Validation of Hybrid Program Design through Stakeholder Surveys

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Abstract

Achieving shared understanding of program educational objectives should be the first step in defining program structure and selecting appropriate pedagogies. A discipline specific profile that describes the holistic behaviors and observable actions of a practicing expert in the field is a useful tool that can be used to guide the development of educational objectives, learning outcomes expected of graduates, primary areas of emphasis, and preferred learning experiences. In this paper, a profile of an expert engineer is used to explore the benefits of a hybrid program design that combines traditional classroom experiences with engineering co-operative experiences at Kettering University. The profile was used to elicit input from key program stakeholders, especially alumni. The profile included four technical roles (analyst, problem solver, designer, and researcher), three interpersonal roles (communicator, collaborator, and leader), and three professional roles (self-grower, achiever, and practitioner). Findings suggest that the co-op experience complements the traditional classroom experience in the promotion of the roles of analyst, problem solver, and designer. Furthermore, the co-operative experience offers distinct benefits in the promotion of the roles of collaborator and practitioner.

Introduction

In higher education, there is variation in the design of educational programs, definition of expected results, and implementation of relevant learning experiences, not only from one discipline to another but also from one institution to another. To assure consistency and to improve quality, there have been a growing number of national reports and articles that document the need for increased accountability as well as the incorporation of innovative forms of teaching (U.S. Department of Education, 2006; Baer, Cook, & Baldi, 2006). However, in order to achieve accountability and to discern whether an educational program or a teaching strategy actually delivers the desired results, the program and its learning experiences must be intentionally designed and continuously assessed by program stakeholders (Collins & Apple, 2007).

To be accredited, educational programs are usually assessed based on a set of selected outcomes. In engineering disciplines, for example, the Accreditation Board for Engineering and Technology (ABET, 2010) has outlined and continues to update the set of necessary educational outcomes for accreditation. As of 2005, these included:

a) An ability to apply knowledge of mathematics, science, and engineering
b) An ability to design and conduct experiments, as well as to analyze and interpret data
c) An ability to design a system, component, or process to meet desired needs
d) An ability to function on multi-disciplinary teams
e) An ability to identify, formulate, and solve engineering problems
f) An understanding of professional and ethical responsibility
g) An ability to communicate effectively
h) The broad education necessary to understand the impact of engineering solutions in a global and societal context
i) A recognition of the need for, and an ability to engage in, lifelong learning
j) A knowledge of contemporary issues
k) An ability to use the techniques, skills, and modern engineering tools necessary for engineering practice

While these outcomes represent the minimum to be achieved at the end of the program, some educational researchers suggest that these outcomes may not be detailed enough to capture the spectrum of characteristics required in a successful engineer and that there are perceived gaps in the skills of graduating engineers from U.S. institutions of higher education (Shuman, Besterfield-Sacre, & McGourty, 2005; King, J. El-Sayed, Sanders, & M. El-Sayed, 2005).

To intentionally design, refine, or continuously improve an educational program, a set of clear objectives and outcomes must be defined. In addition, all learning experiences, courses, and activities should be aligned to deliver these outcomes and ultimately achieve the program objectives. In this work, we discuss the

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development of meaningful educational objectives based on feedback from program stakeholders. In addition, we study the roles of two different learning experiences selected to achieve these objectives for a hybrid program. While the examples provided in this paper are from an engineering context, the methodology is applicable to professional programs in other disciplines.

Formulation of Professional Degree Program Objectives and Outcomes

Developing educational objectives for any program is usually a demanding task due to the multitude of stakeholders that the program serves. Direct stakeholders include students, parents, alumni, employers, professions, and society at large. To develop educational objectives to meet the needs of such a diverse and large number of stakeholders, program designers should focus on the required performance attributes of a practicing individual graduating from such a program. In engineering, the Transferable Integrated Design Engineering Education (TIDEE) consortium of colleges in the Pacific Northwest developed an engineer profile by compiling accreditation criteria, codes of ethics, attributes valued by employers, and core competencies valued by professional societies. Synthesis of these traits produced a set of ten holistic behaviors of an engineer (D. Davis, S. Beyerlein, & I. Davis, 2006). These ten roles include those of analyst, problem solver, designer, researcher, communicator, collaborator, leader, self-grower, achiever, and practitioner. The skill set implied by the profile of an engineer includes characteristics that, once mastered, would make an engineer deemed an "expert" in his or her profession.

