Session #2457

An Integrated First Year Curriculum in Industrial and Systems Engineering

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Abstract

A new, integrated first year curriculum has been developed in Industrial & Systems Engineering (ISE) at Rochester Institute of Technology (RIT) that possesses increased practical content, additional active learning opportunities, and a stronger sense of identity among first year Industrial Engineering students, who typically have difficulty defining the common roles and contributions of professional Industrial Engineers. The new first year curriculum was designed so that ISE students have a thorough introduction to Industrial Engineering concepts, tools/software, and analysis techniques.

The revamped four course sequence makes use of common case studies throughout the year for continuity and practical content and students gain a vivid understanding of what an Industrial Engineer does. The courses that have been revamped are Introduction to Industrial Engineering, Materials Processing, Computer Tools, and Freshman Seminar. Students are exposed to the conceptual areas of problem solving, integrated product and process design, work measurement methods, manufacturing processes, layout, and ergonomics to name a few. The students are also provided with a set of tools/software to learn and use throughout the integrated sequence that have been identified by faculty, students, and co-op employers as key tools for Industrial Engineers, namely AutoCAD, Access, MS Office, and MS Project. The classroom and laboratory experiences are supplemented with plant tours, common case studies, and a variety of demonstrations. Analysis techniques are typically taught in team-based, application formats that provide the student with exposure to the methods, which has been shown to increase the enthusiasm of students. The main thrusts of the new curriculum are active learning and exposure, with details and theory to follow in more advanced courses later in the curriculum. Additionally, a benefit to the new structure is that ISE students are in class together during each quarter of the first year and are able to form a more cohesive and productive group with retention as a side benefit.

The integrated structure and content of the course sequence, case studies, and projects will be described. In addition, changes and additions to the sequence will be presented in light of student evaluations and feedback.

Existing Curriculum

The 1st year courses in the existing curriculum did not possess much 'applied-design' content and were not integrated in a meaningful way. Students took two independent 4-credit hour courses to learn basic methods/measurement and materials processing concepts (i.e., Introduction to IE and Materials Processing). Students then took a 2-credit hour "Computer Tools" course, where they did tutorials to learn some necessary computer-aided drafting (e.g., AutoCAD) and database (e.g., Access) programming, and a 1-credit freshman seminar which provided a potpourri topics not covered in other 1st year courses (e.g., co-op, field trips, etc.). Even though the courses required projects, they were not applied, or real-world, in nature. The courses had been receiving low course evaluations, with students indicating that the lectures were "boring" and they wanted to do more "design", even though the students later admitted the material was useful and necessary. In addition, it was unclear whether students needed additional skills in these courses to prepare themselves for co-op and subsequent course work in their 3rd year (e.g., Microsoft Project). Previous work has shown that topics taught in team-based, application formats that provide the student with exposure to the methods increase the enthusiasm of students and improve the retention of material.[1, 2]

Initial Assessment

In an effort to better prepare our first-year students for co-op and subsequent course work, we gathered input from our constituents via student course evaluations, student co-op reports, employer co-op reports, student focus groups, and our industrial advisory board. The feedback we received can be summarized below. The development of the proposed curriculum attempted to address these issues.

- Students indicate they do not need instruction in MS Office (MS Word, Excel, and PowerPoint), they are now coming to RIT with these skills already
- Students want to design 'things' and not just do process design
- Students indicate tutorial method of teaching Computer Tools is boring
- Students indicate they REALLY like plant tours
- Students like the 'hammer' project in Materials Processing, but lecture is boring
- Employers want students with AutoCad, Access, and MS Project
- Employers indicate students still need basic work methods and measurement skills

Proposed Curriculum

Provost's Learning Innovations Grant - Support for curriculum development and innovation at RIT is provided on a competitive basis through the Provost's Learning Innovations Grant (PLIG). The authors were awarded a PLIG for fiscal year 2003-2004 to support faculty time necessary for the curriculum development described here. A significant effort has been made to develop case studies that can be integrated throughout the four course sequence to provide the students with as much continuity as possible.

