

Academic Threads - Curriculum Integration for Specific Capabilities

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Abstract

This paper will begin with a discussion of learning objectives and illustrate their application within a number of different basic courses in industrial and systems engineering. It will then introduce the notion of “Academic Threads” and present a number of different situations where specific topics might be considered as appropriate for integration at a number of different points within the curriculum. A plan for the creation of an Academic Thread will be discussed. The paper will then show how the thread can be woven into the learning objectives for specific courses. A discussion of some of the strengths and weaknesses of this approach will then be presented. An extension of the idea of academic threads into more technical areas will also be presented.

Learning Objectives

In the literature, learning objectives have been labeled many different ways. Such terms as, “educational objectives,” “instructional objectives,” “behavioral objectives,” and “performance goals,” have been used to express the basic idea presented here as learning objectives^(2,3). Learning objectives can be defined as, “statements that describe what students will be able to do after completing a prescribed unit of instruction”⁽²⁾. A more detailed definition is provided by Mager, “the objectives must include three characteristics: (1) a statement about what the learner must be able to do, (2) a description of the conditions under which the performance is to occur, and (3) a description of the criteria for acceptable performance”⁽⁴⁾. Common to both of these definitions is the focus on what the learner/student must be able to do at the completion of the learning unit. Learning objectives provide detailed descriptions about the exact behavior a student should demonstrate to show competence in a particular area. For this reason, objectives usually contain active verbs (e.g.: analyze, create, locate, perform, etc.) that explicitly state the behavior expected of the student that will be used as an indicator of completion of broader educational goals.

Learning objectives exist at two levels of education, the program level and the course level. At the program level, the selection of learning objectives creates the overall picture of a program and provides guidance and motivation for individual courses. At the course level, instructors can tailor the objectives to his/her course needs, student needs, and teaching style. Program learning

objectives are determined directly from the program goals. Course learning objectives address specific objectives of the program while providing the detail needed at the course level. When considering the program level objectives, the set of objectives that a program uses is more important than any single learning objective in that it defines what the program is all about.

At Virginia Tech, the university has placed a significant emphasis on course learning objectives since the mid 1980s when the university transitioned from a quarter oriented curriculum to a semester system. Since then, every course proposal that is passed through governance for approval must identify the “Learning Objectives” associated with the course. The course proposal preparation guide specifically states this section of the course proposal must answer the question: “What new capabilities, skills, and levels of awareness will students derive from this course?” Additionally, it states that the objectives must be measurable and that action verbs such as: define, make, explain, outline, construct, describe, identify, discuss, demonstrate, prove, write, program, show, apply, build, prepare, compose, etc., should be used in stating the learning objectives. To illustrate the learning objectives in a course proposal and to set the stage for further development, three specific courses will be introduced and their learning objectives stated. The course will be discussed in more detail subsequently.

ISE 3014 Work Measurement and Methods Engineering is a survey of methods for assessing and improving performance of individuals and groups in organizations. It is taught as a first semester junior course and includes basic industrial engineering tools, such as: work analysis, data acquisition and analysis, performance evaluation and appraisal, and work measurement procedures. As conceived, the course was to have two lectures and a three-hour laboratory each week of the term. According to the syllabus of record, the course learning objectives are as follows:

Having successfully completed this course, the student will be able to

- Describe the role of work measurement in the work place, conduct a methods engineering study of a particular job, including methods analysis, time studies and work sampling studies.
- Acquire and statistically analyze work place data.
- Design a work place layout using methods analysis.
- Apply the appropriate industrial engineering tools to investigate and document organizational performance.
- Design the major components of a performance measurement system.

ISE 3214 Facility Planning and Material Handling focuses on the theory and concepts involved in model formulation for design and analysis of facility plans. Topics covered include facility layout, facility location and material handling system design. It stresses the application of quantitative tools and techniques for flow analysis, layout planning, and automated material handling system design. The course is a second semester junior course and has ISE 3014 as a prerequisite. It is taught in a 3-lecture per week format. The course learning objectives are as follows:

Having successfully completed this course, the student will be able to

- Construct models for design and analysis of facility layouts, facility location, and material handling systems.

- Describe the techniques and approaches used to develop facility layouts, locate facilities, and design material handling systems.
- Identify major material flows, determine activity relationships, and specify space requirements.
- Describe techniques for design and operation of a warehouse.
- Apply theory and concepts to the design of facilities.

ISE 4005-4006 Project Management and Systems Design is a senior level, two-semester capstone design sequence for ISE majors. ISE 4005 (fall semester) is a survey of methods and techniques used to plan, manage, and control projects. Students work in teams to develop a proposal for and initiate work on a real-world project from a manufacturing or service industry. In ISE 4006, the students apply their knowledge and skills of ISE to analyze, design, and evaluate solutions to this real-world project. This sequence must be taken as a fall/spring sequence during the same academic year as the students work in teams on the project. Since this is a two-course sequence, the learning objectives are split between the two courses.

