USING RUBRICS TO ASSESS THE DEVELOPMENT OF CDIO SYLLABUS PERSONAL AND PROFESSIONAL SKILLS AND ATTRIBUTES AT THE 2.X.X LEVEL

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ABSTRACT

The Department of Aerospace Engineering at the United States Naval Academy joined the CDIO Initiative in July 2003. The Naval Academy already emphasized many of the skills in the CDIO Syllabus, such as ethics, leadership, teamwork, systems thinking, and communications that are part of design-build projects, integral components of a CDIO program. What was lacking was the overall framework for developing a curriculum consistent with our goals and one that could be used to guide outcomes assessment. The CDIO syllabus provided that framework. This paper describes the process of developing and implementing the CDIO syllabus personal and professional skills and attributes (2.x.x.).

We first completed the stakeholder survey to determine the level of understanding desired for each of the CDIO Syllabus topics. Following that, we completed a benchmark survey of our courses to identify where we introduce, teach, and use each of the topics in our CDIO Syllabus. In the next step we evaluate student and program performance in each of the topics. This year we are focusing particularly on the personal and professional skills and attributes (2.x.x). In the courses where we have identified that we teach or use the 2.x.x topics, we are asking each faculty member to evaluate student's performance on the topics by answering a set of questions pertaining to the 2.x.x topics. These questions are applied to course homework, projects, exams, and class participation.

The CDIO Initiative also provides assessment tools necessary for the successful development and continuous improvement of our program. However, there was a need to create valid and reliable rubrics to assess the specific personal and professional skills and attributes that are most highly valued in the USNA Aerospace Engineering program, which were identified during the process of syllabus adaptation. Developing the assessment rubrics involved, first, identifying criteria for judging the achievement of 2.x.x. level skills and attributes; second, creating scales related to each criterion to guide the evaluation of students' achievement of the desired skills and attributes; and third, validating the criteria and scales so that standards of achievement could be set. This process resulted in valid and reliable assessments rubrics that provide information used to guide the continuous improvement of the Aerospace Engineering program.

INTRODUCTION

The CDIO (Conceive-Design-Implement-Operation) project learning assessment model is based on the principle that product and system lifecycle development and deployment are the context of Engineering Education. Its mission is to graduate engineers able to Conceive-Design-Implement-Operate complex value-added engineering products and systems in modern team-based environments so as to appreciate engineering processes and contribute to the development of engineering products while working in engineering organizations. As a result, intended attributes of CDIO graduates include understanding disciplinary fundamentals, understanding design and manufacturing, possessing a multi-disciplinary system perspective, exhibiting good communication skills, and having high ethical standards.

Of course, each CDIO program develops expected student learning outcomes that are consistent with the program mission and are validated by program stakeholders. Typically, program outcomes include technical knowledge and reasoning, personal and professional skills and attributes, interpersonal skills such as teamwork and communication, and conceiving, designing, implementing and operating systems in the enterprise and societal context.

USNA ADOPTION OF CDIO

The Department of Aerospace Engineering at the United States Naval Academy joined the CDIO Initiative in July 2003. The CDIO Initiative provides us with the framework and tools necessary to make and assess changes in our program. Before describing why and how we adapted CDIO to our program it is necessary to understand the mission of the United States Naval Academy: *Develop midshipmen morally, mentally and physically and to imbue them with the highest ideals of duty, honor and loyalty in order to provide graduates who are dedicated to a career of naval service and have potential for future development in mind and character to assume the highest responsibilities of command, citizenship and government.*

The mission of the Aerospace Engineering Department must follow from the mission of the Naval Academy, while at the same time emphasizing the role of the aerospace engineering major. Our departmental mission and vision are a direct result of our participation in CDIO. Our mission is to: Provide the Navy and Marine Corps with engineering graduates capable of growing to fill engineering, management and leadership roles in the Navy, government and industry, maturing their fascination with Air and Space systems. Our departmental vision follows our mission: Mission fulfilment requires a program wherein Midshipmen Conceive – Design – Implement – Operate complex mission-effective aerospace systems in a modern team-based environment.

The Naval Academy already emphasized many of the skills in the CDIO Syllabus, such as ethics, leadership, teamwork, systems thinking, and communications that are part of design-build projects, integral components of a CDIO program. What was lacking was the overall framework for developing a curriculum consistent with our goals and one that could be used to guide outcomes assessment. The CDIO syllabus provided that framework. This paper describes the process of developing and implementing the CDIO syllabus personal and professional skills and attributes (2.x.x.).

We first completed the stakeholder survey to determine the level of understanding desired for each of the CDIO Syllabus topics. Following that, we completed a benchmark survey of our courses to identify where we introduce, teach, and use each of the topics in our CDIO Syllabus. In the next step we are evaluating student and program performance in each of the topics [1]. This year we are focusing particularly on the personal and professional skills and attributes (2.x.x). In the courses where we have identified that we teach or use the 2.x.x topics, we are asking each faculty member to evaluate student's performance on the topics by answering a set of questions pertaining to the 2.x.x topics. These questions are applied to course homework, projects, exams, and class participation.

