AC 2012-2988: COOPERATIVE EDUCATION IMPACT ON ENHANCING MECHANICAL ENGINEERING CURRICULUM

Dr. Nashwan Younis, Indiana University-Purdue University, Fort Wayne

Nash T. Younis is a professor of mechanical engineering at Indiana University-Purdue University, Fort Wayne. He has been the cooperative education coordinator of the mechanical engineering programs since 2000. He received his Ph.D. in engineering mechanics from Iowa State University in 1988. Younis is the recipient of the 2002 Illinois/Indiana Section of the American Society for Engineering Education Outstanding Educator Award. In addition to curriculum and assessments issues, his research interests include sensors and optical experimental stress analysis.

Cooperative Education Impact on Enhancing Mechanical Engineering Curriculum

Abstract

The engineering practice continues to evolve; yet engineering education has not changed at the same rate. To ensure relevancy, engineering programs must stay abreast and adjust their curricula to the ever rapid changing employer market requirements. Most assessments focus on evaluating curricula utilizing reports and surveys. The intent of this paper is to start conversation among cooperative education professionals and researchers regarding the impact of co-op work on the whole mechanical engineering curriculum. The emphasis is on the importance of site visits.

Introduction

Higher education institutions (HEI) can no longer operate in isolation. The need for engineering education change has led industry and constituents to question the relevancy of engineering programs. According to the analyses conducted by The American Society of Mechanical Engineers[1], it is common for engineers to participate in or lead project management teams, which require working knowledge of procurement, financial analysis, sales and marketing, and other non-technical areas. As a result, updating the program educational objectives and the course outcomes is essential for every engineering program.

Engineering programs utilize assessment methods that include both direct and indirect measures. Many articles have been written about important assessment tools such as alumni feedback, employer surveys, constituents input, etc., with much emphasis on surveys. On the other hand, faculty assesses the outcomes in their classes and are very creative in developing assessment methods. However, traditional assessment techniques are not always adequate to measure student learning. Rover[2] lists many important questions for educators to ask and answer regarding what to teach, how to teach it and, becoming increasingly more important, when to teach it. Therefore, HEI must keep up with pace changes in the "real world" through non-traditional assessment tools. One of them is the interaction with industry through the co-op site visit.

This paper deals improvements related to engineering program effectiveness. The emphasis is on enhancing the curriculum utilizing our unique co-op mechanism of interaction with employers. Details to be presented are of a non-traditional assessment tool for engineering programs: the cooperative education feedback and industry site visitation. The validity of this supplementary assessment tool is discussed regarding the achievement of program outcomes and enhancement of curriculum.

Cooperative education

Cooperative education is a structured educational experience where students alternate between sessions of full-time work and full-time traditional study. Thus, an engineering co-op program enjoys a unique relationship with employers in business and government as suppliers of motivated and educated students in exchange for paid on-the-job learning experiences. The impact of co-op education on engineering students has been examined by many professionals. For example, Blair et al.[3] results indicated that engineering students who completed a three-semester co-op education program earned higher GPAs than non-coop students and earned more in terms of starting salaries, but took two semesters longer to complete their undergraduate program. In addition, at Indiana University-Purdue University Fort Wayne (IPFW):

- 94% of Co-op students persist to graduation
- 91% of Co-op graduates land career-related jobs within 1-2 months of graduation
- 75% of Co-ops accept full-time career-related jobs with Co-op employers

Cooperative Education was created at The University of Cincinnati in 1906 as a new teaching methodology in its College of Engineering. Today, hundreds of thousands of students across the country, studying everything from accounting to zoology, continue this growing educational experiment, combining traditional classroom learning with paid, major-related professional experiences, just like those first University of Cincinnati co-ops. Despite this long history and the great benefits to students, little was known about the faculty's reaction to cooperative education. In 2005, Contomanolis[4] surveyed engineering faculty at the six largest engineering cooperative education programs in the United States to assess their views about the academic value of co-op education. The results suggested that HEI should more aggressively seek ways to better engage faculty with cooperative education to maximize the co-op student's learning experience.

Curriculum-Co-op relationships

As a co-operative education faculty coordinator, I have come to understand that learning can be achieved in many ways. While there are definitely opportunities to learn in the classroom, learning comes, for many students, from hands-on experiences such as co-op. The co-op experience can be extrapolated to the mechanical engineering curriculum to benefit all students in the program. This will ensure faculty engagement because faculty are passionate and protective of curriculum matters. Regarding co-op learning, a qualitative research study by Jones in 2007 explored the importance of connected learning in co-op education in Canada[5]. There are many important studies about work-integrated learning[6, 7] as well as research on the impact of cooperative education experience on students' academic performance[3, 8]. There is a sound body of knowledge in co-op education curricula such as Johnston[9] who introduced the notion of critical pedagogy to the cooperative education curriculum. Fleming and Ferkins[10] focused on the structure and delivery of the co-op courses within sport degree programs in eight HEI. However, the impact of co-op work on the whole curriculum is an under-researched area.