Having successfully completed ISE 4005, the student will be able to

- Identify, describe, and evaluate the specific features of a project.
- Select and establish the proper organization structure for different kinds of projects.
- Apply project management methods and techniques to a real-life project from a manufacturing or service industry.
- Write a proposal establishing a project plan and specifying mechanisms for project management and control.

Having successfully completed ISE 4006, the student will be able to

- Solve a real-world problem from a manufacturing or service industry applying knowledge and skills of industrial and systems engineering.
- Work effectively as a member of a project team on the solution of an engineering problem.
- Design and deliver an oral presentation of the results, conclusions, and recommendations of their project.
- Prepare a written report detailing the analysis, recommendations, and appropriate supporting data in proper engineering format.

As can be seen by the above, course learning objectives tend to be focused on specific subject matter or technical skills. ISE 4005/4006 is somewhat different in that it is a capstone design experience. Even as initially conceived it began to integrate some of the softer skills of teamwork and communications into a “define, analyze, synthesize, and design” oriented course.

There are two other aspects of a Virginia Tech course proposal that should be mentioned before proceeding. The Catalogue Description is a brief description of the course, as it will appear in the Undergraduate Catalogue. It is limited in detail but serves as a first cut at telling everyone what the course is about. Additionally, there is a Justification section of every proposal that presents arguments establishing the educational significance of the proposed course with respect to a curriculum or program of study.

Academic Threads

In curriculum design, there are many topics that are addressed in a number of different places within the program requirements while other topics are addressed by specific courses. For example, the fundamentals of facilities design might be addressed in a single course while questions of engineering ethics might appear at a number of different places. Recent development to introduce “writing across the curriculum” pedagogy is an excellent example of a desired skill or capability that can be integrated at a number of different points within the program. An “Academic Thread” is suggested as a paradigm for formalizing the integration of a topic across a number of different courses within the curriculum. While the desire for curriculum integration and the idea of integrating a topic across multiple courses is not new, Academic Threads and the ABET emphasis on program and course learning objectives are proposed as avenues to formalize and better focus these integration efforts.

As conceived, an Academic Thread consists of a number of different elements. There should be a “Description” of the thread that introduces the topic and provides limited insight into its content. Unlike a course description, which is created for publication in a course catalogue, the thread description should use complete sentences and provide a brief explanation on content and reason. Next, there should be a “Justification” section that establishes the reason for inclusion of the thread in the curriculum. This should include arguments for the educational significance of the thread within the curriculum. Additionally, it should address why a thread is considered to be an appropriate mechanism for including the topic in the curriculum. One common justification for the use of a thread is that there is limited space in the curriculum for additional course work and the topic can be integrated across a number of courses. Another justification is that it may be felt that the material is best taught by integrating the concepts within other discipline specific courses. One final justification that has been advanced is that the proposed thread is really a strengthening of a basic concept or idea that was covered earlier in the curriculum. (More will be said about this idea.) The heart of an Academic Thread is the thread “Learning Objectives.” Like course learning objectives, the thread learning objectives indicate what the students should be able to do upon completion of the associated courses. These thread learning objectives are then woven into the course learning objectives in a “Plan for Integration.” This “Plan” is the critical, new element associated with an Academic Thread. It details how a specific set of courses will be used to satisfy the thread requirements while continuing to address course specific goals and objectives. While somewhat conceptual, consideration must be given for implementation issues associated with incorporating the thread into each of the courses. Finally, each course proposal and the course learning objectives must be revised to include the thread within the official course document. This is done to ensure that the thread will be included in each and every course indicated in the Plan for Integration irrespective of who is teaching the course. Like individual courses and course learning objectives, Academic Threads should be included in the course and program evaluation cycle to measure performance and to provide feedback for possible revisions.

Oral Communications as an Academic Tread

As with many engineering programs, there has been an increased emphasis on communication skills with the ISE curriculum at Virginia Tech. Strong feedback from employers’ surveys and the ISE Advisory Board emphasized the need for continuous improvement in oral and written

communication skills. Additionally, alumni feedback indicated the importance of communication skills. One of the ISE Program Learning Objectives specifically addresses the desire for this emphasis with the curriculum:

“Students should demonstrate effective oral and written communication skills and demonstrate effective skills for team building and participation in group problem solving.”⁽¹⁾

As the university has a mandated Writing Intensive requirement, the ISE Undergraduate Curriculum Committee (ISE UCC) turned its attention to the area of oral communications and the then current curriculum to establish what was in place and to look for ways we might improve if desired. It was quickly established that it was not possible to simply add a course in public speaking to the curriculum. The program already had a large number of required credit hours when compared to many of the programs that were reviewed. Additionally, there was limited flexibility in the curriculum within the elective sets and each set of electives existed for a specific reason. It was proposed that three specific required undergraduate courses (3014, 3214, and 4005/4006) be enhanced to include oral communication pedagogy as part of the course. Two of the courses that were selected already involved student presentation from time to time, but there was not a formal requirement in one and the level of emphasis was instructor dependent. The first course had a little “slack time” and had involved student presentations a number of years ago. Additionally, because of the course prerequisite structure, one course could build on ideas and communication skills introduced in the previous course.

