Using Knowledge Management Approaches to Integrate Co-Operative Education

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The Problem
The integration of co-operative educational experiences into the overall development of students is part of an issue with far broader application. The current model of curriculum design in higher education seems to have more in common with biological evolution than intelligent design. Even if a curriculum was originally developed with a clear set of program objectives and student learning outcomes – a situation far from the norm in most colleges and universities – over time, curricula drift away from that initial design. Faculty are hired for their research expertise, new developments in the field require specialized courses, some faculty may teach more to their own comfort level than to the needs of the program or students, and the original design quickly becomes distorted and in some cases, even moderately incoherent. Added to this is the tendency for faculty in higher education to teach in isolation and the situation develops in which information and knowledge becomes compartmentalized. The impact on the students can be profound and leads to situations that belie the benefits of obtaining a college or university degree. Two examples from the author’s experiences will help to illustrate the point.

The author has taught at several institutions over the past 28 years and at both graduate and undergraduate levels. For some years, it was his responsibility to teach a three-course sequence in biomedical science to graduate students with undergraduate degrees in engineering who wished to obtain Master’s degrees in biomedical engineering. The students in this program came from many highly regarded institutions in the United States and internationally. The first course in the sequence focused on evolution through cell biology and tissues, the second on systemic physiology and the third on neuroendocrine control systems. Thus, the course sequence built upon the individual components to generate an overall familiarity with fundamental life science. However, when the author announced that finals would be cumulative throughout the sequence and that materials from first course could be made into questions on the examinations in the second course, the students protested vigorously. Their argument was that it was not fair to require them to recall materials learned in a previous course in another course in the sequence. The implication of this claim is profound: knowledge is to be retained only until it can be demonstrated on an examination and then immediately discarded. Thus, knowledge gained through the curriculum is temporary and critical only to obtain grades. This as summarized by a student who referred to this type of learning as ‘final and flush’.
A second example is equally disturbing. In this case, the author was teaching an upper undergraduate division course in neuroscience. As part of the course, students were required to understand aspects of electrophysiology. This, in turn, required knowledge of membrane dynamics and this necessitated some experience and background in chemical thermodynamics. After reviewing the basic principles for several weeks, the author gave an examination and students did more poorly than expected. Frustrated, the author asked the students to explain how they could do so poorly on an examination which was, after all, entirely concerned with materials learned previously in pre-requisite courses. One student supplied an astonishing answer. He explained that the author had asked questions about chemical thermodynamics in what was essentially a biology class. Again, the implication was that such questions were inherently unfair: questions about chemical thermodynamics can only be asked in a chemistry class. While these results may or may not be entirely typical, the tendency of students to compartmentalize knowledge and information makes it extremely difficult to build a developmentally sound understanding of the complex materials involved in higher education. Whether this is a direct consequence of the compartmentalization of faculty instruction or the result of other factors, these observations reinforce the need for true curriculum design.

The problem of integrating educational experiences can be exacerbated when considering co-operative education. During their co—op experiences, students are often off campus and fall out of touch with classroom activities. The work in which students are engaged may or may not be directly related to materials recently learned. In addition, the work environment is often so different from campus life in terms of activities, schedules and expectations as to represent a different world. Given student tendencies to compartmentalize their learning experiences as described above, it can be predicted that students will not naturally integrate work and classroom learning. Students may have a difficult time transitioning back into the classroom from their co-operative educational experiences and thus an alternating pattern of co-operative and classroom-based experiences might actually impede rather than enhance some aspects of intellectual growth. To fully realize the potential of co-operative education, a closer and more integrated association between these alternative forms of learning is needed. To create such an association requires specific and deliberate curricular planning.

**The Initial Steps**

Recognizing that integration of co-operative education with classroom activities is a special case of overall curriculum design, the initial step in the process must be to develop a curriculum model which generates a developmentally appropriate series of learning opportunities which transform students into productive members of society. To achieve this, the phrase ‘productive members of society’ must be clearly defined. This is accomplished through the creation of what ABET, Inc. calls ”program educational objective” (PEO) which are defined as knowledge, attributes, skill sets, etc. displayed by the alumni of a program several years after graduation. An
example of such an objective (from the School of Biomedical Engineering, Science and Health Systems at Drexel University) is: *The majority of graduates are engaged in some form of continuous learning and/or professional development.* A majority in this instance was defined as 67% or more. Each program must generate its own objectives in line with that program’s expectations for their graduates.