According to Breen and Hing[11], cooperative education partnerships benefit universities as it enhances the range and quality of educational offerings, as well as university status and reputation in the discipline. The intent of the next sections of this article is to highlight the interaction between employers through co-op and the mechanical engineering curriculum at Indiana University-Purdue University Fort Wayne. To achieve this, we start with introduction of our co-op program.

Indiana University-Purdue University Fort Wayne Co-op

This year IPFW's Co-op is celebrating its silver anniversary. The mission of the IPFW Cooperative Education Program "is to offer high-quality, academically-enhancing paid employment opportunities to bachelor's degree students. We strive to prepare them intellectually, technically, culturally, ethically, professionally, and socially for the demands and opportunities of an increasingly changing world". The program is highly successful and has a proven history of benefits to students, employers, and IPFW as more than two thousand-co-ops worked with more than four hundred employers mainly in northeast Indiana but other locations, too. The university co-op office and the department's co-op faculty coordinators actively encourage participation in this program.

Students have the opportunity to choose from the following options:
Alternating Co-op **-** Students have the opportunity to alternate semesters of full-time study with full-time employment. They can co-op 3-5 semesters.

Parallel Co-op **-** Students work 10-24 hours per week while attending IPFW. A minimum of two semesters are required and the student may continue working with the employer until graduation. An employer may also request full time work from the student during summer break.

Internship **-** Students work one semester only paid internships; usually fulltime in the summer or part-time (24 hours) in the fall/spring. Majors approved for this model are non-engineering.

The following requirements must be met:

- Currently enrolled bachelor's degree student with an established IPFW GPA
- Completed freshman requirements in the major
- Earned a minimum overall GPA of 2.5/4.

This is a well monitored program as each co-op student reports to a supervisor at their work site. The cooperative education office partners with employers covering a wide range of academic areas. Through this collaboration, employers provide job opportunities and our university submits applicants eligible for co-op meeting company job requirements.

Table 1: Listed curriculum advantage

One of the listed advantages of co-op to:	*is*
students	Test *classroom theories* in an employment setting
employer	Provides input into university *curriculum*
IPFW	Keeps *curricula* up-to-date with changes in industry

Curriculum

The mechanical engineering (ME) program is accredited by the Engineering Accreditation Commission of the Accreditation Board for Engineering and Technology (ABET)**.** ABET requires that engineering programs seeking accreditation use appropriate, regularly documented processes to assess and evaluate attainment of program educational objectives and student outcomes. Also, the program is required to show evidence that the results of evaluations are used systematically as an input for continuous program improvement. The mechanical engineering program outcomes are listed in the Appendix I. Next, the work site visit will be explained, as well as, the utilization of industry as an avenue for direct input into college education.

Mid-term work site visit

There are tendencies that academic professions become ever more specialized as a result of field knowledge increase as well as rapid technological development[12]. Our constituents need is that graduates must be academically diversified. Assessment can be instrumental in encouraging and maximizing learning[13]. Therefore, after students begin work, the ME co-op faculty coordinator and the university co-op program director visit the work site at the mid-point of the work experience (around mid-term grade time during a full semester co-op placement). The length of the visit is 30-45 minutes with time split between the student and supervisor. During the visit, university representatives meet with the student to discuss the student's job responsibilities and their applicability to curriculum. Students are expected to assist in the scheduling of the visit as an assignment. They must prepare for the visit by making a presentation of their work. Faculty co-op coordinator, university co-op director, and industry supervisors guide students in their efforts to construct meaning from their experiences, develop personal and professional insights and future goals. The site visit is critical to:

1. The success of cooperative education experience

Many employers in northeast Indiana and northwest Ohio sponsor cooperative education opportunities for our ME students. The mechanical engineering co-op faculty coordinator approves co-op positions based on the general description of the position assignments and departmental criteria. Upon position approval, students may begin the interview process. The coordinator revisits the job tasks during the site visit through student's presentation of past and current projects, in addition to the supervisor's proposed projects for the student. This process ensures that the co-op experience gives students the chance to explore how classroom theory relates to actual employment opportunities as we discuss how and what students are learning from their co-op participation.