The basic plan was as follows. In ISE 3014, the “available” unscheduled third lecture hour would be used for individual student presentations. First, the students would be given two presentations on public speaking and then they would be asked to prepare and present material found in an article of their choosing from *IIE Solutions*. In addition to giving their presentations, students would be required to critique others to help focus on the fundamentals of public speaking. In ISE 3214, the emphasis would shift to team presentations with a technical emphasis. Material would be presented in class to indicate aspects of presenting and selling technical ideas. The student presentations are group oriented and focus on the results of the students’ design efforts. In the capstone design course, ISE 4005/4006, oral communication has historically been emphasized from a number of different perspectives. As the student teams are involved in a number of meetings with their faculty advisors, the course coordinator, and the company contacts, basics of planning and conducting meetings are discussed. Additionally, personal interactions with people from the companies “at the shop floor level” are frequent elements of a project and communications aspects of these interactions are discussed. Formal presentations are emphasized through the proposal presentation during the fall term and a spring presentation of the final reports. While the proposed plan is effective, it is still professor dependent. The “syllabus of record” fails to convey these ideas and a professor may or may not choose to emphasize oral communications.

To solve this latter problem, an Oral Communications Thread is being created to document the education emphasis. While it will be an internal department document, it will be approved by the ISE UCC and the faculty much like any curriculum change. Additionally, the Plan for Integration will map the thread learning objectives into the learning objectives of the specific courses. While the process may seem to add burden to curriculum development, it is felt that it

substantially increases the integration of the curriculum, which can be a problem in many programs and is specifically problematic in larger programs like ours.

As stated earlier, the first step in the process is to create a thread Description. We are reviewing the catalogue description and the learning objectives for COMM 2004 Public Speaking to get an insight into what a Communications faculty might write into a course proposal. The catalogue description for the course states:

Basic skills of public speaking; speech organization and delivery; emphasis on in-class delivery of speeches.

The course learning objectives for COMM 2004 are:

Students should be able to:

- learn the basic theory/concepts of oral communication in a public setting.
- become more effective communicators...to do this, they should develop or refine their skills in: a) analyzing and adapting to the audience, b) selecting, researching, and supporting topics, c) organizing, outlining, wording, and delivering extemporaneous presentations, and d) speaking individually, and in group contexts, in informative, persuasive, constructive feedback and question and answer formats.
- understand the impact of, and incorporate new technologies, including computer presentation software, in oral communication.
- become more critical thinkers, speakers and listeners.
- learn the concepts of, and practice ethical communication.

From the ISE program standpoint, an Oral Communications Thread should address the basic theory and concepts of oral communication much like a Communications course. Additionally there should be an emphasis on personal and small group communications associated with one-on-one meetings and shop floor discussions. We want to focus specifically on having the students present the results of their analysis and designs developed in the courses and do not feel the need to address the areas of gathering and organizing information and data associated with more general presentation. Rather, there is a strong emphasis presenting the solution they are proposing and on highlighting aspects of their methodology. While the initial student presentations given in ISE 3014 are informative in nature, presentations in the subsequent courses emphasize persuasive arguments. From the above, it is fair to say that the Oral Communications Thread includes the concepts and skills necessary to present and explain concepts of an engineering design. Both formal and informal communications are emphasized through in-class and field-based experiences. While descriptive presentation concepts are covered, persuasive arguments are emphasized.

There are two different aspects of the justification for inclusion of an Oral Communications Thread within the ISE curriculum. We believe it is simply not enough for an engineer to be able to perform an appropriate analysis or create a design to solve a problem. To be successful, the engineer must justify their analysis to their supervisor or convince a decision maker that their design solution is the one that should be selected. Good oral and written communication skills are a must. Next, the current Communications course lacks an emphasis on persuasive

presentation skills desired in the ISE 3214 and ISE 4005/4006 courses. It is felt that inclusion of the thread will place the desired emphasis in this area. While having the students take COMM 2004 prior to these courses would be ideal, there is not enough room in the curriculum to add that requirement. ISE 3014 serves as the introduction to oral communications for all but a few of the students. Students that are seen to have a problem in this area are counseled to take COMM 2004 as a non-technical elective.