Davis and Beyerlein (2007) grouped the ten holistic behaviors into three areas: technical roles, interpersonal roles, and professional roles. Tables 1, 2, and 3 define several roles relevant to each area and outline observable actions associated with each role. Technical roles include the roles of analyst, problem solver, designer, and researcher. Interpersonal roles include communicator, collaborator, and leader. Professional roles include being a self-grower, achiever, and practitioner.

The holistic behaviors or roles profiled in Tables 1, 2, and 3 are broader and more far reaching than the ABET educational outcomes. Ideally, these behaviors should become fully developed in engineers three to five years from graduation. Therefore, the ten holistic behaviors are good tools for engaging program stakeholders about program educational objectives.

By defining an acceptable level of performance at the time of graduation with respect to each role, a set of program outcomes can be derived. These outcomes should describe an intermediate state of professional development that provides a positive indication that long-term behaviors will ultimately take hold. The following example illustrates the use of the profile in developing a program outcome that is anchored to professional practice. In the area of self-growth, graduates of the program should display:

- An ability to take ownership of their own personal and professional growth
- An ability to define personal professional goals that support lifelong productivity and satisfaction
- An ability to self-assess personal growth and challenges to achieving personal goals
- An ability to develop plans to reach personal goals
- A recognition of the need to seek out mentors to support future growth and development

Selection of Professional Degree Program Learning Experiences

Once educational objectives and program outcomes are defined, the selection of program components and learning experiences follows (Davis & Beyerlein, 2007). For professional degree programs, a means for promoting theory-oriented and practice-oriented dimensions of the curriculum is a hybrid program design that integrates two or more complementary learning experiences. In this paper, two common and complementary learning experiences are considered: classroom learning experiences and co-operative learning experiences.

Traditional classroom education is conducted primarily by an instructor. In addition to providing the fundamental knowledge and skills needed for professional practice, some classroom learning activities attempt to emulate professional practice. However, the contextual environment for gaining knowledge, mastering theories behind common applications, and engaging in problem solving, design, and research emulate only a small portion of the complexity and ambiguity that exists in an actual workplace. To more completely address authentic situations faced by professionals in the field, more experiential forms of education are often used to complement classroom activities. These include special laboratory courses as well as work experiences.

Before formal organizations of higher education existed, the common way that a young person would learn a profession was through apprenticeship. An apprentice would shadow the master craftsman to learn through observation and interaction. Slowly the apprentice would pick up the craft, first by doing elementary tasks under the full supervision of the master, and, as the apprentice

Table 1 Technical Roles and Their Attributes (adapted from Davis, 2007)

Analyst	***Designer***
When conducting engineering analysis, the engineer adeptly applies principles and tools of mathematics and science to develop understanding, explore possibilities, and produce credible conclusions. Observable actions that support this role include: a. Searching strategically to identify all conditions, phenomena, and assumptions influencing the situation b. Identifying applicable governing principles of mathematics, natural sciences, and engineering sciences c. Selecting tools for analysis that are efficient, and consistent with governing principles, desired results, and assumptions d. Producing and validating results through the skillful use of contemporary engineering tools and models e. Extracting desired understanding and conclusions consistent with the objectives and limitations of the analysis	When facing an engineering design challenge, the engineer develops designs that satisfy stakeholder needs while complying with important constraints of implementation and societal need. Observable actions that support this role include: a. Searching widely to determine stakeholder needs, existing solutions, and constraints on solutions b. Formulating clear design goals, solution specifications (including cost, performance, manufacturability, sustainability, and social impact), and constraints that must be satisfied to yield a valuable design solution c. Thinking independently, cooperatively, and creatively to identify relevant existing ideas, and to generate original solution ideas d. Synthesizing, evaluating, selecting, and defending alternatives that result in products (components, systems, processes, or plans) that satisfy established design criteria and constraints to meet stakeholder needs e. Reviewing and refining design processes for improved efficiency and product (solution) quality
Problem Solver	***Researcher***
When facing an engineering problem, the engineer produces solutions that properly address critical issues and assumptions, and that are conceptually and contextually valid. Observable actions that support this role include: a. Examining the problem setting to understand critical issues, assumptions, limitations, and solution requirements b. Considering all relevant perspectives, solution models, and alternative solution paths c. Selecting models for obtaining solutions consistent with problem type, assumptions, and solution quality d. Using selected models, methods, and data to produce a desired solution e. Validating results, and interpreting and extending the solution for wider application	When conducting applied research, the engineer designs and conducts studies that yield defensible results and answer important applicable research questions. Observable actions that support this role include: a. Formulating research questions that identify relevant hypotheses or other new knowledge sought b. Planning experiments or other data gathering strategies to address questions posed and to control error c. Conducting experiments or other procedures carefully to obtain reliable data for answering questions d. Using accepted data analysis procedures to infer trends, parameters, and data error e. Interpreting and validating results to offer answers to posed questions and to make useful application

