Using Reflective Analysis to Integrate Co-Operative Education into Academic Curricula

Abstract

The integration and assessment of co-operative educational experiences within the academic curriculum is a difficult process to achieve. Students and faculty tend to compartmentalize these experiences while survey approaches to assessment suffer from diversity in supervisor understanding and participation resulting in significant inter-rater variability. The later issue can be especially problematic insofar as the rater may or may not have direct experience with the student and may thus be completing the survey based upon second- or even third-hand information. In addition, survey questions in large co-operative education programs, such as found at Drexel University (Philadelphia, PA USA) must be general enough to satisfy the needs of multiple programs. This results in a loss of specificity and a reduction in the resolution and applicability of the results. To overcome these limitations, Drexel and the School of Biomedical Engineering, Science and Health Systems are implementing directed reflection as both an assessment and integration process. Students returning from their co-operative education experiences are required to provide short 400-word essays about their experiences. One such essay concerns the students' goals and experiences during their works experiences and is being used to assess students' writing skills. A second essay requests that students assess the impact of their academic curriculum on work expectations and requirements, forcing students (and the faculty who read these essays) to determine the level of integration of curriculum with work experiences. How results from this cost-effective method of data collection are being used for curriculum integration and enhancement will be discussed.

Introduction

Higher education in the United States is at a crossroads. As tuition continues to rise, there is a question as to whether or the costs of a college education can be justified in terms of student learning and performance (Bennett and Wilezoi, 2013). Data from a number of studies suggest that student learning is not taking place at a rate commensurate with the costs involved (Baer, et al., 2006; Casner-Lotto and Barrinton, 2006; McNamara, 2009). At the same time, traditional modes of instruction based upon simple information transfer (the 'sage on the stage' model) appear less and less efficacious in light of the levels of free information available through the Internet and World Wide Web. Faculty hired mainly for their research qualifications and expertise may not have the skills or temperament needed to be effective facilitators of student learning. One critical aspect of this situation is a narrow intellectual focus, often beneficial for scholarly activity, which limits the ability of faculty instructors to make the broad connections needed to place information in context and promote learning. This narrow focus has helped to generate a 'functional silo syndrome' (Ensor, 1988) within American education.

Functional siloing occurs when individual faculty teach courses limited in scope to the faculty's specific research interests. This creates a certain efficiency - faculty need learn little beyond that their own specific sub-disciplines where they are already maintaining familiarity in order to continue with their research. Unfortunately, such 'instructional silos' on the part of faculty appear to promote 'learning silos' in the students. Students see no reason to retain information from term to term or transfer learning from class to class. The loss of both vertical (retention) and horizontal (transfer) learning significantly reduces the efficacy of the educational experience.

In response to these challenges, accrediting bodies such as ABET, Inc. have begun to support assessment-driven, evidence-based curriculum design and quality improvement. Superior design is based upon having established goals and then creating a process by which those goals can be achieved. In the ABET model, there are several tiers of aligned goals. The highest goals are embodied within the missions of the university, college, department and program. Aligned to these broad goals are program educational objectives (PEOs) - achievements demonstrated consistently by *alumni* from an educational program that fulfills academic program mission. Supporting these are the student learning outcomes (SLOs) - characteristics of *students at the time of graduation* - knowledge, skills, attitudes, etc. which provide sufficient foundation for

alumni to be successful on the PEOs. A well-designed curriculum can then be defined as *a set of inter-related and integrated activities that facilitate student learning in a developmentally appropriate manner in order to foster satisfactory achievement of student learning outcomes which, in turn, generate alumni who successfully attain program educational objectives.*

Program Educational Objectives should be developed in collaboration with an academic program's stakeholders. In addition to the program's faculty and students, stakeholders include those individuals external to the program who are in a position to evaluate alumni. These can include commercial and business leaders, clinicians, industry partners, government officials, etc., who are either likely to hire or interact significantly with individuals graduating from the program. The development of PEOs in association with external stakeholders ensures relevance of the PEOs to the actual environment encountered by the graduates, an environment most likely to be quite different from academia. The development of PEOs by collaborating with multiple stakeholders can take some time and effort (the recent development of PEOs at the School of Biomedical Engineering, Science and Health Systems at Drexel University took approximately a year to fully complete) raising the question of how to maintain PEO relevance in a rapidly changing global community.

