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A Meta-analysis of the Effect of Industry Engagement on Student Learning in Undergraduate Programs

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PEER-REFEREED PAPER ▪ PEDAGOGICAL PAPERS

A Meta-analysis of the Effect of Industry Engagement on Student Learning in Undergraduate Programs

Mr. Caleb Burns and Dr. Shweta Chopra

ABSTRACT

Universities incorporate industry engagement alongside classroom teaching to prepare today's students to become tomorrow's entrepreneurs, workers, or researchers to make the world a better place. Successful industry engagement activities provide students with life-changing experiences that can: (a) enhance students' networking connections with professionals who can potentially provide employment references and future job positions, (b) give students an opportunity to gain practical experience by observing and applying the methods and theories learned in classroom to real-world scenarios, (c) allow students to gain experience in their prospective career path, and (d) improve students' professional communication skills. Existing research has suggested that student learning is enhanced through industry engagement. However, most research has focused on individual industry engagement activities such as internships, plant tours, case studies, etc. There has been little research on the holistic evaluation of the effectiveness of multiple industry engagement activities. For this study, a review of various engagement activities was conducted and ways in which these activities were useful not only for students but also for the industry and the educational institution were identified. Once best practices for most effective industry engagement activities are identified, they can be utilized for creating a more methodical learning environment. This study provides a framework using continuous improvement for a holistic evaluation approach to be implemented when engaging in multiple industry activities. From this study it was identified that each industry engagement provides valuable learning experience to students. Industry engagement not only enhances learning for students but it also provides a vision about their future career. Similarly, industry representatives gain an opportunity to interact with students to learn about the curriculum and the student's skill sets.

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BACKGROUND

College–industry collaboration is a vital component of successfully preparing undergraduate engineering and technology students for their professional endeavors. This collaboration allows students to engage in up-to-date industry practices, learn more about their major, and develop skills to be more effective students (Herrmann, 2013). Applying course content to workplace challenges provides students with an opportunity to bridge the gap between their classroom education and real-world experiences. Providing students with the ability to become engaged with industry professionals is the first step in closing that gap. Faculty members must incorporate a variety of teaching techniques because students comprise a diverse group and do not all learn in the same way (Rodrigues, 2004). Teaching techniques can fall into two main categories: active learning and passive learning. These two categories, as well as how industry engagement activities can be considered either active or passive learning, are discussed in more detail in the following paragraphs.

Passive learning techniques comprise the more traditional learning styles. Rodrigues (2004) defined passive techniques as lectures by the instructor, reading textbooks, guest speakers, videos shown in class, and student presentations. Passive learning relies on individual students to learn by way of lectures or books rather than through interactions with other students or instructors (Hwang, Lui, & Tong, 2005).

Dewey (1997) designed active learning techniques that allow students to become more engaged in the learning process. Active learning techniques use students' prior knowledge to develop the skills needed to solve problems (Rodrigues, 2004), Rodrigues (2004) suggested various active learning techniques such as case studies, individual research projects, group projects, and classroom discussions. Active techniques can also involve students working together in small groups to solve a problem (Hwang et al., 2005). Braxton, Milem, and Sullivan (2000) defined active learning as activities that require students to accomplish a task, such as solving a problem, and then to reflect on that task. Active learning activities include discussions among peers and cooperative learning experiences (Braxton et al., 2000). When students observe, experience, and/or practice what they have learned, they are usually able to retain the information better (Nilson, 2010). Braxton et al.

(2000) discovered that students who partake in active learning believe their college experience is rewarding on a personal level and thus are better able to retain information. Graham, Tripp, Seawright, and Joeckel (2007) stated that active participation in the learning process has a positive effect on academic achievement.

Student industry engagement techniques are a vital part of improving a student's learning experience (Rodrigues, 2004). Smith et al. (2009) stated that students who are engaged with industry during their coursework often succeed in their career after graduation. Professors and lecturers can include student engagement activities in their courses along with their lectures to provide students with the best possible learning experience. The present study focused on reviewing student learning outcomes resulting from various teaching techniques used in multiple industry engagements. Some of the industry engagement activities reviewed in this study were active activities and others were passive, as defined by the literature. This study focused on reviewing industry activities using a holistic approach. These activities represent those currently used in university curricula, and it is important that they be evaluated to gain understanding of their effect on student learning.