Interestingly, PEOs are often treated almost as an after-thought in the curriculum design process, especially when compared with student learning outcomes. The latter are the knowledge, attributes, skill sets, etc. which are displayed by student participants in the program at the time of graduation. If we continue to use ABET as an example, the organization supplies learning outcomes for engineering programs – the famous or infamous ABET a-k criteria –but does not specify PEOs. The justification for this may be that data on PEOs, measured on alumni, are far harder to collect than data on graduating students. The problem with this approach is that it reinforces the notion that learning is temporary. The learning outcomes become a kind of final examination for the program and it is more important to pass the final than it is to make any long-term use of the knowledge or skills presumably needed to pass this hurdle. Thus, to truly engage in effective curriculum design, the author contends that the development of PEOs must be of primary concern.

So, how are PEOs created? The first step would be to identify the main stakeholders. Externally, these stakeholders represent the career paths being followed by graduates from the program. For example, the School of Biomed found that its undergraduates were divided among those entering private industry, those pursuing a medical career and those seeking advanced professional study. The School then formed an association – the Biomedical Community Advisory Board – to assist in development of PEOs which included representatives from industry, physicians, members of professions, government representatives, and alumni. The latter are in an excellent position to provide feedback of how materials being taught actually influence post-graduation success. The faculty are another major set of stakeholders whose views must be examined. Finally, students should be included, especially when a program involves co-operative education. This allows for students to use their practical experiences to impact curricula development and is one way to help integrate co-operative education and classroom experience. Thus, the process of curriculum design itself can be used to start breaking down learning compartmentalization.

Once PEOs are established, the next step is to create a set of supporting “student learning outcomes” (SLOs). These outcomes should be designed such that students who succeed in obtaining the learning outcomes will have a high probability of achieving program objectives. It seems clear that the logical approach to the design process in this instance is to begin with program objectives and then develop learning outcomes to support them. However, this is not standard practice and learning outcomes are usually created almost independent of PEOs. As stated above, this practice reinforces the concept of limited learning and implicitly denigrates the
impact of a college or university education. Nonetheless, many accrediting organizations, such as ABET, provide far more guidance on SLOs when compared to PEOs. To partially overcome this perspective requires a thoughtful development of clear and useful PEOs and creation of a data collection system capable of long-term measurement of alumni achievement.

However, even SLOs can prove to be a challenge in terms of effective measurement. For example, consider the student learning outcome below, derived from ABET criterion a:

*Ability to apply knowledge of mathematics, science and engineering to solve problems at the interface of engineering and biology*

How does one measure this in terms of academic performance? ABET recommends the development of so-called *performance indicators*. Performance indicators or criteria (these concepts go by several names) are constituent, measurable elements of a SLO\(^1\). The actual measurement of such elements often uses a method of categorization called *rubrics*.

**Figure 1. Relationships between Student Learning Outcomes, Performance Indicators and Rubrics.**

Rubrics create categories of student achievement within a given performance indicator or criterion\(^4\). The number of levels varies between 3 and 5 depending on the resolution one wishes to achieve. In Figure 1, the relationships between an SLO, its associated performance indicators and rubrics are displayed. Performance indicators 1-4 are components of the SLO. Figure 2 displays a specific example from the School of Biomedical Engineering, Science and Health Systems.
Mapping