Intro to Industrial and Systems Engineering (ISE)- Intro to ISE has been revamped to include additional design content and to allow students to be able to not only learn about process design, but also learn about product design. The first half of the course focuses primarily on product design, while the second half of the course focuses on process design. By exposure to the entire design cycle, students are better able to understand and appreciate the interaction between product and process design (e.g., students wished they considered alternative designs once they try to minimize the assembly time). There is a design project supporting the course content that requires students to work in teams to design and build a simple product (e.g., medieval style ball launcher) to given specifications, as well as consider process requirements (e.g., design of workstation to build product, product assembly/disassembly time, etc.). In addition, there are additional projects that focus on applying other process tools to real-world manufacturing and service tasks (e.g., time study of radiator fan assembly task, process flow of cafeteria). Students are also required to learn/use Microsoft Project to track their design project as well as use Microsoft Word, Excel, and PowerPoint to generate project reports and presentations. Finally, the course is enhanced with field trips, so that students can see IE tools applied in the real-world, trips to both manufacturing and service industries are included.

Computer Tools- Computer Tools is a course designed to give students an appropriate background in computer software tools to support their future education and career needs. The students are given exercises and case studies in AutoCAD that support both part design and plant layout. The students use the radiator fan case study that they have seen previously in Intro to ISE to design an assembly cell and an overall plant layout. Additionally, the students develop a major project in Access to do inventory tracking and control. The students once again use the radiator fan assembly as a basis for this project. The students are also required to use MS Office to produce reports, Cambridge Material Selector to do material and process background work, and World Wide Web browser / e-mail for research and project submission.

Materials Processing- This is a long standing course with significant tradition at RIT. The content of the course is design, materials, and manufacturing processes, and the interaction of the three. The students have a lab in a machine shop once per week and manufacture the beloved RIT hammer. Working with machines and materials is supplemented by a theoretical and practical treatment of the subject in 3 lecture hours per week. The students leave the course with an understanding of how things are manufactured at the component and assembly level in modern manufacturing.

Freshman Seminar- The purpose of the Freshman Seminar is many-fold. The course serves as a forum to introduce the students to critical services and activities on campus such as student services, co-op office, library services, academic advising, as well as a forum to provide the students with a great deal of perspective. The introduction to services is rather straightforward, and includes a campus wide scavenger hunt. Co-op (required at RIT) is typically introduced to the students through a panel of upper classmen and a short talk from the co-op office director, with liberal time for questions and answers. Perspective in ISE is achieved by a lecture and group discussion of engineering ethics, and a few team projects that integrate topics from the rest of the first year courses. The main project is a design and programming exercise that uses a Lego MindStorms platform to complete some automated task. An end of year contest is always a highlight of the first year and serves to solidify the group for the subsequent four years of their education together.

Integration of the Curriculum

The key to the success of the new first year curriculum is the integrated nature of the education the students are receiving (Figure 1). Through the new first year curriculum the students are introduced to a complete set of tools to serve them throughout their entire engineering education. This is accomplished by design activities, through case studies that are used throughout the sequence, and a natural progression and building of the topics covered. By the end of the first year the students have a complete picture of Industrial and Systems Engineering, they have studied a variety of industrial case studies in depth, and they have used a variety of analysis tools. The natural progression of the curriculum has been designed to allow the students to begin with elementary analyses and techniques such as manual charting methods and progress to more advanced techniques including database design and development. The only major obstacle to this method of instruction is that students cannot begin their study at any time of the year other than in the fall with the beginning of the sequence. This can put transfer students and those students with the need to repeat courses at the disadvantage of having to wait for the next yearly course cycle to begin.

