AC 2009-789: A LEARNING-OUTCOMES SURVEY OF ENGINEERING COOPERATIVE-EDUCATION STUDENTS: PRELIMINARY FINDINGS

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Ms. Benzinger holds Bachelor of Commerce and Master of Education Degrees. She has implemented student and learning support services for nineteen years and has served as the University’s Director of the Centre for Career Education for the past seven years. She co-chairs a University-level Cooperative Education Committee aimed at improving and expanding cooperative education at the University. She has initiated a project to identify, support and assess learning outcomes for cooperative education and is part of a group geared at developing a model of assessment for University Career Centres that incorporates learning outcomes.
Introduction

Since the inception of cooperative education at the University of Windsor, the work terms have been structured as four-month work terms (one semester), alternating with academic terms throughout the undergraduate degree program per guidelines provided by the Canadian Association for Cooperative Education Programs\(^1\). At the University of Windsor, a minimum of three work terms satisfy the requirement for an undergraduate engineering degree with a co-op designation. Increasingly, there have been requests by industry to have students complete consecutive or extended work terms of eight months or more to fully utilize trained students, minimizing workforce turnover and in turn generate their own pool of experienced candidates for full time employment after graduation. In general, the extended work terms are viewed by students as an opportunity to fully explore the profession and industry in which the positions are offered, to increase their involvement in more complex assignments, and to establish a network of contacts in a company where they may consider seeking future work term placements or full time employment following graduation.

The University of Windsor has recently established formal learning outcomes for the co-op program and implemented new educational strategies to support the achievement of those outcomes\(^2,3\). A survey was recently administered to graduates and senior students of the cooperative engineering program at the University of Windsor (the control group) to assess their perceptions of the effect that co-op had on the following: their academic and career-related goals and motivation; identification of personal strengths, weaknesses and preferences; understanding of academic theory and technical knowledge; development of attributes; and the ability to effectively contribute in the workplace through identified complementary industry-related skills. The control group responses with respect to learning outcomes, activities and assessment methods that were implemented in the program following their participation in co-op were also analyzed. The second phase of the survey, the administration of the same survey to the group of students participating in the revised program (the experimental group), is taking place during the current academic year.

The survey’s demographic section incorporated questions about the length of the work term that the respondents completed in order to address the research question about the effect of longer term placements on student perception of co-op as it relates to the skills identified. While the majority of students in the control group indicated that their participation in co-op did result in achievement of the identified outcomes, preliminary analysis of the control group responses suggests that, at least subjectively, the benefits of the extended work term exceed those of the traditional shorter work term on many of the outcomes.

Literature Review

For over 100 years, cooperative education and internship programs have been an option for post-secondary education with the premise of assisting students’ transition from school to workplace. These programs have been defined as structured educational strategies integrating academic
learning through productive work experiences in a field related to career goals. Groenewald determined that cooperative education has four core dimensions: “(a) an integrated curriculum, (b) learning derived from work experience, (c) cultivation of a support-base, and (d) the logistical organization and coordination of the learning experience.” The basic concepts of alternating school with work over a substantial portion of the student’s college or university career and allowing the progression in complexity of both the academic studies and the work experiences is fundamental to cooperative education. Employer and student performance evaluation data have traditionally been used to reflect on and improve student or employer performance in an informal way. An emphasis has been placed on developing evaluation criteria through learning outcomes that meet the needs of the cooperative education programs and the Accreditation Board for Engineering and Technology (ABET) or the Canadian Engineering Accreditation Board (CEAB).

Research on cooperative education and engineering students has shown a positive impact on earnings and grade point averages at the cost of extended education beyond the four-year program. According to Parsons et al. the environment of engineering education has changed over the past decade with new broader learning objectives as required in the ABET criteria. These objectives include ethics, teamwork, and critical thinking. Many of the learning outcomes in the ABET engineering criteria will be embedded in the social context within which engineering work is done. The need arises in creating learning outcomes that include social skills development woven into the cooperative education experience.