On the other hand, the co-op program director's role on the visit is to maintain student and employer compliance with program policies and procedures. The director ensures the student is supervised by a qualified manager and that the student is provided with diverse work of increasing difficulty and responsibility commensurate with the co-op's abilities and curriculum progress. The director also monitors that the employer does not hire the co-op student before the student graduates so persistence to graduation is not negatively impacted. Regarding student compliance, the director makes certain that the student does not exceed the maximum of allowed work hours, follows course enrollment guidelines and is following the applicable model of placement (alternating or parallel). Due dates for co-op assignments and return to their co-op position are reviewed with the student. The director is also at the visit to cultivate and develop the relationship with the employer, discussing current and future opportunities for student positions.

Students enrolled in our co-op education programs acquire many positive results, but they do not come without effort. In order to succeed, co-op students must draw on multiple resources. One important resource is the relationships that learners build with supervisors, co-workers, co-op staff and faculty. Through these relationships, our co-op students have the opportunity to work, converse, listen, and learn. During the site visit, students practice connected learning as they present the assignments and projects completed. In addition, student's reflection in experiential education is recognized as a valuable tool in learning and development[14]. According to the study by Griffin, Lorenz, and Mitchell[15,] reflection is the most important aspect of the InCoRe model. In this sense, reflection refers to the process of linking current experience with prior experience in an attempt to increase the attainment of program outcomes within a given discipline and self efficacy.

When co-ops are asked what they learn, the majority reply that it is their ability to apply theories and concepts to everyday situations and make appropriate suggestions for the completion of the projects. This educational outcome can be accomplished because co-op is a training program. Indeed, employers do design assignments based on students' academic development with supervisors and mentors to help students. However, few students assess the experience as not directly related to the mechanical engineering field. Sometimes the ME coordinator cannot map the co-op work to the mechanical engineering program outcomes. The approved co-op job description (3-5 semesters) serves a good starting point for remedy. The director and coordinator discuss the students' current, past and future projects with the supervisor and link it to the job description approved prior to student placement. After the above personal interaction, the director and coordinator follow-up on the projects to ensure the success of the cooperative education experience for the student's second half of the semester. Waiting until the end of the semester to resolve issues could jeopardize the intended success of the co-op experience and perhaps discourage the students (and possibly their parents) from continuing participation in the co-op program. The assessment loop will be closed at the end of the semester to maintain the integrity of the educational process as the primary focus of cooperative education.

2. *Assessing the context of learning outcomes closer to the application of knowledge in working life*

Implications for educators and students regarding reflection and attainment of program outcomes will be discussed here. Many educational theorists advocate an approach that people learn from experience and by doing and education is grounded in experience[16]. Because co-ops are active learners who take responsibility for their own learning, the practical involvement in applying mechanical engineering concepts can be used to assess the curriculum effectiveness in achieving the program's outcomes. For example, there is an emphasis to include a communication instruction in the engineering curricula[17]. A co-op faculty coordinator can assess the ability of students to communicate effectively (ABET outcome g). This is a unique assessment tool because of the nature of the work and the industrial element of the co-op assignment compared to a traditional academic report or presentation. In general, the co-op students write better than traditional students due to the industrial experience. As co-op student engineers, they write technical reports, memos and make presentations. In addition to the technical and engineering fundamental components, realistic engineering economics, marketing, feasibility, and manufacturing elements are required in both oral and written communication. Thus, the students' feedback and supervisor's input can be utilized to improve the programs' communication outcome.

The table below shows five samples of assignments presented by students and reported by supervisors during site visits. These academically related and challenging content of student work assignments are mapped to the ME program outcomes. Also, sample inadequacies and curriculum observations are listed.

Table 2: Sample work and curriculum notes

Academic Standing	Work related to	Program Outcome	Curriculum
sophomore	1. Computer aided design	6	3-D needs more coverage
	2. Product inspection	1	good
	3. Documenting safety procedures and codes	7	adequate
	4. Dimensions and tolerances	6	weak/could be enhanced
	5. Testing	5	good
junior	1. Design of experiments	3,5	good**,** but statistics can be improved
	2. Manufacturing process	2	weak
	3. Materials/development	1, 2	good/processing weak
	4. Evaluate tooling requirements	6	adequate/knowledge of manufacturing can be enhanced
	5. Failure analysis	4	very good
senior	1. Design of machine components	1,4	excellent
	2. Presentation of final product to engineers	8	very good
	3. Research & development	9	good/manufacturing terminology
	4. Actuators control	1, 5	good
	5. Product reliability	2, 7	satisfactory

The red remarks need to be addressed. The repeated weaknesses and concerns will be reported by the co-op faculty coordinator to the assessment committee and the loop must be closed.