In the following sections of this paper, the literature review section first presents a discussion on different definitions of engagement, including the definition of engagement used for this study, and then presents a discussion of various teaching techniques and expected learning outcomes. Next, the discussion section introduces the various benefits for the three stakeholders (industry, educational institution, and students) involved with industry engagement. Finally, based on the literature, two topics for future work—to holistically review industry engagement activities and to provide an idea for implementing continuous improvement—are presented.

LITERATURE REVIEW

Defining Student and Industry Engagement

There are three stakeholders involved in student industry engagement activities: the industry, the educational institution, and the student. To elaborate, students take classes at the educational institution that prepare them for their future professional endeavors upon graduation. Educational institutions collaborate with industry to create opportunities for students to experience how classroom learning can be applied to industry. This industry–university collaboration may allow for future cooperative research opportunities, which could provide students an opportunity to participate in that research.

Literature on the scholarship of teaching and learning provides a number of definitions of engagement. One definition states that student engagement is student involvement with an in-class or out-of-class learning activity (Trowler, 2010). Another definition states that student engagement is more related to student feedback, student representation, and student approaches to learning in the classroom (Coates, 2005). Being engaged means students have to do more than just show up for an activity; rather, they must participate intellectually and physically in the activity and gain further understanding about the subject matter through such involvement (Graham et al., 2007). Harper and Quaye (2009) defined engagement as students being involved in a conversation, asking questions, and being part of the activity. Hu and Kuh (2001) defined engagement as students' efforts to be involved in activities undertaken for their learning. A student must choose whether or not he or she wishes to be engaged in learning activities. Faculty members may assign credit for activities, but it's still up to the student whether or not to be engaged. A student may participate in the activities, but that does not assure active engagement.

For the current study, industry engagement was defined as a student's active participation in various industry activities, such as an industry tour, a guest speaker, a case study, an internship, involvement with a professional organization, a virtual plant tour, and industry-focused final projects, that are conducted as a part of the curriculum. Krause (2005) defined active participation as when students are involved with student-centered activities or learning experiences that require students to reflect on their experience.

Industry Engagement Activities

Internship/cooperative experiences. Smith et al. (2009) defined internships and cooperative experiences as those in which students are in the workplace gaining experience that is accompanied by classroom learning. These kinds of learning experiences have been studied to determine what aspects of student learning occur during such assignments. According to Cates and Jones (1999), transfer of knowledge or learning during cooperative activities occurs when students take previous knowledge and implement new ideas. Schamback and Dirks (2002) suggested that students are able to reinforce their previous educational coursework during a cooperative or internship experience. Upon completion of an internship, students should (a) have a better understanding of classroom learning and ways in which the knowledge gained in the classroom relates to the work environment, (b) have more marketable job skills that can enhance their future employability, and (c) be able to clarify their career goals (Schambach & Dirks, 2002).

Fleming and Eames (2005) found that students believed that, while in the workplace, they learned multiple skills including communication, time management, reflective thinking, and problem solving along with a greater understanding of the workplace and its environment. Other benefits of cooperative experiences include enhanced thinking, motivation to learn, learning about the work environment, and understanding personal career interests (Smith et al., 2009). Kift, Butler, Field, McNamara, and Brown (2013) stated that students use internships to gather real-world experience before graduation in order to be prepared for the workplace upon graduation. Schambach and Dirks (2002) discovered that students are able to use internships to better understand coursework and bring a new focus toward excelling in their academic work. The research method and student learning outcome for the aforementioned studies related to internships and cooperative experiences are displayed in Table 1.