Co-operative education and/or other forms of work-related experiences offer significant advantages to these processes if properly utilized. Co-Op experiences can help students to understand how classroom learning is applied in real-world situations, promoting retention and transfer of learned materials. By examining student performance, insights can be gained as to the efficacy of educational methods to facilitate skill development and attainment of SLOs. Through analysis of student experiences, insights can be gained to the relevance of PEOs to alumni success. One major question is how to get to the data in an effective and efficient way.

That is not the only issue, however. A significant barrier to the utilization of co-operative educational experiences is a variant of one of the problems that such experiences would be expected to overcome – functional siloing. If higher education has difficulty with individual faculty teaching in isolation, the problem of integrating off-campus work experiences with the on-campus academic program is far greater. For many faculty, co-operative education is something done 'out there' with limited relevance to the critical materials being taught on campus. Once again, the attitudes of the faculty can be reflected in the students, who often consider the academic and work experiences as two wholly unrelated activities. Implemented in

such a manner, co-operative education has the potential to actually make many of the problems of relevance, retention and transfer of learned material worst rather than better compared to programs without such work experiences.

In this paper, we examine the utility of directed reflection as a method of both measuring the efficacy of educational approaches and gaining insight into a curriculum structure. Although merely a pilot project, the results support the hypothesis that directed reflection can be used as a significant technique to promote integration of co-operative education with academic instruction.

A Comment on Surveys

There is a definite difference between collecting information for accreditation purposes and collecting such information for quality improvement. A significant disadvantage to the accreditation process is that it can be viewed by both faculty and administration as an end in itself. This can lead to creating validation measures in contrast to collection of information needed for quality improvement.

As an example, consider the data provided in Tables 1 and 2. These are data from Drexel University's co-operative education program and provide results from the entire University, the College of Engineering (COE) and the School of Biomedical Engineering, Science and Health Systems (BMES) (analysis provided by Dr. James Mitchell from the Drexel College of Engineering).

In the Tables provided, some BMES numbers are below those found in COE and the University as a whole. How is this to be interpreted? Consider the difference in #6 – *critically analyze and solve complex problems*? The College of Engineering result is 3.94 vs 3.87 for the School. Even if this were to be *statistically* significant, would a difference of 0.05 be of *practical* significance? How would one go about correcting the situation, assuming the difference was significant at the both the statistical and practical level? What kind of analysis or problem-solving abilities are lacking? What measures should be taken? How would one determine the efficacy of the intervention, assuming an intervention could be developed?

There are numerous other issues with such data. For example, the employers in each group – COE vs. BMES – are not the same and thus the results are being generated by different individuals under different circumstances. The results are from one co-operative education cycle – in order to determine if an intervention is needed, several cycles would have to be analyzed for

significant trends. The validity of the data is not clear – are the students' supervisors actually rating them or is this someone from Human Resources with no direct knowledge of the students' performances? Do the employers fully understand the rating system – what is the inter-rater reliability?

Table 1. *Summary of BMES Co-Op Survey Results Spring and Summer Terms 2012 (ABET a-k related Survey – average employer response, comparison of Drexel total, COE and BMES) The rating scale was a variation of the Likert scale where 1 (lowest) is unsatisfactory performance, 3 is acceptable and 5 (highest) is exceptional.*

					BME
		General Survey - Employer		Respondents	59
ABET a-k	**Q**	**Question Value (0 to 5 Scale)**	**Drexel Avg. Answer**	**CoE Avg. Answer**	**BME Avg. Answer**
f, h	1	Attendance	4.41	4.40	4.36
f, h	2	Punctuality	4.32	4.31	4.31
d, f	3	Initiative	4.10	4.06	4.10
d	4	Leadership	3.86	3.77	3.89
f, h	5	Time Management	4.03	3.97	4.03
f, h	6	Dependability	4.30	4.26	4.27
d	7	Interaction with Others	4.31	4.24	4.37
d	8	Teamwork	4.38	4.33	4.42
N/A	9	Productivity (quality/quantity of work completed)	4.20	4.15	4.19
d, f	10	Attitude appropriate for the workplace environment.	4.38	4.32	4.42
d, g	1	Communicate effectively through writing (reports, emails, official letters, etc.)	4.05	3.93	4.09
g	2	Demonstrate effective verbal communication (discussion, presentations, etc.)	4.05	3.95	3.97
g	4	Provide feedback about assigned projects and tasks.	4.00	3.96	3.86
a, b, c, e, k	5	Contribute original and relevant ideas, strategies, or solutions.	4.00	3.95	3.98
a, b, c, e, k	6	Critically analyze and solve complex problems.	3.97	3.94	3.89
f, h	7	Uphold ethical standards in the workplace	4.38	4.27	4.40
b, c	8	Make well-reasoned, data supported decisions.	4.10	4.05	3.95
e	9	Use information effectively to accomplish a task.	4.18	4.09	4.15
N/A	10	Set goals and monitor progress.	3.96	3.87	4.07
a, j, k	11	Use appropriate technologies to complet assigned tasks.	4.32	4.26	4.43
d, g	12	Work effectively with people who have diverse backgrounds, beliefs, values, or behaviors.	4.41	4.32	4.52
I, j	13	Improve skills important to success in a field or industry.	4.21	4.16	4.25
d	14	Effectively integrate into the workplace culture and hierarchy.	4.25	4.19	4.36
d	15	Build professional relationships.	4.16	4.09	4.25