Mapping is the process by which performance indicators are associated with specific events within a program or curriculum. Performance indicators differ from course grades in several significant ways. First, they are specific performance metrics whereas course grades are usually a combination of many different metrics. As an example, a course grade may be composed of assignment results, written papers, problem sets, examinations, etc. A final grade of A or B does not indicate student performance on specific activities any more than an average of a population provides detailed information on individual measurements within that population. A performance indicator, on the other hand, would be focused solely on written communication or the ability to solve specific types of problems. Performance indicators thus provide superior resolution which cannot be achieved using class grades. Second, performance indicators are general characteristics of students that should be applicable in multiple different situations and environments. Thus, while a course grade is measured within the context of a specific course, performance indicators can be measured across courses, in extra-curricular activities, during employment and service activity, as well as within particular courses. They can be tracked during a student’s progression through the academic program and will provide key intervention points in curricular re-design. Finally, performance indicators can easily be adjusted to measure different cognitive states of development. Thus, performance indicators can be applied to freshman and seniors to demonstrate the appropriate levels of change, whereas grades tend to be static markers of performance in a specific class, with a specific instructor. Thus, mapping with grades makes little design sense while mapping with performance indicators can provide detailed charts of student cognitive progress.

Mapping is a complex and iterative process. The School of Biomed began with 14 SLOs, based on the standard ABET a-k criteria plus custom additions, resulting in 74 performance indicators.
for the biomedical engineering undergraduate program. The Undergraduate Curriculum Committee (UGCC) then established an initial mapping of these indicators into our courses by matching course content and objectives to the performance indicators. The mapping was refined through interviews with course instructors and made into a list of courses with their associated performance indicators.

This initial listing displayed certain anomalies that had not been previously apparent. Some performance indicators were over-represented and others were under-represented within the curriculum. As a result, a secondary review of the situation in consultation with the faculty resulted in a limited redesign of the curriculum and a partial redistribution of the performance indicators to create a more balanced and efficient treatment.

The list was further refined by creating categories or levels by which a course might be associated with a performance indicator. The levels were Introduced, Reinforced and Emphasized as used by the New Jersey City University Business Administrative Program. The courses, with their associated levels of performance indicator, were then placed into a temporal context by creating a template of the courses in the order in which students would progress through the curriculum. Again, numerous anomalies appeared in the design. For example, a course might be listed as reinforcing a topic before that topic had been introduced or the same topic might be introduced as many as 10 times without being reinforced or emphasized. In consultation with the faculty, the UGCC further refined the curriculum and the category associations to remove these anomalies and ensure a coherent and progressive placement of each performance indicators.

The I, R and E designations do not lend themselves to effective assessment. Therefore, Bloom’s taxonomy of educational objectives can be applied to each category resulting in a curricular map associating courses and other activities with specific cognitive characteristics (knowledge, comprehension, application, analysis, synthesis, and evaluation). The resulting mapping can then be used to develop multiple assessment tools such as internal (in class assignments, problems, etc.) and external (standardized examinations, performance evaluations, etc.) assessment instruments.

An example of an outcome/indicator map set up in terms of sequential course offerings is displayed in Figure 3.

Before proceeding, it should be noted that mapping manually can be an exceeding time-consuming and tedious process. Mapping tools available from such software packages as AEFIS (Academic Evaluation, Feedback and Intervention System) make the procedure far more manageable and efficient and are highly recommended.
The numbers in Figure 3 represent learning outcomes and performance indicators. The number 1.1, for example, represents the first performance indicator associated with student learning outcome 1. The actual outcomes and indicators displayed are not, however, the essential point of the figure. What is important is that specific outcomes and indicators are mapping into the co-operative education section of the curriculum at a developmentally appropriate level. Thus, co-operative education has been fully integrated into the design of the curriculum with specific expectations which can be assessed and evaluated.

Figure 3. Performance Mapping in a Temporal Context

Translating Design into Practice

Essential as the proper curriculum design may be, it is not sufficient to ensure actual integration of co-operative education into a program. At Drexel University, several approaches are being evaluated to foster this integration.

Mapping and Reflective Analysis

As an initial step, the evaluations completed by employers and students have been modified to include at least some of the learning outcomes and indicators mapped to co-operative education by the various programs. This serves the dual function of providing assessment data for evaluation of student work experiences while also providing employers and students with a sense of what is to be accomplished related to curricular goals by the co-op experience. Currently, the
survey forms completed by employers and students have combination of general assessment questions and questions specific to individual programs. As data accumulate, the surveys will be refined to generate more and more useable information.