developed, he or she would graduate to performing more advanced tasks in a more independent and self-directed fashion. The master would model all characteristics of an expert in his or her field. Apprenticeship still exists today in many fields. While apprenticeship provides access to real situations faced by real professionals in daily work, deep mastery of the fundamentals, deep theoretical understanding, and transferable knowledge needed for tackling a broad spectrum of problems across sub-disciplines may be lacking or slow to develop.

There are many benefits of integrating classroom learning with experiential learning situated in the workplace (Bowers, Sonnet, & Bardone, 1999; Grosjean, 2003). In engineering, for example, the modern day version of apprenticeship is co-operative education (co-op). In a co-op situation, the undergraduate alternates between working in an industrial setting and receiving classroom instruction at a university. Through work in a co-op, a student is exposed to exactly the type of complex environment that he or she will face as an engineer. If

Table 2 Interpersonal Roles and Their Attributes (adapted from Davis, 2007)

Communicator
When exchanging information with others, the engineer prepares, delivers, and receives messages that achieve desired outcomes. Observable actions that support this role include: a. Listening, observing, and questioning to assess audience background and information needs b. Documenting and mining available information and differing perspectives for understanding and application c. Preparing a message with the content, organization, format, and quality that fits the audience and purpose d. Delivering a message in a timely, credible, and engaging way that efficiently achieves desired outcomes e. Assessing the communication process and responding in real time to advance its effectiveness
Collaborator
When working with others in joint efforts, the engineer supports a diverse, capable team and contributes to the achievement of its collective and individual goals. Observable actions that support this role include: a. Respecting individuals with diverse backgrounds, perspectives, and skills important to the effort b. Valuing roles, accepting role assignments, and supporting others in their roles c. Contributing to the effective cooperation of the team in its development of consensus goals and procedures d. Resolving conflicts and promoting enhanced buy-in, creativity, trust, and enjoyment by all e. Contributing to and accepting feedback and change that support continuous improvement
Leader
When providing needed leadership, the engineer promotes a shared vision to individuals, teams, and organizations, and empowers them to achieve their individual and collective goals. Observable actions that support this role include: a. Facilitating and articulating a shared vision valued by targeted individuals, groups, or organizations b. Motivating others to action by crafting a compelling yet credible case for achieving individual and organizational goals c. Providing authority and resources, and removing barriers to aid others' success d. Supporting risk-taking and growth by creating trust, providing counsel, and modeling desired attributes e. Encouraging achievement by recognizing and rewarding individual and group successes

Table 3 Professional Roles and Their Attributes (adapted from Davis, 2007)

Self-Grower
Motivated for lifelong success, the engineer plans, self-assesses, and achieves necessary personal growth in knowledge, skills, and attitudes. Observable actions that support this role include: a. Taking ownership for one's own personal and professional status and growth b. Defining personal professional goals that support lifelong productivity and satisfaction c. Regularly self-assessing personal growth and challenges to achieving personal goals d. Achieving the development planned to reach personal goals e. Seeking out mentors to support future growth and development
Achiever
When given an assignment, the engineer demonstrates initiative, focus, and flexibility to deliver quality results in a timely manner. Observable actions that support this role include: a. Accepting responsibility and taking ownership in assignments b. Maintaining focus to complete tasks on time amidst multiple demands c. Taking appropriate actions and risks to overcome obstacles and achieve objectives d. Monitoring and adapting to changing conditions to ensure success e. Seeking help when the challenge, including time constraints, exceeds ones current capability
Practitioner
Driven by personal and professional values, the engineer demonstrates integrity and responsibility in engineering practice and contributes engineering perspectives in addressing societal issues. Observable actions that support this role include: a. Displaying integrity, consistency, ethical behavior, and a professional demeanor in engineering practice and relationships b. Embracing and employing appropriate professional codes, standards, and regulations c. Engaging with engineering professionals and organizations to support excellence in engineering practice d. Demonstrating citizenship through service to society on local, national, and/or global scales e. Bringing responsible engineering perspectives to global and societal issues