Table 2. *Summary of BMES Co-Op Survey Results Spring and Summer Terms 2012 (Program (ABET-mandated) Specific Survey – average employer response)*

				BME
		College Outcomes - Employer	Respondents	59
ABET	**Q**	**Question Value (0 to 5 Scale)**	**Drexel Avg. Answer**	**BME Avg. Answer**
Program	1	Identify and categorize the biological/physiological phenomena being measured.	-	4.00
Program	2	Describe the sepcifications and operation of measuring.	-	4.11
Program	3	Collect, analyze and interpret data collected from measuring eqipment.	-	4.28
School	4	Analyze biomedical problems or situations from a variety of perspectives.	-	4.13

Faced with such problems, there is a temptation to generate a satisfactory cut-off point – say 3.6 – and only intervene when a series of co-op surveys list the same question as below the cut-off. This would increase the potential validity of the analysis but does little to circumscribe

the nature of any intervention. Since general questions are necessary to provide suitability to varying co-operative education positions, it becomes difficult to create very specific questions that would guide potential curriculum improvements. Surveys are also inherently limited by the questions being asked. You must already have an idea of the information you need to obtain and this limits the responses to what might be expected. Surveys – especially those linked to Likert-type scales – are very unlikely to generate new or unexpected data. And yet, that is exactly the kind of data that has the most potential impact on curriculum design and quality improvement.

Use of Co-Operative Education Reflective Analysis to Evaluate Writing Program Efficacy

Drexel University has one of the oldest and most extensive co-operative education programs in the United States. Based in Philadelphia, PA, Drexel University students participate in co-operative education at the local, regional, national and international level. The University is based upon the quarter system, with 4 terms per year. Beginning in the sophomore year, the majority of students begin a alternating cycle of work and classroom experiences, with 6 months in the classroom and 6 months in co-operative education experiences for three years (sophomore, pre-junior and junior). These cycles are divided such that students can either be on Co-Op in their Fall and Winter terms and in class in Spring and Summer or alternatively, in class Fall and Winter and working Spring and Summer. Some students will select an alternative approach with one Co-Op or internship and obtain their degrees in 4 instead of 5 years. Thus, the Co-Op experiences can be sequential (first, second or third) or singular (first/only).

In 2010, Drexel University developed and adopted 11 Drexel Student Learning Priorities (DSLPs), 9 of which could be defined as SLOs and 2 as PEOs. One DSLP concerns communication skills and states that Drexel

> *Graduates will employ an understanding of audience, purpose and context to communicate effectively in a range of situations using appropriate media.*

This is similar to many other SLOs, including ABET criteria g, which states that graduates form an accredited engineering program must have an ability to communicate effectively (3g1 orally, 3g2 written). Communication is clearly an essential skill set.

As a result, Drexel augmented its three-term freshmen writing program (FWP) with a common reflective analysis assignment at the end of each term. These assignments provide a: 1) foundation of reflective practice that students could use to process and analyze new experiences; 2) common experience for first-year students and instructors to facilitate conversations about first-year writing goals and outcomes and 3) baseline of reflective writing to use to gauge future writing growth.