CDIO ASSESSMENT USING RUBRICS

A student learning assessment model is used to guide CDIO practice (figure 1). This model provides an approach to student learning assessment that is based on the CDIO standards and the local program context. The model may be used at the course, program or institutional level. It describes four elements of student learning assessment: learning objectives, curriculum and instruction, assessment of student learning, and use of assessment results. The model highlights the importance of aligning teaching, learning, and assessment with the CDIO and local program's intended learning outcomes, as well as the use of assessment results to improve the processes of teaching, learning, and assessment.

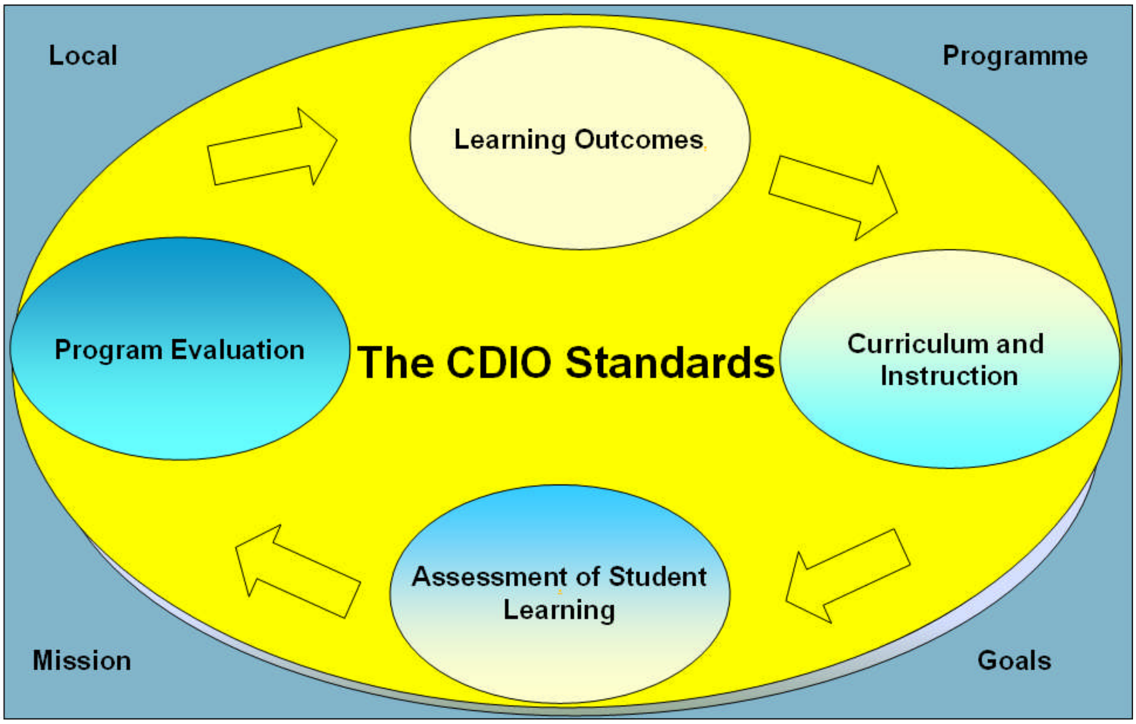

Figure 1: CDIO Student Learning Assessment Model

Assessment requires faculty members to communicate explicit and public statements of learning outcomes and criteria of performance. By doing so, they refine their own understanding of expected abilities, clarify for the colleagues the basis for their judgements, and enable students to understand what learning and level of performance are required [2].

A CDIO program uses a variety of evaluation methods to determine whether or not students have acquired the knowledge, skills, and values specified in the CDIO Syllabus. Methods available to gather and evaluate student learning include written tests as well as rating scales (i.e., rubrics) for evaluating student performance in the form or journals of student reflections, portfolios of student work over time, capstone projects (e.g., design/build efforts), and oral presentations, in-class discussions, and technical reports.

In developing a rubric the instructor must consider, first, what precisely is expected from an assignment in terms of learning outcomes and, second, the characteristics of various levels of satisfactory or unsatisfactory performance. Therefore, a well designed rubric should include specific criteria for assessment, standards of performance, and quality indicators.

This year the Aerospace faculty members focused particularly on the personal and professional skills and attributes (2.x.x in the CDIO syllabus). In the courses where we have identified that we teach or use the 2.x.x topics, we are asking each faculty member to evaluate student's performance by answering a set of questions pertaining to the 2.x.x topics in the form of a scoring rubric. Figure 2 shows the criteria for assessment of each of the personal and professional skills and attributes included in the 2.1.x level in the syllabus.