3. Utilizing the employers input through discussions for continuously improving the curriculum

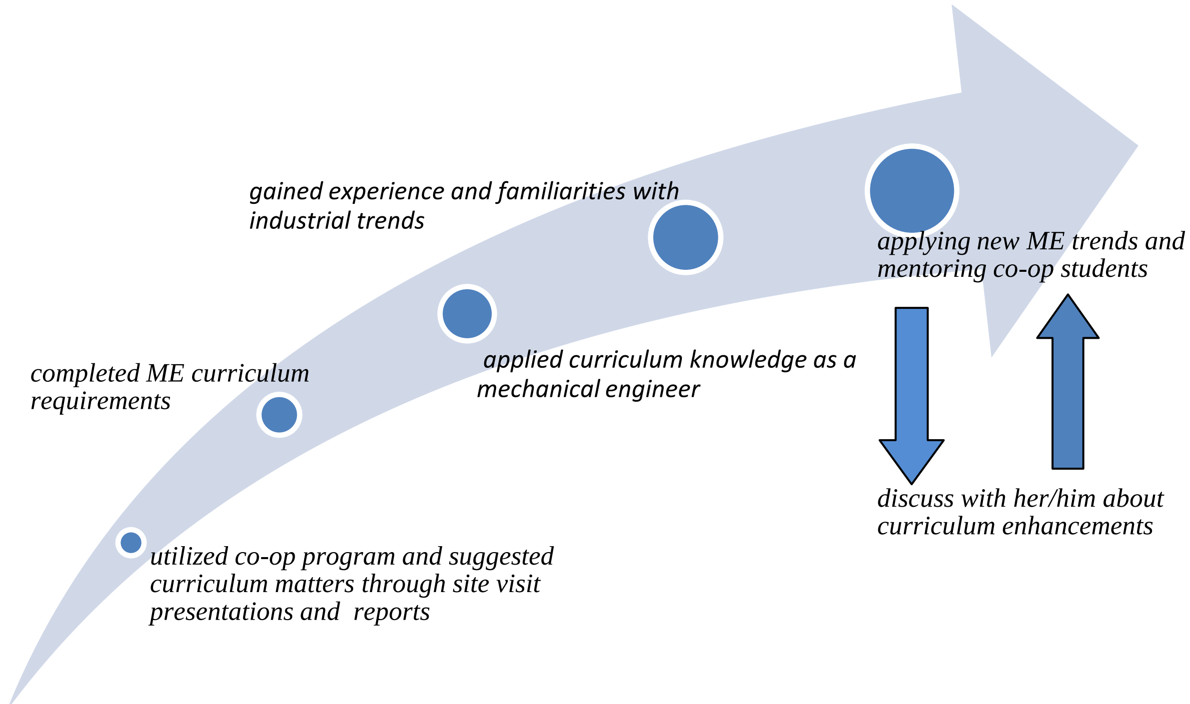
While student gains a firsthand look at cooperate culture and an organization's working environment, co-op potential employees are excellent resources for future employers. Employer inputs can indicate how well students are prepared for the workforce, and they can assist program faculty to assess how well their curriculum relates to industry needs. Unfortunately, finding ways to reach employers with surface mail and e-mail surveys is difficult as the number of employers responding to mail surveys is typically small and decreasing since more academic programs are seeking employer input. Employers value not only partnerships with HEI but opportunities to provide input on quality and relevancy of HEI curricula. Thus, faculty must become more creative in finding avenues to reach employers. For instance, a focused discussion group's approach assessment data provides an opportunity to probe for deeper understanding of responses[18]. Liangrokapart[19] et al. describe procedures for planning and conducting focused discussion group sessions with corporate recruiters. For robust curriculum development, we utilize the co-op site visit by discussing with supervisors the relevance of the students' theoretical training from our university to their on-the -job training and learning.