To build on these skills and assess any changes in writing ability during their academic programs, Drexel implemented an Evidence-Based Reflective Analysis requirement that students complete at the end of each co-op cycle. The prompt that students respond to is:

> *Please submit a 400 word reflective analysis on how one aspect of this co-op experience relates to a personal, academic, or professional goal that you are pursuing at Drexel. Be specific about both your goal and how one aspect of the co-op relates to this goal.*

The purpose of initiating the reflective analysis was to encourage students to reflect on their co-op experiences and to provide a common writing experience that provided data about how well students meet Drexel's Communication SLO. The writing samples have had unexpected further benefits; meta-analysis of the samples reveal data about the link between co-op and academics that is not gathered in any other form, and the co-op reflective analysis is being used as a counseling tool for Co-Op advisors who use the writing to discuss future goals and plans with students. Portfolio theory (Yancey, 2009) as well as theories of adult intellectual development and learning (Baxter Magolda, 2001, Fink, 2003) hypothesize that the act of reflection serves to facilitate knowledge acquisition and emotional growth. In this instance the tool itself adds value to the skills measured and is, by design, not neutral. Additionally, the data provide a window into the communication skills of our growing international population and are being used to redefine admission predictors for this cohort.

Methods

Reflective analyses writing samples from Fall, 2010 – Winter, 2011 were scored as evidence-based Arguments. Each reflective analysis scored received an overall evidence-based analysis score based on a 5-point scale (Table 3) measuring how well students create and support

arguments about achieving a learning goal. Parallel rubrics were used for FWP and Co-Op scoring so data could be viewed longitudinally. The Co-Op scoring added a 3-point sentence-level language score to provide evidence about students' skills at the sentence-level (Table 4).

For both scoring cycles, raw data sets of samples from each of 4 co-ops per fall/winter and spring/summer cycles were collected. In the second (undertaken in 2013) scoring, students from countries where English is not the medium of instruction (non-EMI) were intentionally oversampled to allow for comparisons with EMI students.

Sets of 37 live samples were created insuring randomization of samples. Three identical pre-scored samples were inserted at positions 8, 16, and 24 in each set so that each scorer scored 40 essays, which contained monitor papers.

Scorers were sent training samples and a rubric prior to the 1.5 hour online training session. During the online training, scorers were trained on the 5-point evidence-based argument rubric (Table 3) and the 3-point language/style/clarity rubric that focused on language skills at the sentence level (Table 4).

January 2012 Co-Op Scoring:

The first Co-Op training and scoring (January, 2012) served two purposes: to assess the quality of writing over the course of students' Drexel careers, and to provide professional development to faculty in the Department of English and Philosophy. By training FWP faculty to score the co-op reflective analysis (which is an outgrowth of the FWP Reflective analysis learning outcome), faculty were introduced to common language and scoring tools and understood how the skills they taught students transferred beyond the first year writing program.

January 2013 Co-Op Scoring:

The second Co-Op scoring (January, 2013) used the study design of the first scoring but broadened the scope of the original scoring in three ways; the scoring added additional co-op cycles to the analysis; the scoring invited faculty members from across Drexel to be trained and score responses; and the scoring intentionally oversampled International Students in order to be able to make claims about their writing ability (a full discussion of these results can be found in the next section). The 27 additional faculty who were trained to score the essays represented 7 colleges and several administrators.

Table 3. *Evidence-Based Argument Rubric*

Descriptor	Score	Rubric
Very Effective	5	Student has one central argument about how co-op relates to a personal, professional, or academic goal. If more than one goal is listed, the goals are linked and subordinated to one central argument. Evidence from the co-op is specific, detailed, and appropriate. The organization and language of the response support the central argument.
Effective	4	Student has one central argument about how co-op relates to a personal, professional, or academic goal. If more than one goal is listed, the goals are somewhat linked and mostly subordinated to one central argument. Evidence from the co-op is generally specific, detailed, and appropriate, though it may lack some depth or cohesion. The organization and language of the response mostly supports the central argument, though there may be some lapses in organization or clarity.
Somewhat Effective	3	Student makes an argument about how co-op relates to a personal, professional, or academic goal, though there may be more than one competing argument. If more than one goal is listed, the goals are not well subordinated to one central argument. Evidence from the co-op is generally present, though its depth and specificity do not directly support one central argument. Evidence presented may lack depth, analysis, or cohesion. The organization and language of the response occasionally supports an argument, though there are lapses in organization or clarity
Ineffective	2	Student makes one unconvincing argument about how co-op relates to a personal, professional, or academic goal, or lists goals that do not cohere. If more than one goal is listed, the goals are not subordinated to any sense of one central argument. Evidence from the co-op is general, lacking in specificity, or does not support the argument presented. Evidence may be very sparse or, if copious, lacks depth, analysis, and/or cohesion. The organization and language of the response do not support the writer's position; many lapses in organization or clarity are present.
Very Ineffective	1	Student fails to make a clear argument about how co-op relates to a personal, professional, or academic goal. Evidence is not presented, or evidence presented does not support a clear argument. The organization and language of the response do not support the writer's position, or the response is too short to make an informed judgment about organization. Lapses in language and/or clarity interfere with meaning in much of the response.