TABLE (1): INTERNSHIPS AND COOPERATIVE EXPERIENCES AND STUDENT LEARNING OUTCOMES

Paper cited	Method of study	Student learning outcome
Cates & Jones, 1999	Literature review of internships and design of a way for students to evaluate internship experience.	Students experienced workplace culture, new skills, and motivation to learn.
Fleming & Eames, 2005	Questionnaire surveyed 42 students. Examined whether or not amount of time spent in cooperative experience was enough to understand the workplace and learn about what skills can be applied from their classes. Also reviewed what students learned during cooperative experience.	Students practiced communication and interpersonal skills and experienced workplace culture and responsibility of a project.
Kift, Butler, Field, McNamara, and Brown, 2013	Focus groups and online surveys were conducted on senior law students at an Australian university to learn about the impact of various learning techniques on students.	Students gained work experience and valuable interpersonal skills from the internships. They learned that there is value in the skills and knowledge they gain from their coursework.
Schambach & Dirks, 2002	70 students in computer science, information systems, and telecommunications majors were surveyed to reflect on internship experiences.	Students practiced technical skills and interpersonal skills. They obtained valuable real-world experience while observing potential employers.
Smith et al., 2009	Online survey of 32,000 students at Australian universities with some follow-up interviews were conducted about their cooperative experience and what students were getting out of it.	Students practiced technical and personal skills to become more marketable. They also experienced real-world settings and exposure to the industry.

Industry tours/field trips. Kisiel (2006) described field trips as the most common learning experiences that take place out of the classroom. One example of a field trip is going to a facility and touring the facility in person. Field trips often focus on activities that cannot be conducted in the classroom (Kisiel, 2006). Industry tours allow students to view and understand the work environment (Patil et al., 2012). Students observe workers while on the tour, allowing them to see what skills are used and can be applied in the workplace as well as new technologies in the industry (Townsend & Urbanic, 2013). Usually, students returning from their first tour have increased motivation to learn topics covered in class (Patil et al., 2012). Sivan, Wong Leung, Woon, and Kember (2000) found that students were able to make direct contact with business managers to understand real-world situations. Technological advancements now allow for virtual field trips to replace actual field trips as in-class learning experiences. Spicer and Stratford (2001) studied the effect that replacing a real field trip with a virtual field trip has on students. For the virtual field trip, the students were given the software "Tidepools" to be used during class time. Tidepools is a computer program used in the classroom to simulate a biology environment. After going on the real field trip, students expressed that Tidepools was not a viable option over a real field trip. However, they did believe that Tidepools would be useful to prepare future students for a real field trip (Spicer & Stratford, 2001). Some students mentioned that the virtual field trip turned out to be a "good and enjoyable way to learn" but that there was no way that it could replace a real field trip (Spicer & Stratford, 2001). Details of industry tour studies and student outcomes are provided in Table 2.

TABLE (2): INDUSTRY TOURS AND STUDENT LEARNING OUTCOMES

Paper cited	Method of study	Student learning outcome
Patil et al., 2012	Used industry tours, team based projects, and lab experiments to see what students learned from four mechatronic classes over three academic years (2008–2011) at Clemson University (class sizes not stated).	Students observed a manufacturing environment, interactions between humans and machines, workplace culture, important skills, and importance of multidisciplinary studies.
Sivan Wong Leung, Woon, & Kember (2000)	Reviewed videos, quizzes, handouts, assignments, games, presentation, case studies, discussions, and a hotel trip to see which was better for creating interest learning effectively among students from hotel human environment, human resources management, and economics majors.	Students rated the hotel trip to be the most effective when learning, case studies; discussions were also rated highly. Videos, assignments, and quizzes were rated among the least effective. Students learned about preparing for careers, applying knowledge, and developing independent learning skills.
Spicer & Stratford, 2001	Surveyed 59 total students via questionnaire looking at student perceptions of virtual field trip versus actual field trip.	Students do not have the same experience with virtual field trip as they do with an actual field trip.
Townsend & Urbanic, 2013	Used the plan-do-check-act in a class of 17 students to determine if industry tour aligned with students' learning outcomes.	Students experienced workplace culture which led to observing important skills needed, daily duties of the workers, and new technologies.

Guest speakers. Guest speakers are subject matter experts who speak to classes to share their personal or professional experiences and knowledge with students. Metrejean, Pittman, and Zarzeski (2002) studied the reflections of students and faculty members upon having a guest speaker in the classroom. Their findings showed that the guest speaker provided a good opportunity for students to obtain information about the working environment, which is usually not discussed in the classroom, and that students also obtained an understanding of the numerous kinds of jobs available upon graduation. The guest speaker topics included interviewing for jobs and types of job opportunities, and students were exposed to real-life experiences. Directly after a guest speaker event, students completed feedback forms that included questions about the benefits of the speaker's talk and also asked for suggestions for continuous improvement, which would be implemented for the next speaker.