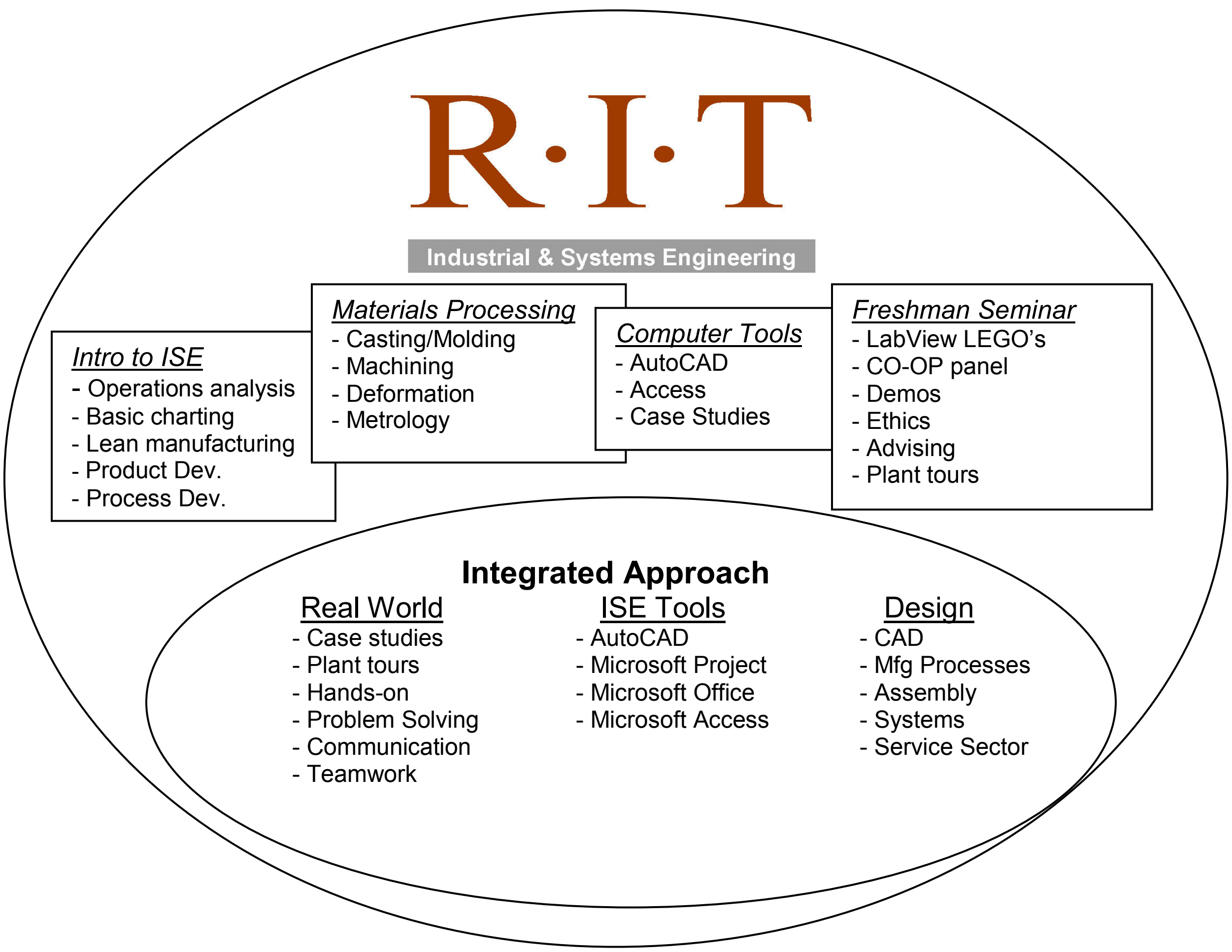

Figure 1: An integrated approach to design in the first year ISE curriculum

The primary case study was provided by Valeo, a local company, in the form of an automotive radiator fan assembly (Figure 2). The recurring reference to the same assembly case gives the students a complete picture of what is needed to design, manufacture and assemble a real product and they achieve a level of confidence and familiarity that is often missing in first year students[3].

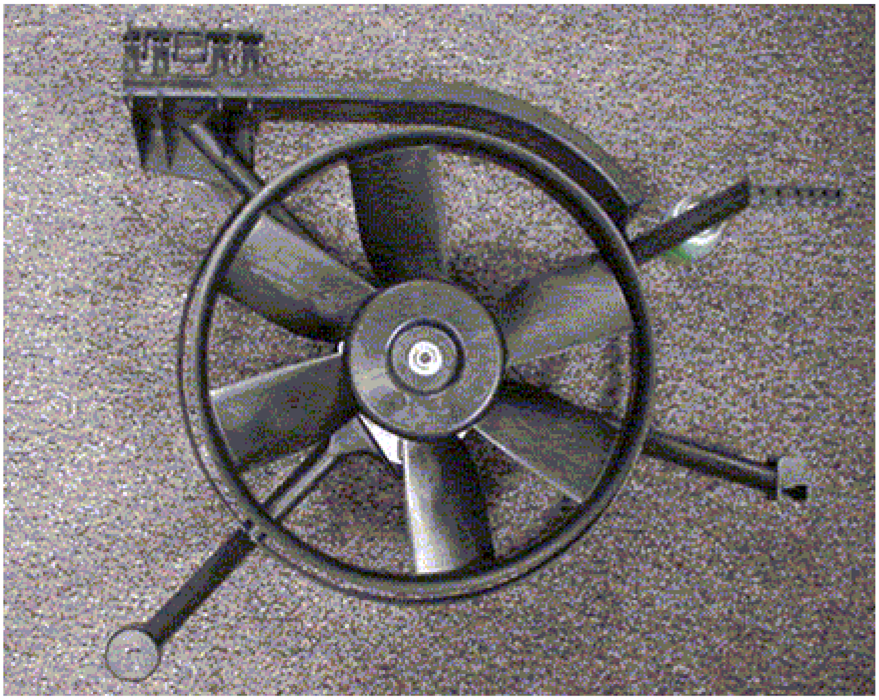

Figure 2: Automotive radiator fan assembly used for first year case study, courtesy of Valeo.