Table 4. *Language/Clarity Rubric*

Descriptor	Score	Rubric
Clear	3	Sentences are mostly free from errors, and errors do not impede meaning
Somewhat Unclear	2	Sentence-level errors are slightly distracting and begin to interfere with meaning.
Unclear	1	Sentence-level errors are distracting and interfere with meaning

Scoring Reliability

Inter-rater reliability was examined for all scoring cycles of the co-op assessment and for the FWP assessment using three monitor essays that scorers encountered in identical positions. Analysis reveals that the chance of scorers scoring within one score-point of the pre-scored score in the 5-point evidence-based analysis scoring is high (85-88%). In general, single-scored free-

response samples cannot be scored reliably enough to assign individual scores to students with confidence, but can be used to make general statements about representative cohorts. Large-scale writing assessments (NAEP, SAT, AP, CLEP, etc.) rely on linking scores from highly reliable multiple-choice questions to less-reliable free response scores to give individual scores. In general, the scaled weight of the multiple-choice portions is slightly higher than that of the free-response in recognition of the variable nature of subjective scoring. Data for the writing assessments analyzed in this report should be viewed as generally predictable.

Results

Figure 1 displays the means and 90% confidence intervals of the evidence-based score for the EMI (831 students) and non-EMI (60) populations by Co-Op cycle. The blue triangles are the EMI population means while the red triangles are the means for the non-EMI population. The dark lines are the 90% confidence intervals.

Figure 2 displays the means and 90% confidence intervals of the evidence-based and language scores for the EMI and non-EMI populations. The blue triangles are the EMI students' means and the red triangles are the means for the non-EMI population. The dark lines are the 90% confidence intervals.

Even without statistical testing, it is clear from Figure 2 that the non-EMI populations scored significantly lower in both the evidence-based and language clarity scores. Given the disparity in the use of English as a means of communication between the two groups, this result is hardly surprising.

What is surprising, however, is the clear indication in Figure 1 that the evidence-based scores have decreased between the first co-op cycle and the third.

To investigate this further, an analysis of variance was performed with the results provided in Table 5 (Note that the data were transformed prior to analysis such that 5 = 1; 4 = 0.75; 3 = 0.50; 2 = 0.25 and 1 = 0)

Specific group comparisons were undertaken using the Bonferroni method. The results indicated that evidence-based scores from writing submitted by students after their third co-op experience were significantly reduced ($p < 0.05$) when compared to the first, second or first/only co-operative education experiences. This indicates that either the assessment is not measuring the

correct metric for writing or the writing program at the University is not resulting in sustained improvements in this aspect of written communication.

Table 5. *Analysis of Variance of Evidence-Based Scoring Across Co-Operative Education Cycles Combining Data form EMI and Non-EMI Student Populations.*

ANOVA					
Evidence-Based Scoring					
	Sum of Squares	**df**	**Mean Square**	**F**	**Sig.**
Between Groups	**3.439**	**3**	**1.146**	**11.395**	**.000**
Within Groups	**89.221**	**887**	**.101**		
Total	**92.659**	**890**			

No differences were found between the various co-operative education cycles on language clarity scores while non-EMI students scored significantly less on both evidence-based and language clarity scores across all co-operative educational experiences (Figure 2).

Figure 1. *Evidence-Based Rubric Scores of Reflective Writing by Co-Op Cycle and Population (EMI (blue triangles) vs, Non-EMI (red triangles))*