In another study, Riebe, Sibson, Roepen, and Meakins (2013) stated that students learn about teamwork in the workplace, problem-solving skills, communication skills, and self-management from guest speakers. Students may also learn about the guest speakers' experiences within the workplace and the transition from college to jobs after college (Rodrigues, 2004). Furthermore, Goldberg, Vikram, Corliss, and Kaiser (2014) studied students' experiences with guest speakers during a capstone project and found that the guest speaker discussed topics that were applicable to the student's projects. Students also indicated that guest speakers did a good job of discussing post-college career paths and opportunities of which the students could take advantage (Goldberg et al., 2014). The research method and student learning outcome for the aforementioned studies related to guest speakers are displayed in Table 3.

TABLE (3): GUEST SPEAKERS AND STUDENT LEARNING OUTCOMES

Paper cited	Method of Study	Student learning outcome
Metrejean, Pittman, & Zarzeski, 2002	158 accounting students attending speaker events were surveyed; students completed a feedback form for feedback after listening to guest speakers.	Students listened to speakers share their experiences with job interviewing, job duties, and Certified Public Accountant exam.
Riebe, Sibson, Roepen, & Meakins, 2013	150 business students are surveyed for their perceptions of the impact of guest speakers on their knowledge of employability skills development	Students learn about teamwork, communication, problem solving, initiative and enterprise, self-management, and social responsibility and accountability.
Rodrigues, 2004	Questionnaire completed by 631 students and 58 faculty members. Looked into different teaching techniques used in colleges; respondents rated each technique on a Likert-type scale.	Students listen to speakers share experiences of workplace environment.
Goldberg, Vikram, Corliss, & Kaiser, 2014	180 students in two sections. Used guest speakers to share experiences with students.	Students hear speakers share their experiences of workplace, applications, patents, and teamwork.

Project-based learning. Project-based learning can be defined as learning that comes from group projects (Thomas, 2000). Thomas (2000) provided the following five criteria for designing these kinds of activities. First, projects should be centered on what students are learning in the course and should be part of the curriculum. Second, these projects should drive students to encounter concepts central to the course. Third, project-based learning activities should have some form of constructive investigation attached to them. Fourth, the projects should be student driven to give the students responsibility for the project. Last, projects must have a real-world aspect to them. Mills and Treagust (2003) stated that project-based teaching helps engineering students apply what they are learning. Jollands, Jolly, and Molyneaux (2012) stated that students are able to gain time management and project management skills during a project, skills that increase their marketability after college when they are trying to find a job. Boaler (1997) discovered that students who were taught using project-based learning were able to understand the importance of topics for future experiences. Grossman (2002) concluded that projects provide students with an opportunity to gather, clean, model, and communicate data from a technical analysis. Details of project-based learning studies and student outcomes are provided in Table 4.

TABLE (4): PROJECT-BASED LEARNING AND STUDENT LEARNING OUTCOMES		
Paper cited	Method of study	Student learning outcome
Boaler, 1997	Researched differences in student performance between a traditional school and a project-based school	Students were able to practice the skills and knowledge during the project.
Grossman, 2002	Reviewed the impact faculty members had on 500 business students during their projects.	Students stated that faculty members were not preparing them well enough during projects.
Jollands, Jolly, & Molyneaux., 2012	Interviewed recent graduates from civil, chemical, and environmental engineering about the effect projects had on them.	Students found the projects beneficial for using skills not taught during lecture as well as overall project management skills.
Mills & Treagust, 2003	Looked at Central Queensland University engineering program and the benefits of projects to the students.	Students developed skills in teamwork, communication, computing, and problem solving.