The employer assumes the primary role as educator while supervising IPFW students. Progress and performance are reviewed by the supervisor with the student. The site visit can help create a bridge between the employer and the student's academic institution by providing a vehicle for corporate input into academic studies. Indeed, employers of our co-op students have provided valuable feedback about course curricula and content as shown in Table 2. It is worth mentioning that several remarks in the table are the repeated by many supervisors. Through mentoring of our co-op students, supervisors are able to discuss the strengths and weaknesses of students' academic preparations. Moreover, a focused discussion at a work site offers the opportunity to ask questions about specific and in-depth curriculum issues and may yield data or insights that are unlikely to emerge from individual responses to a survey questionnaires or end-of-the semester employer evaluations. This is because people are less inclined to complete long questionnaires. Short simple questionnaires usually attract higher response rates than long complex ones[20]. For instance, one of our employers' survey questions that was conducted in April 2011 is …engineering graduates:
"*Possess a sound foundation in the mathematical, scientific and engineering fundamentals necessary to solve engineering problems*"
First, the response rate was as expected low (20%). Nonetheless, the results were positive. A similar question was used in the alumni survey conducted at the same time: Based on your experiences, do you feel that the IPFW engineering department has achieved these objectives?
"I possess a sound foundation in the mathematical, scientific and engineering fundamentals necessary to solve engineering problems and to pursue graduate study"
The response rate was 43% and positive, too. According to sample results shown in the above table, the employers generally perceive that the students (based on academic standing) have the basic knowledge in math, science, and engineering fundamentals. However, the devil is in the details! Feedback from co-op supervisors representing orthopedics, clutch, door, and other manufacturers is that students possess the basic knowledge in engineering materials (chemistry and materials science). On the other hand, co-op students, as well as many mechanical engineers, do not recognize the strong interrelationships between material properties and manufacturing processes. This was the trigger for a new manufacturing processes course that will be discussed in closing the loop section of this paper.

Supervisors also provided us with information on current research and development in employer sectors. Many supervisors, former co-op students themselves, are aware of the value of the co-op experience. Alumni as supervisors, mentoring students in the work place, provide the perfect scenario for curriculum enhancement. The figure below is a summary of the employers interaction with a ME curriculum.

Additionally, the department has adopted a set of programs objectives that describe the anticipated accomplishments of our graduates 3-5 years after graduation. Visiting with alumni and supervisors at work sites can be extended to assessing the program's educational objectives.

Conducting focused site discussion sessions with employers offers the opportunity to collect important employer insights while avoiding some of the difficulties associated with other data collection approaches.



4. Gauging the academic preparedness of students as compared to Co-op students from other universities probing

University rankings, novelty years ago, are today a standard feature in most countries with a large higher education system[21]. Wherever rankings and comparison in HEI have appeared, they have met with a mixture of public enthusiasm and institutional unease. Academic performance is measured using the cumulative grade point average (GPA). Other characteristics and educational outcomes such as leadership, exposure, creativity and motivation are not directly reflected in HEI transcripts. It is important not to compare directly the GPA of students from one university to another, as this only tells whether the students from one institution are 'better' or 'worse' than the students from another. In actual fact, it is a result of different curricula, different approaches of teaching and different ways of measuring achievement. This makes comparisons between HEI difficult. However, a comparison in this article is about the preparedness of students to work in the mechanical engineering field. Site visits offer the opportunity to ask probing questions in an informal setting, with one question specific to how academic preparations of our students compare with co-op students from other HEI. This use of student/supervisor/faculty/director interaction yields data and curriculum insights that are unlikely to emerge from individual responses to a survey questionnaire about curricula comparison. The comparison is to gauge our curriculum depth regarding:

- technical ability
- ability to transfer academic training to job requirements
- analytical problem solving skills
- ability to compile information and directed research
- communications skills

- engineering design process

Furthermore, it gives us a sense of the specificity to an employer problem. On the other hand, if the weakness observed by supervisors is explicit to our curriculum; the issue will be reported to the curriculum committee.

Student evaluation

Monitoring student progress at different phases is critical to the success of the co-op experience. IPFW cooperative education students are required each work semester to submit a written academic report as well as a student and employer evaluation. The feedback is an important way of understanding the value of the co-op experience and the results can be used as indirect assessment measures. The students write a 3-5 page technical report summarizing the tasks, plan, project management, learning outcomes, accomplishments, and the work experience.

Furthermore, the co-op students at IPFW submit a standard survey form regarding the learning outcomes of the co-op work experience. The statements are divided into three categories:

- Personal development learning outcomes
- Professional development learning outcomes
- Academic development learning concepts

The report also serves as a means to follow up on possible employer shortcomings identified during the site visit. If a deficiency persists, the university co-op director will take the necessary steps with the employer. If a resolution is reached and the employer continues participation in the program with other students, the director and coordinator will make an early site visit to that employer the next semester to ensure the success of the future co-op educational experiences.

Employer evaluation

In order for the student to receive a passing grade in his/her co-op assignment, the employer evaluation must be returned. A program assessment by an independent engineer is a frank appraisal of strengths and shortcomings. The feedback can be used to assess existing outcomes and enhance the results to satisfy the changes affecting the engineering profession. There are items such as professionalism, academic preparedness, and various skills that are used by the department as a tool to measure the achievement of some of the outcomes.