Whilst the CEAB criteria for accreditation have in the past been more prescriptive, and less outcomes-based, than those of ABET, the new accreditation criteria to be used for accreditation visits starting in Fall 2009, is more outcomes-based. The new criteria specify a set of graduate attributes that are divided into twelve “headings” or sub-sets. These attributes are:

3.1.1 A knowledge base for engineering
3.1.2 Problem analysis
3.1.3 Investigation
3.1.4 Design
3.1.5 Use of engineering tools
3.1.6 Individual and team work
3.1.7 Communication skills
3.1.8 Professionalism
3.1.9 Impact of engineering on society and the environment
3.1.10 Ethics and equity
3.1.11 Economics and project management
3.1.12 Life-long learning

CEAB is very clear that:

*Engineering programs are expected to continually improve. There must be processes in place that demonstrate that program outcomes are being assessed in the context of these attributes, and that the results are applied to the further development of the program.*
Outcomes assessments are critical to the evaluation of cooperative education programs for higher education institutions in the current competitive environment. Defining student learning outcomes is dependent on the education perspective relating educational objects, competencies, skills or achievement. Engineering educators have initiated reform actions focusing on the measurement of student learning outcomes in a systematic and valid manner.

According to the research, outcome-driven assessment processes provide critical information to faculty and administrators on the effectiveness of the design, delivery, and direction of any education program. Cates and Jones affirm that effective cooperative education programs are built on the principles and theories of student learning. Behaviors that maximize student learning should be built into co-op programs including: set expectations, expectancy for success, transfer of knowledge, and feedback. Maximizing student learning becomes the most important benefit from linking co-op with academics. This provides the venue to form and assess clearly defined goals and crystallizes the purpose allowing for valuable outcomes assessment.

Besterfield-Sacre et al. conducted a large study to focus on the eleven intentionally undefined outcomes of EC-2000 as a necessary step to better defining learning outcomes in engineering cooperative education. Through an extensive literature review and a framework based on Bloom’s taxonomy, each outcome has been expanded into a set of attributes that can then be used by engineering faculty in adapting the outcomes to their own program. According to Besterfield-Sacre et al., these outcomes are in a dynamic state that must be updated and modified as more is learned about their specificity and use.

Interestingly, the founder of cooperative education, Herman Schneider, developed the curriculum as a teaching methodology to educate his engineering students in the early 1900’s. He proposed this initiative, implemented it and it worked; however, with any educational initiative involving human development, the reasons are complex and intricately based on theoretical principles of learning. Therefore, to gain insight into assessing the learning outcomes of, and their link to, teaching methodologies and assessment tasks and tools, several theories need to be examined to determine their implications in the development of learning outcomes.

Felder and Brent pledge a student-centered approach that “challenges the beliefs that all knowledge is certain, all problems have one and only one solution and authorities are omniscient and infallible”. They suggest that it have the following five features: “(1) variety and choice of learning tasks; (2) explicit communication and explanation of expectations; (3) modeling, practice, and constructive feedback on high-level tasks; (4) a student-centered instructional environment; and (5) an attitude of respect and caring for students at all levels of development”. Lizzio, Wilson and Simon suggest, however, that the quality of the experience has an impact on the outcomes. This idea had been recognized 70 years ago (1939) by John Dewey:
The quality of cooperative education should be based on clear objectives, appropriate assessment and an emphasis on independence. An understanding of the theories related to learning in cooperative education programs, such as Kolb’s Experiential Learning theory (ELT)\textsuperscript{18, 19}, Lave’s Situated Learning Theory\textsuperscript{20, 21}, Bandura’s Social Learning Theory\textsuperscript{22, 23}, and others, will help shed light on the development of the learning outcomes\textsuperscript{24, 25, 26}.