the experience is designed properly, the student will be able to complete increasingly more difficult assignments with less supervision. While working in a co-op setting, students attempt to mimic the behaviors and characteristics of an engineer in the field until they gain mastery. By being a co-op student and not a full-fledged engineer, a student has more flexibility to experiment with different methods to accomplish tasks and, through reflection, he or she can construct the knowledge of what works and what doesn't work in the field. These experiences help students build frameworks about what it takes to be a successful professional (Grosjean, 2003).

Hybrid Program Assessment

For many years Kettering University has integrated classroom and co-op learning experiences in the delivery of all of its engineering programs (El-Sayed & Kowalski, 2004; King et al., 2005). Students begin their co-op rotation in their freshman year and must successfully complete multiple co-op terms to be eligible for graduation. For continuous improvement purposes, university alumni are periodically surveyed about the hybrid program learning experiences of their classroom and co-op worksite.

Kettering University alumni surveys are conducted by the Office of Institutional Effectiveness. Surveys are conducted with all alumni three years after graduation. The surveys are mailed to each member of the targeted class with an addressed, stamped envelope. The typical number of graduates surveyed is approximately 400 per class with a return rate of approximately 16%. Questions are included that ask respondents to rate the effectiveness of the learning environment of the classroom and that of the co-op in contributing to a large significant increase in their ability for each criterion.

The first alumni survey considered in this study was conducted in 2005 and was based upon the ABET educational outcomes (El-Sayed, 2008). Questions asked respondents to rate (low, medium, or high) how co-op and classroom experiences contributed to learning associated with ABET criteria a-k. Table 4 maps the ABET criteria to the professional roles given in Tables 1-3. Note that roles of leader, achiever, and researcher were not included in the 2005 survey because these are not explicitly addressed in the ABET criteria. Results from the 2005 survey are charted in Figure 1.

To determine whether the 2005 results were repeatable, the 2008 university alumni survey results (El-Sayed & Stodola, 2009) were also mapped to the holistic behaviors. The results of this survey are charted in Figure 2. These data include nine of the TIDEE roles.

The 2008 alumni survey was organized in a different manner and the respondents were asked to circle those characteristics in which they had a large positive change in knowledge. Also, the 2008 alumni survey did not ask the respondents about communication except with respect to the overall educational experience, therefore the classroom and co-op contributions could not be separated.

Alumni feedback from the 2005 and 2008 surveys indicated that both learning experiences contributed significantly to their professional development. Both surveys indicated that co-op education had a higher contribution than classroom experience in five of the ten holistic behaviors (analyst, problem solver, designer, collaborator, and practitioner). The co-op experience also had a higher contribution than classroom experience for the role of achiever in the 2008 alumni survey. One of the behaviors with the highest relative contribution to professional development through the co-op experience was the role of collaborator. This addresses an area of perceived national and global deficiency that is needed for multi-disciplinary project work in engineering practice (Baer et al., 2006).

According to the responses from the 2008 alumni survey, the classroom experience was found to be slightly more significant than the co-op experience for promoting skills related to the role of leader. Neither venue, however, compelled a majority of alumni to respond that they had gained a large increase in their leadership skills. In addition, neither co-op nor classroom education showed a high impact on the development of researcher and self-grower skills. These are areas for possible improvement in the design of Kettering's hybrid program.

Conclusions

The process of designing or reforming an educational program should flow in the following order: a) defining the educational objectives, b) driving the program outcomes, c) selecting program emphasis and learning experiences, d) designing courses and learning activities, and e) addressing assessment and evaluation systems. Stakeholder involvement in early stages of program design helps to validate program intentions. Stakeholder involvement in program assessment helps to identify current program strengths as well as prioritize potential improvements.

Program outcomes should always be aligned with the program's educational objectives to provide assurance that professional growth in the desired direction is well underway. For professional degree programs, the use of a profile describing the holistic behaviors and observable actions of an expert practitioner in the field is a valuable tool in surveying alumni perceptions about the program and its added value in the workplace. The profile is also an excellent tool for introducing the profession and its ways of being to the next generation of practitioners.