The employer evaluation is a measure of student's competence, and therefore can be used to assess the program outcomes. The IPFW cooperative education employer evaluation consists of two parts: Performance factors survey and comments. The performance factors assess the achievement, during work terms, in these areas:

- Professionalism
- Academic Preparation
- Skills

The achievement of understanding the professional and ethical responsibility (ABET outcome f), and the ability to use techniques and skills (ABET outcome k) are difficult assessment tasks for educators when it is done solely based on academic performance. However, a supervisor can assess these outcomes easily based on a daily industrial performance. On the other hand, the academic preparations can be mapped directly to the program outcomes. The academic preparedness factors at our university are shown in Table 3.

Table 3: Academic performance factors

Performance Factors	Levels of Performance					
Academically Preparations	1	2	3	4	5	NA
Ability to integrate theory (academic learning) and practice (co-op experience).						
Academically prepared for this job (course preparation).						
Communicates clearly in written form.						
Communicates clearly verbally.						
Demonstrates ability to design.						

1 = Outstanding   2 = Very Good   3 = Average   4 = Marginal   5 = Unsatisfactory   NA = Not applicable

The comments include brief curriculum recommendations that could impact the outcome of the co-op student's performance and any specific courses or special training that the student should take that would be especially helpful in his/her effort to achieve career goals. The employer performance appraisal is very useful regarding what the students can do with what they have learned. It also provides a mechanism for follow-up on issues raised during the site visit.

Coordinator report

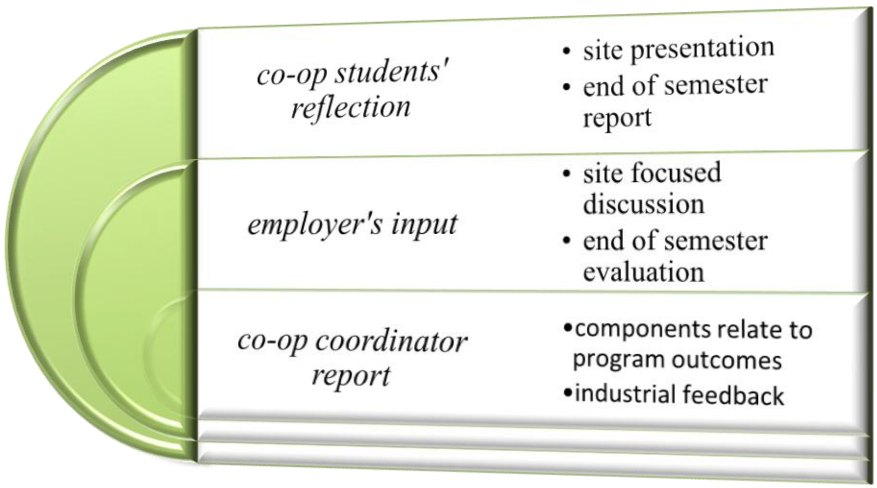
Among other responsibilities, the ME co-op faculty coordinator at our university makes a company visit. The purpose of employer visit is to ensure that the co-op experience is rewarding as well as the assessment tool, which is a vital component of experiential education and the learning process.   One of the most important aspects of education is the ability to transfer academic knowledge to job performance. This is a difficult objective and outcome to be assessed on campus. On the other hand, the co-op coordinator can assess the program effectiveness regarding this issue through the discussions with students and supervisors, at the company visit. The expectations of employers that employ engineers are changing. In addition to sound academic background, employers want engineers to be:

- Self-directed
- Market-focused
- Agile
- Continuous expansion of knowledge
- Knowledgeable with Industrial trends

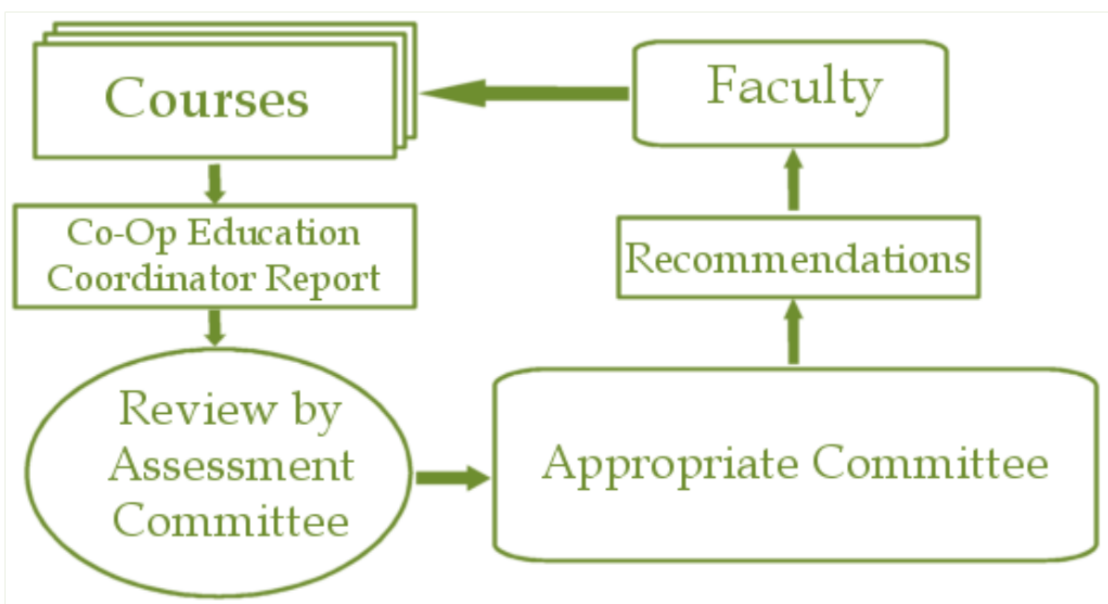
Upon completion of the company visit, analyzing the students' reports and supervisors' reports, the coordinator submits an assessment report to the department's assessment committee.