Problem-based learning. Problem-based learning uses problems to increase knowledge and understanding of course content (Wood, 2003). There are different types of problem-based learning that can be incorporated in the classroom. One type of problem-based learning is the use of case studies, which can be defined as real or simulated studies used to help students understand topics better. As part of such an activity, small groups of students work together to understand the problem and collaborate to come up with a solution for the problem (Loyens, Magda, & Rikers, 2008). Herreid (1994) stated that students who participate in case studies learn by doing. Students develop analytical and decision-making skills and better understand how to deal with real-world problems (Herreid, 1994). Hung, Jonassen, and Liu (2008) found that students have better long-term retention of knowledge, better problem-solving skills, and increased confidence after using case studies in class. Hmelo-Silver (2004) suggested that students develop problem-solving skills, increase their ability to collaborate on work, and become more motivated to learn through the use of case studies. Savery (2006) suggested that students who collaborate during problem-based learning are able to build communication, work ethic, and analytical skills. The following section provides a discussion of the results from the literature review and the advantages of industry engagement for industry, academic institutes, and students.

DISCUSSION

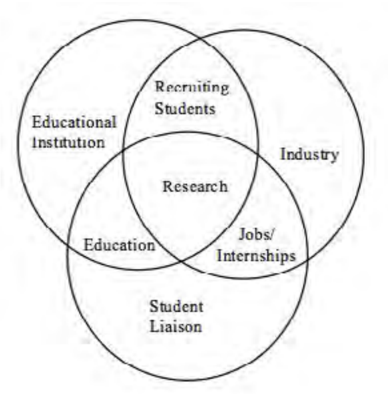
The reviewed literature provides a strong case that industry engagement is an important part of student learning due to the experience and knowledge gained through each engagement activity. The majority of previous studies, with some exceptions such as those by Rodrigues (2004) and Spicer and Stratford (2001), focused on reviewing an individual activity as opposed to multiple activities. Other studies have reviewed one particular activity within the realm of student industry engagement, with the focus being on what students obtained from the engagement activity, how students learned from the activity, and if the activity was effective at increasing student learning.

Student industry engagement is advantageous not only for students but also for the educational institutions and the industries who participate in the engagement activities (d'Este & Perkmann, 2011). Educational institutions are able to receive feedback about their academic programs and any changes that could be made to improve the programs. Student intern and industry feedback informs the institution of skills or knowledge that can be incorporated into future program curricula and courses (Schambach & Dirks, 2002). Educational institutions can also gain research opportunities with a company by, for example, helping to improve existing products or solving a problem that the company has. Perkmann (2007) described how university–industry partnerships can vary in size from a small temporary project to a large project that involves hundreds of people. He also discussed how students can be involved with university–industry partnerships through working for faculty members who are in contact with the industry. Research partnerships allow students and educational institutions to promote new patents, papers, and academic consulting (Perkmann, 2007).

Student industry engagement also provides industries with opportunities for future recruitment of interns and full-time workers as well as possible opportunities to have an impact on curriculum design (Schambach & Dirks, 2002). D'Este and Perkmann (2011) researched how industries interact with educational institutions to promote university–industry centers where research can be conducted. Academic–industry partnerships can take the form of collaborative research, consulting, and contract research (Perkmann et al., 2013). Industries also can collaborate with universities to gain support for the training and recruitment of students (d'Este & Perkmann, 2011).

Students benefit from industry engagement both while still at the university and in the future. Industry engagement activities allow students to gain real-world experience, whether the activity is in or out of the classroom setting. Guest speakers, case studies, and virtual plant tours allow students to gain an understanding of the workplace while still in the classroom. Guest speakers provide students with information about topics that can include what students can expect in their future workplace, how to get internships, and what different opportunities there are in the industry. Case studies require students to apply their classroom learning to solve a real-world problem. Out-of-class experiences can range from internships to plant tours. Students gain valuable job experience with companies while they are participating in an internship or cooperative experiences (Schambach & Dirks, 2002). It is possible for some internships or cooperative experiences to turn into full-time job offers upon completion of the students' education (Smith et al., 2009). After graduation, students can act as a liaison between companies and their alma mater (Perkmann, 2007). How the educational institutions, industry, and students interact is shown in Figure 1.