Selecting program emphasis and learning experiences is necessary before designing a set of courses and learning activities. The investigation of classroom and co-op learning experiences performed in this study illustrates that learning experiences are not equal in their contribution towards achieving program educational objectives. From the alumni surveys presented in this work, it is clear that both have a role in facilitating growth in professional behavior by young engineers. The co-op element, in particular, reinforces the roles of analyst, problem solver, and designer addressed in the traditional classroom and has potential to remediate perceived deficiencies of graduates in the roles of collaborator and practitioner.

Table 4: Mapping ABET Outcome Types to Professional Roles

Role or Objective	ABET Outcomes	Role or Objective	ABET Outcomes
Analyst	a, b	Collaborator	d
Problem Solver	a, e, k	Leader	-
Designer	b, c	Self-Grower	i
Researcher	-	Achiever	-
Communicator	g	Practitioner	f, h, j, k

Figure 1

Percent responding that this learning experience accounted for a large increase in ability (2005 Alumni Survey)

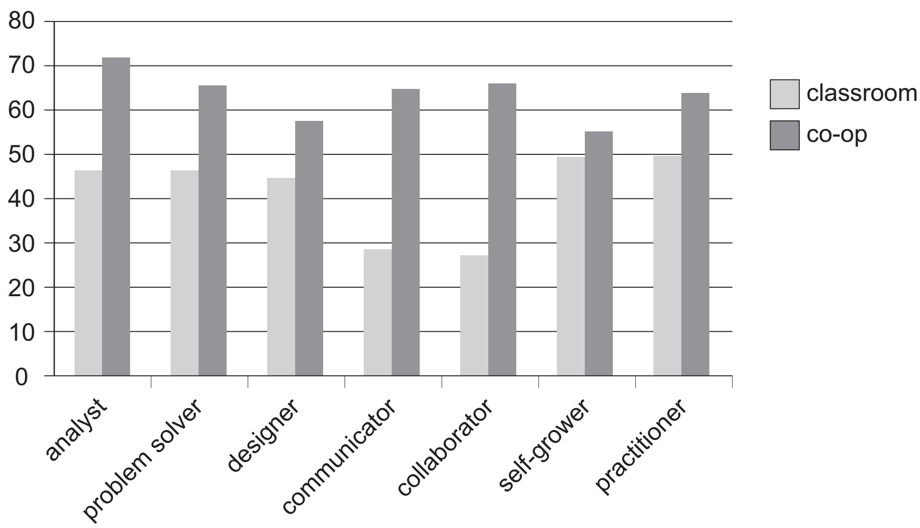
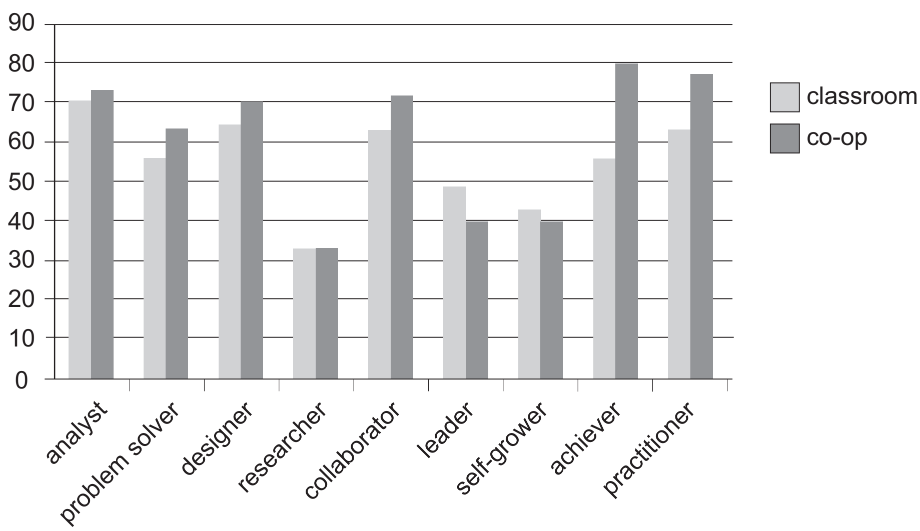


Figure 2

Percent responding that this learning experience contributed to a large increase in ability (2008 Alumni Survey)



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