One issue that is addressed in this survey is the length of the work term and the effect of longer term placements on student perception of co-op as it relates to the skills identified. There was little in the published literature that addressed this issue. Ryan, Toohey, and Hughes\textsuperscript{27} in their review article on the purpose, value, and structure of the practicum in higher education (in this context practicum includes cooperative education and internships) identify “the length and structure of the placement” as a particular issue requiring attention due to the scarcity of its treatment in current literature. Ryan et al.\textsuperscript{27} do, however, caution that “the ideal length and structure cannot be considered outside the context of the goals and objectives of the practicum”. Ryan et al.\textsuperscript{27} identify three practicum formats in common use:

- **the extended single placement** usually situated toward the end of the training course (commonly called the **thick sandwich** model in the UK);
- **multiple, shorter block placements**, usually distributed throughout the training course (called the **thin sandwich** in the UK); and
- **part-time placements of one to three days per week** extending over a semester or a year, sometimes called the **concurrent** model.

They point out that examples of the extended single placement are common in cooperative education programs in business and engineering and in most medical degrees. Au Yeung et al.\textsuperscript{28}, in their paper on engineering and technology courses in the UK and Hong Kong note that the sandwich courses offered by the former Polytechnics and Colleges of Advanced Technology mainly consist of placements exceeding thirty-six weeks duration, and the tendency is for this period to lengthen. Ryan et al.\textsuperscript{27} found little rationale in the literature for choosing a single period of work experience that extended from six months to one year (or longer). Wright\textsuperscript{29} has argued that the longer placements allow students to see a project, such as an engineering or product development project, through all its stages and to participate in the full range of organizational and work life experiences.

**Survey**

A survey was designed to gauge the success of the recently established formal learning outcomes by assessing student and alumni perceptions of the effect that co-op had on the following: their academic and career-related goals and motivation; identification of personal strengths, weaknesses and preferences; understanding of academic theory and technical knowledge; development of attributes; and the ability to effectively contribute in the workplace through identified complementary industry-related skills. It was administered to senior Engineering and Computer Science students and Alumni having participated in the pre-learning outcome cooperative education program (the control group).
The second phase of the survey, the administration of the same survey to the group of students participating in the revised program (the experimental group), is taking place during the Winter 2009 semester.

The survey was comprised of a section of demographic questions and a section related to educational goals, whereby respondents were asked to reflect on their cooperative education experiences and perform a self-assessment. The demographics identified those students and alumni having participated in standard length work terms (less than eight months in duration) and extended length work terms (eight months or more duration). The preliminary findings reported in this study are an analysis of the responses of the standard versus extended work term engineering co-op participants.

Preliminary Findings: Standard versus Extended Work Term

The survey was administered to Computer Science and Engineering co-op students and alumni. In total, 674 surveys were sent out in 2008. The overall response rate of the survey was 34.72%. 45% (105) of respondents were Engineering alumni, while 38% (90) were Engineering students. The remainder of the respondents consisted of Computer Science students and alumni, the responses of whom are not considered in the scope of the results presented here.

Four survey questions concerning education goals were answered using a five-point Likert scale (1 – Increased greatly, 2 – Increased somewhat, 3 – Had no effect, 4 – Decreased somewhat, 5 – Decreased greatly). The standard and extended work term respondents’ responses were consolidated to examine the results with respect to the percentage of respondents who answered in a positive fashion (grouping responses of 1 – Increased greatly and 2 – Increased somewhat) against those who reported no effect or a decrease. The percentages of participants reporting an increase in each of the standard and extended work term groups were then compared using the Pearson Chi-Square test of statistical significance at the critical $\alpha$-level of 0.05 and one degree of freedom. The null hypothesis for each survey question suggests that there is no significant difference between the percentages reported for the extended and regular work-term groups.

Question 1

To what extent did participation in the co-op program affect the following?

- a) Your academic motivation
- b) Your clarity regarding academic goals
- c) Your clarity regarding career goals
- d) Identification of personal strengths related to academic options
- e) Identification of personal weaknesses related to academic options
- f) Identification of personal preferences related to academic options
- g) Identification of personal strengths related to workplace options
- h) Identification of personal weaknesses related to workplace options
- i) Identification of personal preferences related to workplace options
- j) Your understanding of theories taught in the classroom
- k) Your technical knowledge in your field

The responses to this question are summarized in Figure 1 and Table 1.
Figure 1: Percentage of respondents who perceived an increase in the identified areas (Pearson Chi-Square statistic).
Percentage of respondents who perceived an increase in the identified areas (Pearson Chi-Square statistical indicator):

