communication. To ensure relevance, necessity and sufficiency of math and science curriculum, and its proper integration with engineering curriculum, and to design activities, evaluations and assessments, a mapping of math and physics learning outcomes on (mechanical) engineering learning outcomes is also proposed.

KEYWORDS

CDIO Implementation, Project Based Learning, Bus Structure, Integration of Math and Science in Engineering, Curriculum Mapping, CDIO Standards: 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11

INTRODUCTION

Using CDIO tools, students can be given the opportunity to learn math and science in engineering context through hands on projects (CDIO Standards 5, 7, 8) (Ghalati, 2014). Sheridan, which has adopted the CDIO approach in the development of its engineering degree programs, and on a broader basis its evolution towards a Sheridan University (Zebudsky et al., 2014), is incorporating the CDIO standards and attributes from the early stages of these developments.

OBJECTIVES, CURRENT STATUS AND FUTURE WORK

There are two objectives in this work. One is to propose a mapping of the learning outcomes of math and physics courses in Engineering Programs at Sheridan, and the other is to propose Bus Structure Projects to integrate math and physics with engineering courses in these programs. Currently, this has been done for Mechanical Engineering, and the implementation stage is awaiting approval of the proposed Mechanical Engineering Degree Program by the Ontario Ministry of Training, Colleges and Universities.

MAPPING OF MATH AND PHYSICS COURSES

The mappings make it possible to track all the courses in which a given math or physics learning outcome is utilized. This information can be used to enhance lesson plans, develop assignments and projects in engineering context, and set the level of expectations of math and physics courses. Also, if a concept is missing, or concepts from math or physics are delivered but not utilized in other courses, one may track them using these mappings.

SAMPLE BUS PROJECTS

Four Bus Projects are proposed to integrate math and physics with the Degree Program in Mechanical Engineering curriculum at Sheridan. Bus Projects provide students with active integrated learning opportunities (CDIO Standards 8 & 9). The sample projects presented here also address the CDIO skills and attributes: Engineering Reasoning and Problem Solving, Experimentation and Knowledge Discovery, System Thinking, Creative and Critical Thinking, Time and Resource Management, Multi-Disciplinary Team Work and Communication.

Robotic Arm Design Bus Project

The Robotic Arm Design Bus Project (Figure 1) gives first semester students the opportunity to model, design and implement a robotic arm as a truss. Students are given certain conditions on the dimensions and functions of the truss and the material they can use for building the mechanical arm. The truss must be modeled under certain static and dynamic loading prior to the design process.

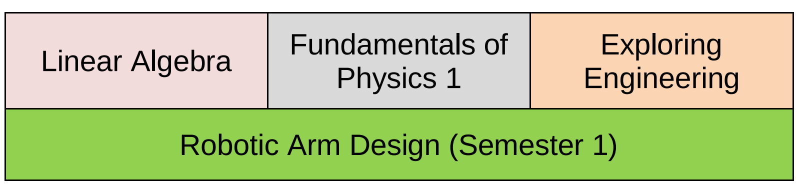

Figure 1. Robotic Arm Design Bus Project

To complete the project, students would need to use MATLAB to solve certain linear systems of equations arising from equilibrium conditions on truss members.

Robotic Arm Path Optimization Bus Project

In this project (Figure 2), first semester students in the Degree Program in Mechanical Engineering at Sheridan will implement and operate a mechanical arm which would sweep through a set of targets within its envelope space in the minimum amount of time, with the

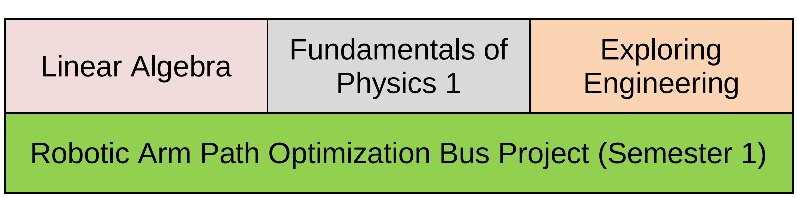

Figure 2. Robotic Arm Path Optimization Bus Project

grip not accelerating beyond a certain limit. The mechanical arm comprises two perpendicular links connected through a servo motor, with one end of one of the links attached horizontally to a horizontal servomotor and the end of the other link attached to a gripper. Students would need to write a MATLAB code to determine the path of least time for the gripper to sweep through a set of objects, considering that the servomotors can rotate both clockwise and counter clockwise and that the targets can be swept in a variety of orders.