Closing the loop

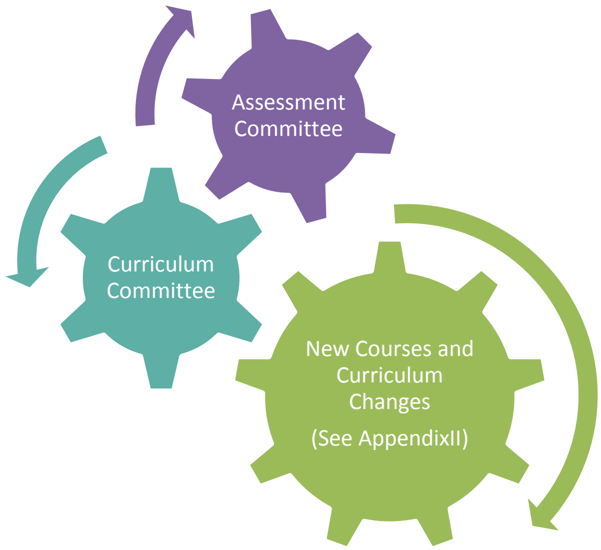
Outcome assessment is a method for determining whether students have learned, have retained, and can apply what they have been taught. Moving from learning objectives to judgments concerning the degree which the program is achieving its learning outcomes requires relevant, appropriate, and informative data upon which judgments can be based. The utilization of cooperative education as discipline specific assessment information can be gleaned from this graphic.



Below is the cycle for the assessment of achieving the program outcomes through the required and technical elective courses.



The engineering field comprises different professional groups that often work in close cooperation. However, they rarely cross paths during their college studies. For example, learning manufacturing tolerances, industrial safety requirements, technical and sales interaction with customers are very beneficial to a mechanical engineering student as shown in Table 2. Engineering programs seeking accreditation are required by ABET to document their continuous program improvement efforts and their outcomes. Inputs from co-op focused site-visit sessions and end-of-semester reports should be analyzed and compared with inputs from other assessment sources to guide faculty in their efforts to improve their program. Any concerns or negative feedback are referred to the appropriate committee to act upon and provide recommendation. In some cases, addition of new courses is necessary as shown in the figure below. It is worth mentioning that the site visit discussions were the trigger for the new courses. The ME co-op coordinator's report was used to justify the new two courses.



Conclusion

Global economic shifts are not only providing challenges to HEI, but also greater opportunities to meet the needs of students and employers. This paper introduced the relationship of co-op site visits to a mechanical engineering curriculum review in hopes of starting the conversation around an issue that has not received a great deal of attention in the co-op community. While faculty are very creative in developing outcomes assessment methods, I sought to assess the achievements of outcomes through the lens of interaction with industry. The preliminary results show, that in conjunction with other assessment methods, co-op site visits can impact the curriculum of an engineering program.

Cooperative education presents a unique learning experience that merits involvement of many faculty in an engineering program. The findings of this paper help provide baseline information about assessing program outcomes through the lens of industry. Future work will include a rigorous cost-benefit analysis.

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Appendix I: Mechanical Engineering Student Outcomes

1. Graduates will demonstrate basic knowledge in chemistry, mathematics, physics, and engineering.
2. Graduates will demonstrate the ability to identify, formulate, and solve mechanical engineering problems.
3. Graduates will demonstrate the ability to design and conduct experiments, interpret and analyze data, and report results.
4. Graduates will demonstrate the ability to design a mechanical system, component, or process that meets desired specifications and requirements.
5. Graduates will demonstrate the ability to function on engineering and science laboratory teams as well as on multidisciplinary design teams.
6. Graduates will use modern engineering software tools and equipment to analyze mechanical engineering problems.
7. Graduates will demonstrate an understanding of professional and ethical responsibility.
8. Graduates will be able to communicate effectively in both verbal and written forms.
9. Graduates will have the confidence for self-education and the ability for lifelong learning. They will have a broad education to understand the impact of engineering on society and demonstrate awareness of contemporary issues.