FIGURE (1): RELATIONSHIP AMONG INDUSTRY, EDUCATION INSTITUTIONS, AND STUDENTS



Developing industry relationships requires a significant investment of time and resources by students, faculty members, and industry partners. Effective industry engagement, partnered with regular classroom learning, provides students with the most advantageous learning experience possible (Herrmann, 2013), and it is important to optimize industry engagement activities to provide students with the most advantageous learning experience possible. Some industry engagement activities may be more effective than others because of how a particular activity is delivered to the students and what kind of information or skills the students utilize during different activities. Currently, there is no systematic way to evaluate if the industry engagement activities being used are the most effective for student learning. The possibility that the most effective industry engagement activities are not being used leads to the need for continuous improvement tools to be utilized when setting up industry engagement activities.

LIMITATIONS

This study was based on literature covering industry tours, field trips, guest speakers, internships and cooperative experiences, project-based learning, and problem-based learning. One limitation is that this research was based on books or papers that were published, as opposed to other work that may have been completed but not published, which may have produced a slight bias toward published work. Another limitation is that not all the papers reviewed were about undergraduate students in the engineering and technology fields. This could be a limitation because students with different majors could respond to industry engagement activities differently. However, reviewing studies that included students not in the engineering and technology field increased the amount of information that could be used to illuminate this study's topic.

CONCLUSION AND FUTURE WORK

Based on the review of the literature concerning the benefits of industry tours, field trips, guest speakers, internships or cooperative experiences, and project-based learning, two main areas where future work should be focused have been identified. First, industry engagement activities should be researched using a holistic approach, which would allow activities to be viewed with regard to student learning as a whole instead of reviewing one individual activity at a time. Researching industry engagement activities with a holistic approach would provide analytical findings that could be used to better determine which of the activities is more effective at increasing student learning. This is important as faculty members look for ways to enhance student learning by providing them with the most effective learning techniques. The researchers suggest implementing a survey or structured interviews to obtain student perceptions of industry engagement activities in a holistic way. The authors also suggest analyzing the data from survey or interview responses in a statistical analysis model such as an analysis of variance or structural equation modeling. Once the more effective engagement activities are identified, the results can be provided to faculty members to assist them when they are setting up their next industry engagement activity.

Second, continuous improvement should be incorporated when looking at the effectiveness of industry engagement. Industries have been using continuous improvement tools for many years to make their process efficient and to save money (Bessant & Caffyn, 1997; Callahan, Jones, & Smith, 2008). Lean manufacturing, six sigma, and lean six sigma are continuous improvement concepts used by companies to reduce processes and waste in systems (Bhuiyan & Baghel, 2005; Jones, Smith, & Callahan, 2010; Todorova & Dugger, 2015). Using continuous improvement tools will allow the more effective industry engagement activities to be used alongside classroom teaching.

The implementation of plan-do-check-act (PDCA), which is already well known in industry for continuous improvement, is suggested here. Toyota's business practices is an example of where PDCA has been incorporated into a company's processes for continuous improvement; Toyota uses PDCA to address problems in a systematic way (Schwagerman & Ulmer, 2013). In addition, Borys, Milosz, and Plechawska-Wojcik (2012) used the PDCA process to strengthen cooperation between industry and the university. Borys et al. (2012) used a survey to determine what students were getting from their internship and how it fit into their coursework; then, they implemented PDCA to improve the internship experience. The PDCA process should be implemented to facilitate continuous improvement with industry engagement.

Currently, the first two steps of the PDCA process are being implemented for industry engagement. First, a faculty member interacts with a company to set up the industry engagement activity. The planning that goes into setting up an engagement activity takes time and dedication from the faculty member and company personnel. To set up an industry engagement activity, the faculty member first must contact a company in advance to discuss what topics they want the students to observe or to cover and agree on a date for the activity. Then, the students participate in the industry engagement activity, whether it is in the classroom or outside the classroom. An activity outside the classroom, such as an industry tour, requires time for the students and faculty member to travel to the facility, complete the tour, and travel back to the university. To continue with the PDCA process, it is suggested that a survey or a semi-structured interview with students and industry personnel be implemented to assess the effectiveness of current activities being used. With the findings from this research, faculty members may assess if the engagement activities they are using are the most effective for the students. To complete the continuous improvement process, the instructors could then act to either keep the industry engagement activity or look to promote a different type of engagement activity, depending on the results of the evaluation tool. The PDCA process is a useful tool to confirm that an industry engagement activity is effective at increasing student learning.

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