Air Engine Bus Project

In the Air Engine Bus Project (Figure 3) students enrolled in the third semester of the Degree Program in Mechanical Engineering at Sheridan will manufacture, program and operate a five cylinder air engine given CAD drawings of the engine. The idea of the project and the original CAD designs for the engine are adapted from a Master's Thesis from Ohio State University (Neal, 2013).

Differential Equations	Electrical Circuits & Power	Manufacturing Process & Engineering Workshop	Engineering Mechanics: Statics & Dynamics
Air Engine Bus Project (Semester 3)			

Figure 3. Air Engine Bus Project

In order to complete their project, students need to calculate the angular velocity of a flywheel attached to the air engine, as well as analyze the periodical motion of the flywheel when it is coupled to a rotational spring.

Stirling Engine Bus Project

The Stirling Engine Bus project (Figure 4), inspired by Urieli among many references, is designed for students enrolled in the fourth semester of the Mechanical Engineering program at Sheridan.

Numerical Methods	Instrumentation & Measurement	Thermodynamics
Stirling Engine Bus Project (Semester 4)		

Figure 4. Stirling Engine Bus Project

Students are provided with a working model of an α-type Stirling engine, and are required to provide with their own design and CAD drawings of the engine (using reverse engineering), its instrumentation and implementation and thermodynamical modeling. In order to model the engine, students discuss the kinematics of the engine and derive the equations governing the thermodynamics of the Stirling engine assuming adiabatic conditions, and write a MATLAB code to solve the resulting differential equations using numerical techniques.

Students would then compare their results with the actual readings from the instrumentation of the engine.

REFERENCES

Crawley, E. & Malmqvist, J. & Östlund, S. & and Brodeur, D. (2007). *Rethinking Engineering Education: The CDIO Approach*, Springer, New York.

Ghalati, R. (2014). Integration of Math and Physics with Mechanical Engineering Degree Curriculum Using CDIO Tools. *Work submitted to the Teaching and Learning Academy, Sheridan College.*

Neal, M. T. (2013). Development, Evaluation and Impact of Hands-on Introductory Mechanical Course. *Thesis, The Ohio State University.*

Urieli, I. *www.ohio.edu/people/urieli/index.html*

Zebudsky, J. & Rayegani, F. & Ghafari, S. (2014). Sheridan Journey, Shaping Ideal Engineering Programs Based on CDIO Approach. *Proceedings of the 10th International CDIO Conference,* Universitat Politècnica de Catalunya, Barcelona, Spain, June 16-19, 2014.

BIOGRAPHICAL INFORMATION

Farzad Rayegani, Ph.D., P.Eng., FEC is a Professor in Mechanical Engineering and Associate Dean of the School of Mechanical and Electrical Engineering & Technology at Sheridan College, Brampton, Canada. As a CDIO collaborator, he is seeking to develop new curriculum structures based on a new philosophy for engineering education. The framework educates students to Conceive, Design, Implement and Operate complex, value-added engineering products, processes and systems in a modern, team-based, global environment.

Ramin Ghalati, Ph. D., is Math Advisor and Professor, Mathematics for Engineering and Science at the School of Mechanical and Electrical Engineering & Technology at Sheridan College, Brampton, Canada. Ramin has a B. Eng. from Shiraz University, and received his PhD in Applied Mathematics (Theoretical Physics) from Western University. Currently, Ramin leads the development of math and physics streams of the Degree Programs in Mechanical and Electrical Engineering at Sheridan, and using CDIO concepts and tools ensures the integration of math and physics streams into engineering curriculum in accord with CDIO syllabi and standards.

Corresponding author

Dr. Ramin Ghalati,
Sheridan College, School of Mechanical and Electrical Engineering & Technology
7899 McLaughlin Rd., Brampton, ON, L6Y 5H9, CANADA
1-905-459-7533 ext. 5446
ghalati@sheridancollege.ca