<table>
<thead>
<tr>
<th>Area</th>
<th>% of Regular Work Term Respondents</th>
<th>% of Extended Work Term Respondents</th>
</tr>
</thead>
<tbody>
<tr>
<td>Your Academic motivation (0.087)</td>
<td>63.7</td>
<td>77.1</td>
</tr>
<tr>
<td>Your clarity regarding academic goals (0.032)</td>
<td>67.1</td>
<td>83.3</td>
</tr>
<tr>
<td>Your clarity regarding career goals (0.903)</td>
<td>91.1</td>
<td>91.7</td>
</tr>
<tr>
<td>Identification of personal strengths related to academic options (0.003)</td>
<td>67.8</td>
<td>89.6</td>
</tr>
<tr>
<td>Identification of personal weaknesses related to academic options (0.173)</td>
<td>55.5</td>
<td>66.7</td>
</tr>
<tr>
<td>Identification of personal preferences related to academic options (0.367)</td>
<td>72.6</td>
<td>79.2</td>
</tr>
<tr>
<td>Identification of personal strengths related to workplace options (0.903)</td>
<td>91.1</td>
<td>91.7</td>
</tr>
<tr>
<td>Identification of personal weaknesses related to workplace options (0.511)</td>
<td>76.7</td>
<td>81.3</td>
</tr>
<tr>
<td>Identification of personal preferences related to workplace options (0.765)</td>
<td>92.5</td>
<td>93.8</td>
</tr>
<tr>
<td>Your understanding of theories taught in the classroom (0.145)</td>
<td>68.8</td>
<td>56.8</td>
</tr>
<tr>
<td>Your technical knowledge of the field (0.048)</td>
<td>88.4</td>
<td>97.9</td>
</tr>
</tbody>
</table>

Table 1: Data plotted in Figure 1. Note the three areas, shown in bold, that indicate statistical significance at the 0.05 level.

It is interesting to note that all but one area (understanding of theories taught in the classroom) showed an increase in perceived benefit by participation in extended work terms. It is possible that extended time away from the classroom distances the student from the theory taught in the classroom. However, an extended work term did increase the respondents’ academic motivation.

Response levels to three of the questions indicated a significant difference with regard to the Pearson Chi-Square statistic (α-level of 0.05) thus indicating a rejection of the null hypothesis for those areas. These learning outcomes included: clarity regarding academic goals, identification of personal strengths related to academic options, and to a lesser extent (as indicated by the Pearson Chi-Square statistic of 0.048) the participant’s technical knowledge of the field.

The idea that extended work terms would positively affect clarity with regard to academic goals and the identification of personal strengths related to academic options could be viewed as related; the source of clarity being just that: identification of personal strengths related to academic options.

Question 2

To what extent did participation in the co-op program help develop the following attributes:
a) Acquisition of knowledge
b) Application of knowledge
c) Integration of knowledge
d) Research skills
e) Critical thinking skills
f) Problem-solving skills
g) Interpersonal skills
h) Communication skills
i) Responsible behaviour to self, others and society
j) Teamwork, personal and group leadership skills
k) Creativity and aesthetic appreciation
l) Ability and desire for continuous learning