As part of the student evaluation, students are now required to undertake a reflective analysis of their experiences. Directed reflection of this type can be used to reinforce learning as well as potentially establish connections heretofore unrecognized between co-op experiences and classroom learning. By asking students to ascertain how a classroom experience prepared them for work or how what they have learned on the job will impact how they approach classroom instruction and learning, Drexel hopes to explore and reinforce the connection between co-operative experiences and the on-campus curriculum.

ePortfolios

To further reinforce this concept, a taskforce of faculty lead by Dr. Karen Nulton is investigating the use of ePortfolios as an integration technique linking co-op and the classroom experience. The LeBow College of Business implemented just such an approach in order to integrate various components of the College’s curriculum. Entitled My LIFEfolios, the project was designed was designed for three objectives: 1. provide evidence of learning across the business curriculum; 2. provide opportunities for student reflection on what was being learned; and 3. provide an archive of student performance and accomplishments. The design of the project involved faculty across a wide spectrum of the University, both within the College and in those units, such as the Department of Mathematics, which provided necessary support courses. The discussions that resulted increased everyone’s understanding of the roles played by the various faculty, their requirements and expectations as well constrains on student progress. Furthermore, in order to proceed with the design, three questions needed to be answered: 1. What were the students expected to learn?; 2. What evidence of learning should the students retain of that learning? and 3. How can the students be convinced to reflect of what they have learned? To answer these questions, the College proceeded to develop four ePortfolios within the My LIFEfolio system for students: a writing, quantitative reasoning, career and business (reflected the student’s area of concentration).

By creating specific Web-based portfolios geared towards specific student learning goals, the ePortfolios archive data and organize it into useable modules that can be effectively and efficiently assessed. Because the ePortfolios were designed and developed by collaborative groups of faculty interested in enhancing student performance, there is ownership of the results and a desire to enhance the program, utilize the results, and participate in the assessment to achieve program objectives. The ePortfolios also leverage student familiarity and comfort with technology and provide a mechanism to self-discovery within the learning process. Drexel University is currently in the design phase of examining the ability of ePortfolios to link student experiences in co-operative education with more traditional classroom instruction.
**Digital Socrates**

Digital Socrates is an ambitious multi-phase project designed to create a virtual learning community linking all aspects of students’ experiences, including the classroom, outside research, extra-curricular activities and co-operative education\(^3\). The primary components are:

**Instructional Decision Support System** or IDSS. The function of the IDSS is to link student characteristics, student performance, instructor characteristics, learning outcomes, and instructional methods to inform faculty decisions on the appropriate educational pedagogy to improve student learning. For example, when an SLO is assigned to co-operative education, the assessment results can be fed back into the appropriate IDSS to guide instructor decision-making and instructional strategies.

**EduApps Portal.** The Portal will function as a Web-based clearinghouse for educational applications. The idea was inspired by Apple’s highly successful iPhone and subsequent development of smart phone applications. Originally envisioned as a method of providing a standard format for instructional ideas, approaches and methodologies to be made available to instructors, we have expanded the idea to include concept and skill tools for direct student use. Thus, the Portal will serve both faculty and students by providing simply, easy-to-use and reliable access to both pedagogical and disciplinary information.

**Guided Personalized Student Learning System** or GPS-Learn. The function of GPS-Learn is to facilitate decision-making by students concerning their own education. The GPS-Learn system will link student and instructor characteristics, learning outcomes, curricular design, study tools and discipline–based learning aids to provide just-in-time assistance and mentoring to students. Thus, the students directly link into past, current and future instruction while on co-op and retain that sense of belonging to a learning community even while working.

**SocraticNet.** SocraticNet is a social learning network to be tied in with the other components. The function of this component is to facilitate communication between instructors, students and the Portal to maximize the development of new ideas, approaches and pedagogies and enhance their dissemination. The name reflects the investigators’ belief that the reflective question-and-answer dialectic approach of Socrates can be applied to modern Web-based communication networks to facilitate learning.

These four components form a knowledge management system capable of adapting to various educational environments and evolving with changes in curricular, faculty expectations, learning outcomes and student characteristics. In addition, by creating such an evolving and adaptive learning environment, all aspects of the curricular experience of students – and not just co-operative education – stand a far better chance of becoming a coherent whole rather than merely a collection of parts.
References


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