Appendix II: New Courses

Course	ME 16000 – Solid Modeling
Type of Course	Required for ME program
Catalog Description	Communication of form and layout of real world objects, solid modeling of objects. Engineering drawing layouts, orthogonal projections, dimensioning, tolerancing and standard drawing symbols, principles of detain design drawings and assembly drawings, and manufacturability. Use of computer graphics and production of drawings.
Credits	Lecture 1; Lab 1
Contact Hours	3
Prerequisite Courses	ENGR 12000 and MA 16500
Corequisite Courses	ENGR 19900
Prerequisites by Topics	Computer drawing, computer graphics, constraining and dimensioning sketches, design variables and equations, coordinates, vectors, matrices, projections, views and visualizations, computer aided design, engineering design and analysis, product development, graphic user interface
Textbook	*Introduction to Solid Modeling Using SolidWorks*, Howard and Musto McGraw Hill Higher Education, current edition.
Course Objectives	The course objectives are an introduction of the solid modeling method and its integrated applications through the use of SolidWorks and engineering related graphical exercises. Students are prepared to identify design intentions, create and modify part or assembly models productively. It will provide you with the essential skills to use a solid model for advanced engineering design.
Course Outcomes	Students who successfully complete this course will have demonstrated an ability to: 1. Select an appropriate CAD tool for various applications. **(k)** 2. Use basic/advanced skills for 3-D part modeling, create solid 3-D model of a part for design concept. (**k**) 3. Use basic/advanced skills for 3-D assembly modeling. **(k)**

4. Create dimensioned drawings and views from a 3-D model. **(k, g)**
5. Communicate important aspects of a solid modeling orally and in writing. **(g)**
6. Use a solid model for motion, simulation, or manufacturing. **(a, g)**

Lecture Topics

1. Fundamentals of solid modeling
2. Engineering drawings
3. Basic and advanced part modeling technique
4. Basic and advanced assembly modeling technique
5. Motion simulation of mechanisms
6. Solid models for finite element analysis
7. Solid models for product life-cycle management

Computer Usage High

Laboratory Experience Medium

Design Experience Medium

Course	ME 432 – Manufacturing Processes
Type of Course	Elective (Group 1) for ME program
Catalog Description	This course provides students in Mechanical Engineering program with an opportunity of learning the fundamentals of modern manufacturing processes. The course introduces the fundamentals of different manufacturing processes, and it also introduces the machine tools and systems for manufacturing processes.
Credits	3
Contact Hours	3
Prerequisite Courses	ME 25200 and ME 30300
Corequisite Courses	None
Prerequisites by Topics	Plane stress, plane strain, and stress-strain laws. Applications of stress and deformation analysis to members subjected to centric, torsional, flexual, and combined loading. Introduction to theories of failure, buckling, and energy methods, Crystal structure, imperfection in solids, mechanical properties of metals, dislocation and strengthening, failure, phase diagrams and transformations, metal alloys
Textbook	J. T. Black and Ronald A. Kohser, *DeGarmo's Materials and Processes in Manufacturing*, current edition.
Course Objectives	1. To gain an understanding and appreciation of the breadth and depth of the field of manufacturing 2. To recognize the strong interrelationships between material properties and manufacturing processes 3. To become familiar with some of the basic casting, forming, metal cutting, welding, and polymer processes 4. To learn and apply the basic terminology associated with these fields 5. To increase your knowledge and broaden your perspective of the manufacturing world in which many of you will contribute your talents and leadership
Course Outcomes	A student who successfully fulfills the course requirements will have demonstrated: 1. An ability to describe mechanical properties of materials(**a,e)**

2. An ability to choose proper engineering materials for specific applications (**a, e**)
3. An ability to determine and apply proper fabrication methods of materials (**a, e**)
4. An ability to describe types of machining operation (**a, e, k**)
5. An ability to describe joining processes including welding, brazing and soldering (**a, e, k**)

Lecture Topics

1. Overview of materials
2. Measurement and inspection and testing
3. Processes of casting
4. Fabrication of plastics, ceramics, and composites
5. Metal forming processing
6. Machining processes
7. Joining processes
8. Machine tools and controls
9. Design projects

Computer Usage Low

Laboratory Experience Medium

Design Experience Medium