Figure 2: Percentage of respondents who perceived an increase in the identified areas (Pearson Chi-Square statistic).
<table>
<thead>
<tr>
<th>Percentage of respondents who perceived an increase in the identified areas (Pearson Chi-Square statistical indicator):</th>
<th>% of Regular Work Term Respondents</th>
<th>% of Extended Work Term Respondents</th>
</tr>
</thead>
<tbody>
<tr>
<td>Acquisition of knowledge (0.115)</td>
<td>82.2</td>
<td>91.7</td>
</tr>
<tr>
<td>Application of knowledge (0.522)</td>
<td>88.4</td>
<td>91.7</td>
</tr>
<tr>
<td>Integration of knowledge (0.094)</td>
<td>84.2</td>
<td>93.8</td>
</tr>
<tr>
<td><strong>Research skills (0.002)</strong></td>
<td>61.6</td>
<td>85.4</td>
</tr>
<tr>
<td>Critical thinking skills (0.166)</td>
<td>83.6</td>
<td>91.7</td>
</tr>
<tr>
<td>Problem-solving skills (0.194)</td>
<td>89.7</td>
<td>95.8</td>
</tr>
<tr>
<td><strong>Interpersonal skills (0.021)</strong></td>
<td>89.7</td>
<td>100</td>
</tr>
<tr>
<td>Communication skills (0.098)</td>
<td>94.5</td>
<td>100</td>
</tr>
<tr>
<td>Responsible behaviour to self, others and society (0.574)</td>
<td>77.4</td>
<td>81.3</td>
</tr>
<tr>
<td>Teamwork, and personal and group leadership skills (0.660)</td>
<td>84.9</td>
<td>87.5</td>
</tr>
<tr>
<td>Creativity and aesthetic appreciation (0.774)</td>
<td>64.4</td>
<td>66.7</td>
</tr>
<tr>
<td>Ability and desire for continuous learning (0.063)</td>
<td>74.7</td>
<td>87.5</td>
</tr>
</tbody>
</table>

Table 2: Data plotted in Figure 2. Note the two areas, shown in bold, indicating statistical significance at the 0.05 level.

While all areas showed an increase in perceived benefit by those participating in extended work terms, only responses to two of the questions indicated a significant difference per the Chi-Squared test. Using a critical $\alpha$-level of 0.05, the results indicating a rejection of the null hypothesis are limited to development of research skills and interpersonal skills.

The respondents’ perceived increase in development of these two skills may also be linked. Performing tasks in an environment outside the classroom requires the ability to locate resources necessary to complete assigned tasks, thus developing research skills. These resources often take the form of relationships with regular employees with experience in the field and knowledge of the company’s more tangible resources. This type of work, in result, develops the co-op students’ interpersonal skills.

Although not of statistical significance at the 0.05 level, there was an increase in the percentage of students who perceived an improvement in “Ability and desire for continuous learning” through extended work terms (Pearson Chi-Square statistic of 0.063). This component addresses “Graduate attribute 3.2.12” of CEAB, namely:

3.1.12 **Life-long learning:** An ability to identify and to address their own educational needs in a changing world, sufficiently to maintain their competence and contribute to the advancement of knowledge.
Question 3
To what extent did participation in the co-op program develop in you?

a) An understanding of workplace culture
b) An understanding of employee health and safety information in the workplace
c) A network of contacts within your field
d) The ability to make an effective contribution in the workplace

Figure 3: Percentage of respondents who perceived an increase in the identified areas (Pearson Chi-Square statistic).
Table 3: Data plotted in Figure 3. Note the one area in bold showing statistical significance at the 0.05 level.

While all areas showed an increase in perceived development by those having participated in extended work terms, the only area indicating a rejection of the null hypothesis at the 0.05 $\alpha$-level was the perceived ability to make an effective contribution in the workplace.

Not only do extended placements provide co-op students with the opportunity to engage in projects of greater depth and complexity, but they also to remain in the workplace for a period of time following completion of a project. In the corporate environment, the effects of change as a result of a project may not be felt until weeks following the conclusion of the project. By participating in an extended work term, the student has the opportunity to experience the changes that may come as a result of their work.

Question 4

To what extent did participation in the co-op program affect your employment opportunities by:

a) Enabling you to identify, assess and develop workplace skills and personal competencies
b) Teaching you how to write an effective resume and cover letter
c) Teaching you how to interview effectively
d) Assisting in the process of career planning
e) Contributing to your post-graduation employment
Enabling you to identify, assess and develop workplace skills and personal competencies (0.903)

Teaching you how to write and effective resume and cover letter (0.968)

Teaching how to interview effectively (0.700)

Assisting in the process of career planning (0.822)

Contributing to your post-graduation employment (0.044)

Table 4: Data plotted in Figure 4. Note the one area in bold showing statistical significance at the 0.05 level.
Three of the five areas showed very similar response levels between the regular and extended work term participants, while one area showed a decrease in perceived effect on employment opportunities: effective interview instruction. It is possible that by participating in extended work terms, overall, the student has fewer distinct employment placements and thus fewer opportunities to participate in interviews.