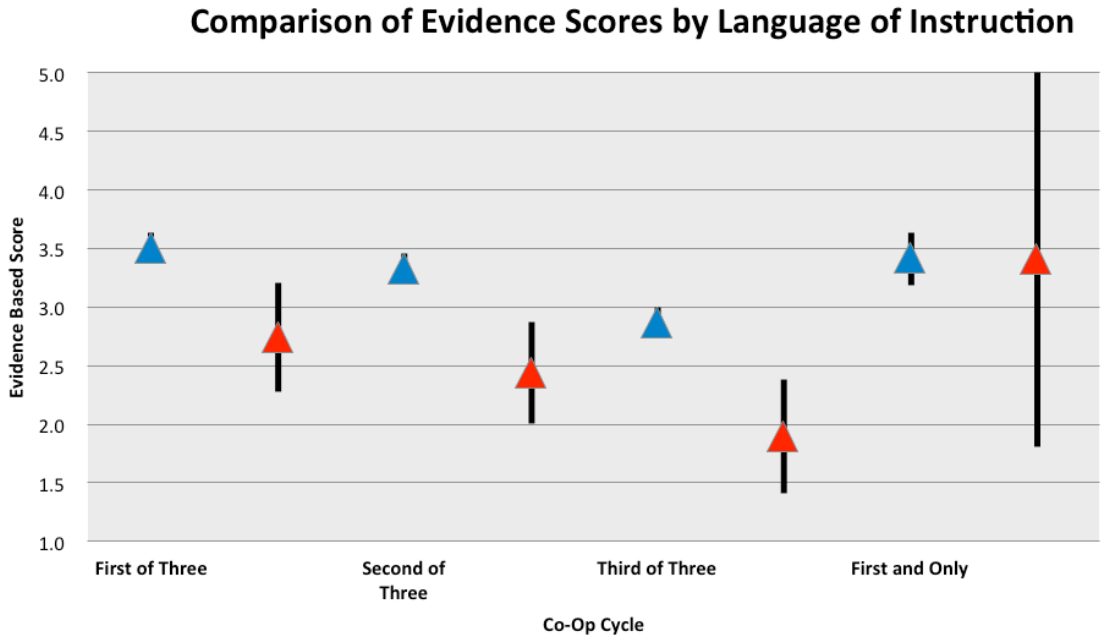
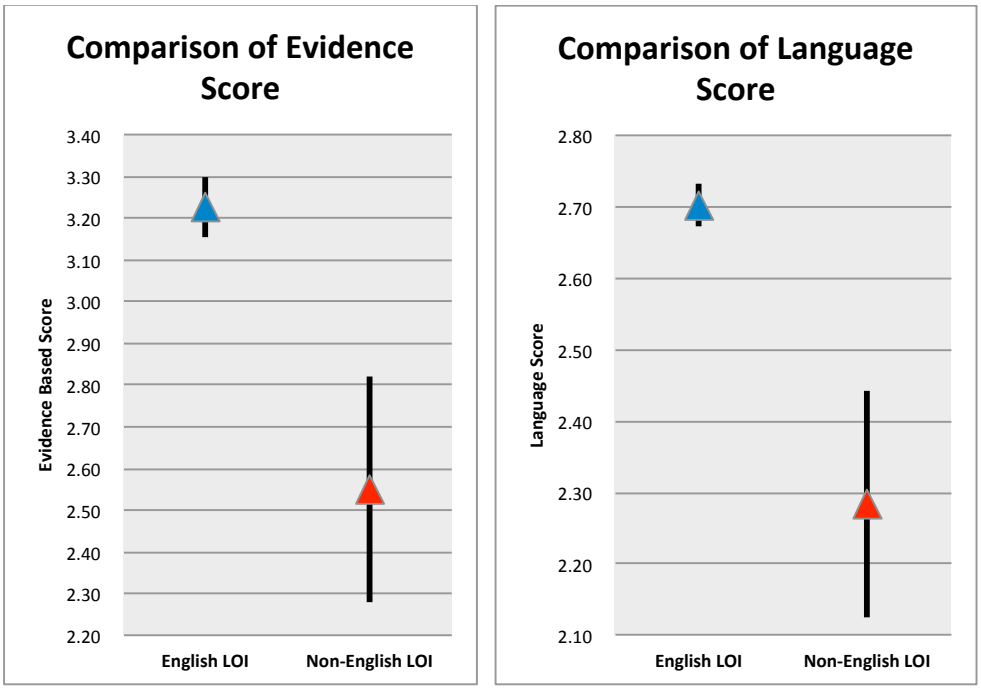


Figure 2. *Comparison of EMI (blue) and non-EMI (red) Populations on Evidence-Based Communication (left graph) and Language Clarity (right graph) over All Co-Op Cycles.*



These results have driven conversations on many levels:

1. A new supplemental reading/writing course was added for non-EMI international students and new metrics were designed to track success of these students in writing intensive courses;
2. The first-year writing program (a mandatory 3-sequence reading and writing program) augmented the role of an English as a Second Language (ESL) coordinator and increased faculty development for ESL faculty;
3. Guided scoring of the Co-Op samples with faculty from across the university allowed conversations about communication goals, skills, and tasks to emerge and queries about meeting the communication DSLP to emerge;
4. The University Committee on Assessment met twice to examine the scoring and results of the Co-Op analysis; this group validated the scoring prompt and rubric and created recommendations based on the data about non-EMI international student performance;

5. The College of Arts and Sciences added a new advisory position for international students was created and new measures were put in place to ensure that students complete the FWP sequence as foundational courses;
6. Longitudinal data—available for the first time—is currently being used to examine individual student performance across the three Co-Op cycles.

Compare these results with the traditional survey-based Co-Op data provided in Table 1. Reflective analysis provided both new insights about the Co-Op experience and a foundation for cross-curricular conversations about teaching and learning. Asking students to respond in their own words moves assessment beyond mere compliance into a more personalized engagement. This engagement is not neutral. In shifting attention from pre-populated Likert-responses to the uncharted arena of lived student experiences, the process becomes more learner-centered. This allows both students and faculty to understand how the curricula are shaping student learning and performance, directing assessment into a more aware, and revisionary, role.

Use of Co-Operative Education Reflective Analysis to Evaluate Course and Curriculum Relevance

Analysis of reflective writing samples made faculty aware of the potential for additional analysis related to curricular and program efficacy. A pilot experiment was then conducted to ascertain if useful information could be obtained relating students' work experiences with classroom learning. During a Spring-Summer Co-Op cycle (AY 2012-13), biomedical engineering undergraduate students were asked to complete a second reflective analysis piece in addition to the evidence-based writing described above. The instructions were as follows:

> *Reflecting upon your recent cooperative education experience, how well do you think your classroom activities prepared you? Was there anything missing that you felt would have better prepared you? Do you have any suggestions on how to improve you classroom activities to prepare you for your career? Please compose a 300-400 word reflective essay addressing these issues, including specific examples whenever possible.*

One hundred and thirty one students responded to the request. Of these, 49 were on their first Co-Op experience, 32 were on their second, 33 were on their third Co-Op and 17 were on their first and only work experience.

Data analysis is currently in progress, but even preliminary results show an extraordinary richness of informational detail. Some examples are provided below:

"My co-op experience was very research oriented. I was often required to read journal articles and get myself up to speed on topics and research. The classes that best prepared me were ones which required me to critically read journal articles and relate them to topics that I had learned about. However, the only courses that I can think of which required that were related to my concentration in neuroengineering. As a biomedical engineer who is interested in research, I think more courses in general should focus on understanding research, both from the perspective of a scientist and engineer."

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"My classes helped prepare me for basic theory but where my classes lack is in real world applications. I have had many classes on the theory or how drugs work, but never got any analytical classes about real world drug engineering. Modeling is becoming increasingly important in pharmaceutical industry for instance and we only have one class. I was well prepared such as knowing the theory behind chromatography, but never was taught how to apply those into learning more about drugs and how they interact with the systems they're targeting. Chemistry and biology have showed me they are very related and you can't really have one without the other. For example, a new drug may be considered a chemical reactions, but the biological process which we are targeting, is most likely run by chemicals."

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"Coming to work at this co-op made me realize how much of my education is applied to the workforce. I can honestly say that every Biomedical Engineering Class I took, especially the design ones, helped me succeed much more in this co-op position. I have a much larger appreciation for the classes I take at Drexel, as well as the importance of it all. Biomedical Ethics, Biomechanics, Biostatistics – all the BMES classes took foothold in my co-op here, be it for only one day or the full 6 months. The process of design and development is so extensively used here, as It is an industry competing with large companies like Medtronic and Johnson &

Johnson, that every day there were new ideas being developed for new products and how to develop them. Taking this process to mechanical testing, the extensive work we did in BMES 301 prepared me to understand what types of tests are done and how the resultant data is understood. Understanding who the "customer" of our products are – the surgeon, the future engineers, nurses, PA's, patients – helps us to have proper design constraints and look at our product from an extensive amount of perspectives to make them the best products in the Spine market. The only thing that I had to learn extensively more about was the machining process and how to create well-done engineering drawings, which I wish I had learned more about Freshman Year and Junior Year."