2.1 ENGINEERING REASONING AND PROBLEM SOLVING

2.1.1 Problem Identification and Formulation

Evaluate data and symptoms
Analyze assumptions and sources of bias
Demonstrate issue prioritization in context of overall goals
Formulate a plan of attack (incorporating model, analytical and numerical solutions, qualitative analysis, experimentation and consideration of uncertainty)

2.1.2 Modeling

Identify assumptions to simplify complex systems and environment
Choose and *apply* conceptual and qualitative models
Choose and *apply* quantitative models and simulations

2.1.3 Estimation and Qualitative Analysis

Estimate orders of magnitude, bounds and trends
Apply tests for consistency and errors (limits, units, etc.)
Explain the generalization of analytical solutions

2.1.4 Analysis with Uncertainty

Question incomplete and ambiguous information
Interpret probabilistic and statistical models of events and sequences
Interpret engineering cost-benefit and risk analysis
Discuss decision analysis
Identify margins and reserves

2.1.5 Solution and Recommendation

Select problem solutions from among candidates
Analyze essential results of solutions and test data
Analyze and *reconcile* discrepancies in results
Choose summary recommendations
Appraise possible improvements in the problem solving process

Figure 2: PERSONAL AND PROFESSIONAL SKILLS AND ATTRIBUTES

An example of a rubric developed and field-tested this year is presented in Figure 3. This rubric was applied to Individual presentations, posters, team presentations, technical reports, lab reports, in-class discussion, and other artefacts of student performance. We selected the seven syllabus topics with the highest scores from our stakeholder survey and we had our faculty rate our students using the same rating scale we used in the stakeholder survey.

EAXXX-Section xxxx

EVALUATOR:

Objectives	**2.1.1 Use**	**2.1.2 Use**	**2.1.3 Use**	**2.1.5 Use**	**2.4.2 Use**	**2.4.4 Teach**	**2.5.1 Use**
Student:	**Scores:**						
	2	*1*	*3*	*3*	*2*	*1*	*4*
	3	*3*	*3*	*3*	*3*	*3*	*4*
	2	*1*	*3*	*3*	*2*	*3*	*4*
	3	*3*	*3*	*2*	*3*	*2*	*4*
	3	*3*	*3*	*3*	*2*	*2*	*4*
	3	*3*	*3*	*4*	*3*	*3*	*4*
	3	*3*	*3*	*3*	*3*	*3*	*4*
	3	*3*	*3*	*4*	*3*	*4*	*4*
	3	*3*	*3*	*4*	*4*	*4*	*4*
	3	*3*	*3*	*4*	*4*	*4*	*4*
	3	*3*	*3*	*3*	*3*	*3*	*4*
	3	*3*	*3*	*3*	*4*	*4*	*4*
	2	*1*	*2*	*2*	*3*	*3*	*4*

TOPICS

2.1.1 Problem Identification and Formulation (4.1/4)
2.1.2 Modeling (3.2/3)
2.1.3 Estimation and Qualitative Analysis (3.6/4)
2.1.5 Solution and Recommendation (3.6/4)
2.4.2 Perseverance and Flexibility (3.3/3)
2.4.4 Critical Thinking (3.6/4)
2.5.1 Professional Ethics, Integrity, Responsibility & Accountability (3.7/4)

BASIS

Individual presentations, posters, team presentations, technical reports, lab reports, and in-class discussions

SCORING

1 To have experienced or been exposed to
2 To be able to participate in and contribute to
3 To be able to understand and explain
4 To be skilled in the practice or implementation of
5 To be able to lead or innovate in

Figure 3: RUBRIC FOR CDIO PERSONAL AND PROFESSIONAL SKILLS AND ATTRIBUTES

LESSONS LEARNED AND NEXT STEPS

Of all the syllabus topics, the Personal and Professional Skills and Attributes (2.x.x syllabus topics) appear to be the most difficult to measure and the most subjective. The task seemed overwhelming until we decided to reduce the number of skills we would assess. Figure 3 presents the results from one course with thirteen students. Based on our curriculum benchmark results, the only CDIO skill taught in this course was 2.4.4 -- Critical Thinking. The other CDIO skills used in this rubric were used in the course and observed by the instructor, but not necessarily taught in the course.

Ratings for all of our courses are not available now, but will be presented at the conference. We will be looking for longitudinal trends, comparing scores from students in the first, second, and third year of our program. We will also compare the scores of our students completing the program this semester with the scores we obtained from out stakeholder's survey. These data will be used to adjust our curriculum where needed. Additional data that might provide additional information are student self-evaluations of these skills. Unfortunately, we were unable to collect these data this year. Next year, we plan on collecting data to assess the 3.x.x CDIO Skills (communication and teamwork). Plus, we hope to refine our data collection techniques.

References

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2. Loacker, G., Cromwell, C., & O'Brien, K. (1986). *Assessment in Higher Education: To Serve the Learner.* In Adelman, C., Assessment in American higher education (pp. 47-62). Washington, DC: US Department of Education

Biographical Information

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