The only area that exhibited a difference deemed statistically significant according to the Pearson Chi-Squared test with a 0.05 \( \alpha \)-level of significance was the increased contribution to post-graduation employment.

Participation in extended work terms not only has perceived benefits for the student, as this paper discusses, but there is also a perceived benefit to the employers. Having adequate time to train and evaluate a co-op student on an extended placement works toward increasing the pool of potential employees following the students’ graduation.

Responses to questions 5 and 6 were free-form and were categorized for presentation. The responses are presented for the students and the alumni, offering the ability to examine the retrospective effect on their responses.

Question 5
Can you identify any additional benefits to your participation in the co-op program apart from those already mentioned?

The summary of responses is shown in Figures 5 (senior Engineering students) and 6 (Alumni), respectively.
Figure 5: Responses of senior Engineering students when asked about perceived benefits from their participation in co-op, in general.
Figure 6: Responses of Alumni when asked about perceived benefits from participation in co-op, in general.

Note that the current students’ mention of money/income is less than half as frequent as the alumni. This could stem from the fact that the impact of the income from co-op placements is not felt until post-graduation, when government student loan repayment programs have been implemented. It could be inferred that the ability to earn money as co-op students during school has a perceived benefit that isn’t fully appreciated until after graduation.

There was consistency in the perceived benefit of co-op to provide work-related skills and experience and clarity of career path in that half of each group expressed this idea.

Question 6
Do you have any suggestions for changes and/or additions to the current co-op program that would have generally benefited all co-op students or engineering students in particular?

The participants’ responses were grouped into categories and listed here in descending order for the students and alumni.

Senior Engineering students:
- More help finding a job/More job opportunities: 22.9%
- Need for more hands-on training/help: 14.6%
- Promote co-op: 10.4%
- Get rid of/Modify work-term report(s): 8.3%
- Lower/eliminate co-op fees: 8.3%
- Employers should have ample/specific work tasks for students: 6.3%
- Shorten co-op classes/work-load: 6.3%
- Reorganize co-op office/department: 4.2%
- 3rd/4th year co-op students should mentor 1st year co-op students: 2.1%
- (Unspecified/unrelated answers: 12.5%)
- (None: 4.2%)

Engineering Alumni:
- More help finding a job/More job opportunities: 19.6%
- Need for more hands-on training/help: 16.1%
- Add extra semesters of co-op: 8.9%
- Lower/eliminate co-op fees: 7.1%
- Get rid of/Modify work-term report(s): 7.1%
- Promote co-op: 5.4%
- Employers should have ample/specific work tasks for students: 5.4%
- Course Sequencing: 3.6%
- Accurate job postings: 1.8%
- More specific job information: 1.8%
- (Unspecified/unrelated answers: 14.3%)
- (None: 3.6%)

In general, both the Engineering students and the Alumni expressed the need for an increase in assistance in locating employment opportunities and hands-on training while at the same time reducing fees and report writing.

Conclusions

The preliminary results of the co-op survey presented here focus on perceived benefits of co-op by senior Engineering students and Alumni based upon their experience in the pre-Learning Outcomes program.

The survey responses were analyzed using a Chi-Squared test for significance for regular versus extended work terms, using a critical $\alpha$-value of 0.05 and one degree of freedom. While, in general, responses indicating an increase in development were expressed by those participating in extended work terms, the null hypothesis was rejected in some specific areas:
- Increased clarity regarding academic goals
- Increased ability to identify personal strengths related to academic options
- Increased technical knowledge of the field
- Increased development of research skills
- Increased development of interpersonal skills
- Increased ability to make an effective contribution in the workplace
- Increased contribution to post-graduation employment
The incorporation of learning outcomes into the co-op program at the University of Windsor is well underway and the survey is being administered to students as they participate in the revised program. It is anticipated that the response analysis with regard to the benefit of learning outcomes and more information about the perceived benefits of extended work terms will be available for publication later in 2009.

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