While it would be appropriate to present the learning objectives for a proposed Oral Communications Thread, we are not to that point. We are presently reviewing the three ISE courses to see what we are doing well and where we might improve. Because the thread is conducted “in-major,” the students are more likely to be interested in the topics selected. In a public speaking course, there are students from many majors and often times the topics are trivial, e.g. “How to bake a cake.” Between the three courses, a reasonable amount of basic theoretical concepts of oral communication are covered, but there needs to be a more specific identification of which concepts are covered in each of the courses. Presently the evaluations done in each course are somewhat independent. Better integration of the presentation evaluations will place more emphasis on improving speaking skills across the four-semester sequence. Opportunities are provided for both individual and group presentations as well as formal and informal oral presentations. Interestingly enough, there is little emphasis on preparation of the presentations, nor is there much thought given to audience analysis. While the former is an assumed capability of all of the computer oriented engineering students, the latter is not. Presentations are taped in both ISE 3014 and ISE 4005/4006 and the students review these tapes with the instructor. In ISE 4005/4006, the students experience the greatest emphasis on oral communications. In these courses, the students

- Use a variety of speaking styles, gradually gaining confidence with extemporaneous speaking,
- Experience a variety of audio-visual media in technical presentations,
- Practice question and answer processes under different questioner scenarios.
- Experience more intense questioning as the term progresses,
- Practice effective voice inflections, loudness, rate and pitch in technical presentations,
- Apply techniques for transitioning among multiple speakers, and
- Are weaned from index cards and other notes and master extemporaneous speaking.

Our next step will be to create a list of thread learning objectives that detail our thoughts on what we should be including in the four-semester sequence. Once this has been done, we will be ready to formalize the Plan for Integration by breaking up the objectives across the courses concerned and revising the existing course to include these objectives in the formal course proposal. As stated earlier, both the Academic Thread document and the revised course proposals will be presented to the faculty.

Possible Extensions and Strengths and Weaknesses

There are a number of Academic Threads under consideration by the ISE UCC. These include:

- Oral Communications
- Written Communications
- Teaming and Team Building
- Engineering Ethics
- Computer Application Skills
- Economic Evaluation of Alternatives
- Applied Optimization

The first four threads are associated with the “soft skills” that are necessary to practice engineering in today’s marketplace. Each of these might be addressed by adding a course to the curriculum, by integrating it within a set of ISE courses, or by a combination of the two alternatives. Since each of these threads represents ideas and concepts that are already covered in various places within ISE courses and in courses taken from other departments, we have the basis for beginning our thread development. Creating an Academic Thread associated with any of these areas will serve to formalize the particular objectives and provide points to make evaluations. The “computer thread” is being considered to ensure that all graduates from the program have the basic skills necessary to use appropriate computer applications in industrial engineering analysis and design. Because we rely on the students gaining these skills through self-education, we do not necessarily measure their performance while they are learning. Rather, we see their capacities when they apply their knowledge for a particular analysis or design. As the particular problem changes with each design experience and an individual student only experiences a limited set of the design problems, we are looking for ways to ensure basic capabilities in all of the students. The latter two threads are somewhat different. They are being considered as a means of insuring that concepts that are covered early in the curriculum are integrated at appropriate points within advanced courses to strengthen the students’ ability to apply appropriate analytic techniques for real-world problems.

There are a couple a positive things that are immediately obvious when you consider Academic Threads. Firstly, as conceived, creating an Academic Thread formalizes the integration of some specific topic across a small set of courses within the curriculum. That “institutionalization” is, in itself, an important factor. The thread learning objectives state what the students should be able to do upon completion of the courses with respect to that particular topic. Secondly, they provide a basis of performance evaluation. Next, we have found that Academic Threads can address narrowly defined ideas as well as broad topics. Thirdly, an Academic Thread serves to integrate curriculum concepts and helps the students view the curriculum as an integrated process where courses build on prior experiences to strengthen and further develop the capabilities of the individual student.

On the down side, creating an Academic Thread is a difficult task that involves multiple faculty. Curriculum integration is not easy. Furthermore, since the thread learning objectives are to serve as inputs for course revisions, the process may threaten a “sacred” course of some particular faculty member. On the technical side, the learning objectives for a thread seem to be more detailed than they have been for a course proposal. This can present a problem when revising the course proposal. Finally, the focus on curriculum integration can lead some departments to eliminate valuable courses offered by other departments and concentrate solely within the

department for the development of the curriculum. Careful examination of the desired outcomes can help avoid this problem.

While we are only in the initial stages of development of Academic Threads, we believe that the concept has significant promise for curriculum enhancement and performance evaluation. The initial attempts at loosely spreading oral communications across the courses identified begins to develop cracks as different faculty are assigned to teach the courses. The Oral Communications Thread will identify the specific course learning objectives of the courses concerned so that a faculty member will know the boundaries of the course he or she is teaching. Additionally, it will let the faculty, as a whole, focus on how we are addressing the critical component of the Program Learning Objectives.

References

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