Preliminary Results

Fifty-two responses (40%) mention specific courses in the curriculum as either being useful or needing improvement while another 27 responses (21%) indicate certain categories of courses (biology, chemistry, etc.) as being either important or not as dictated by the co-operative education experiences. Fifty (38%) responses request more hands-on and practical training in the curriculum to better prepare students for the workplace. Seventeen (13%) of the responses indicate that the students were able to use the communication and presentation skills obtained in the curriculum in the workplace while eighteen (14%) indicated that even more training in these areas is needed.

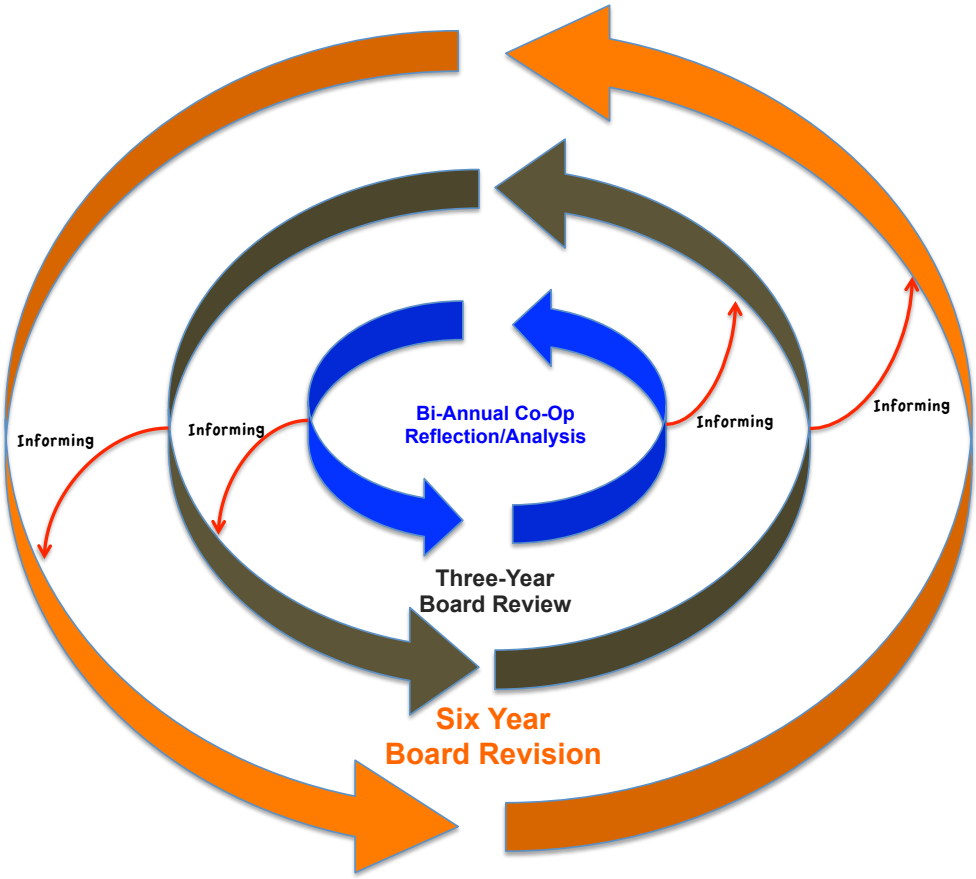
As part of a quality improvement effort, preliminary analysis of the reflective pieces contain at least 145 separate, individual suggestions for enhancing the biomedical engineering curriculum based upon the students' experiences in the workplace.

Conclusion

Reflective analysis integrated with co-operative or other workplace experiences represents an effective way to monitor the efficacy of classroom pedagogy and curricular design (Harvey, et al., 2010). Student responses can either be scored for skills (such as in the writing reflection) or content (as in the biomedical engineering pilot). In the latter situation, data on curricular efficacy and relevance can be gathered without the confounding effects of instructor personalities and/or grades which reduces the utility of student course evaluations. In addition, such data provides an opportunity for students to consider how their educational experiences

interact with the workplace in a way that scaled surveys do not provide. Such reflections also provide faculty and administrators with a direct look into the working environment outside of academia allowing for a continuous reevaluation of the program's educational objectives (Figure 3). Further research into the utility of reflective analysis and its possible integration with other approaches, such as social media-based ePortfolios, is clearly supported by these results.

Figure 3. *Refection/Review/Revision Cycle for School Program Educational Objectives*



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