Computer software tools are integrated throughout the first year through the required use of Microsoft Office Tools (i.e., Word, Excel, Power Point, and Project). Students are required to use MS Word, Excel, and Power Point to generate all project assignments and presentations. In addition, students are required to use MS Project to track project progress in both Intro to ISE and Freshman Seminar. Finally, AutoCad is introduced in an applied project in Computer Tools and also used for part design in Materials Processing.

In addition to the case studies and software tools being integrated across the new curriculum, student projects are continued from course to course so that they build throughout the entire year. The launcher project is developed in three of the four courses and allows the students to experience some added continuity.

The team approach and case study method lend themselves very well to hands-on, active learning which are also integrated throughout the four courses in the first year. Engineering is fundamentally a discipline that deals with things and people using things, thus engineering education must include practical aspects. It is the consensus of educators that students who "do," remember and gain a deeper understanding of the ideas, concepts, and methods they are taught.[4] A 2000 ASME survey of companies showed that the two most valued traits of a graduating engineer are teamwork skills and communication skills[5]. This new curriculum seeks to directly address both of these topics as foundations of the entire curriculum and the students' engineering education.

Engineering education at RIT is very application oriented and has as a main focus preparing students for a career in engineering. Cooperative education requirements are the main way that this objective is achieved in the five year BS program, but co-op sessions typically do not start until the third year. The use of case studies introduces students to real world examples in the first year, but plant tours and demonstrations serve to more effectively expose the students to the real world from the beginning of their education. The new curriculum also integrates a variety of plant tours in both the manufacturing and service sectors into Intro to ISE, Materials Processing, and Freshman Seminar. This exposure is a memorable way to reinforce classroom topics and to let the students hear from practitioners.

It is also important to note that this course sequence directly supports at least five (out of ten) of our ISE program outcomes, which were developed in conjunction with our constituents (i.e., employers, alumni, students, faculty) and required by our national accreditation body, the Accreditation Board for Engineering and Technology (ABET):

- ***"Engineering Foundations"*** - Apply math, science, and engineering principles to identify, formulate, analyze, and solve industrial engineering problems using appropriate techniques, skills, and modern engineering tools necessary for engineering practice.
- ***"Experimentation"*** - Design and conduct experiments, as well as analyze and interpret data, to solve industrial engineering problems
- ***"Multi-disciplinary Teamwork"*** - Function on multi-disciplinary teams to develop team problem solving, project/time management, and communication skills.
- ***"Communication"*** - Communicate effectively through written, oral, and graphical means
- ***"Contemporary Issues"*** - A knowledge of contemporary issues and an understanding of the impact of industrial engineering solutions in a global and societal context

Assessment

At this time, only the revamped Intro to ISE course has been delivered and course evaluations completed (Fall 03). The overall course average increased from 3.65/5.0 in Fall 2002 to 4.3/5.0 in Fall 2003. Students indicated that they liked the quarter-long design project that included both product design and process design. Individual course evaluations will also be completed for the other three courses, once these courses have been delivered (Winter and Spring 04). In addition, a formal assessment tool is being developed that will allow students to evaluate the entire integrated sequence at the end of the four-course sequence (Spring 03) with respect to the integration of the topics covered, retention of these topics, and enthusiasm for these topics. Both qualitative and quantitative data (i.e., rated data and ranked data) will be obtained and evaluated. The new curriculum will also be presented to the department advisory board and additional feedback will continue to be solicited from students in an effort for continuous improvement and assessment.

Conclusions and Future Work

A new first year curriculum has been developed in the ISE department at RIT. The integrated four course sequence includes courses in Intro to ISE, Materials Processing, Computer Tools, and a Freshman Seminar. Integrated case studies used throughout the entire sequence and a focus on hands-on, practical, active learning opportunities have led, at least initially, to greater improved student satisfaction. It is anticipated, with further evaluation, that further improvements will be seen. It is expected that the course sequence and content will also aid in retention and students' preparation for co-op and subsequent course work. The curriculum is due to be fully implemented in the 2004-2005 academic year after preliminary implementation and full assessment in the 2003-2004 academic year.

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Biographical Information

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