Paper ID #37125

BIM: A Bridge to Promote Industry-Academic Partnership in Construction Engineering

Brayan Alexander Díaz

I am a Fulbright Scholar, currently in a program towards a Ph.D. in Learning and Teaching in STEM- Science Education at NCSU. I received a bachelor's and M.Sc. in Chemistry at the University Federico Santa María Technical University (UTFSM). I was very proud to receive a Trajectory Sport Award for athletes who have demonstrated leadership and highlighted sports careers at UTFSM and Undergraduate Research Grant from the Center of Ionic Liquids (CILIS-University of Chile). My interests are focused on studying the pedagogical theories that are linked to teaching-learning strategies. I am especially interested in understanding the linkages between the different learning styles and skills of engineering students and their success in pursuing the goals that they had set for themselves when they entered the University.

Dr. Cesar Delgado (Associate Professor)

Associate Professor, STEM education Dept. at NC State University. Dr. Delgado researches students' knowledge and learning of the magnitude of variables, including spatial and temporal scale. He also studies visual representations, project-based learning and modeling. His externally-funded research includes an NSF EHR CORE grant developing virtual reality environments for the teaching and learning of scale (co-PI), and an NSF IGE grant analyzing and improving graduate engineering and computer science courses (co-PI). He teaches courses on technological tools for teaching, the learning sciences, learning theories, equity and diversity, and methods for teaching. He wrote the supporting materials for a course on project-based learning that is being enacted in 44 universities in 21 states and the District of Columbia.

Kevin Han (Assistant Professor)

Assistant professor, Dept of Civil, Construction, and Environmental Engineering at NC State University.
PI of NSF IGE and IUSE projects. Interested in creating and validating new ways to teach by developing tools and applying educational theories.

BIM: A Bridge to Promote Industry-Academic Partnership in Construction Engineering

Keywords: BIM, Industry-academic partnership, Construction engineering, Work-Integrated Learning, graduate education.

Abstract
This article reports on student perceptions of an innovative graduate construction engineering course using BIM and industry-academic collaboration with extensive construction site internships. The course, Building Information Modeling (BIM) in Construction, was designed and implemented to help students develop deep BIM learning and allow them to apply this software in real engineering companies. The students were immersed in construction companies, as interns on construction sites. Our research goals were to study the students' learning and any impacts on the companies' practices; in particular, how new communication skills, tools, symbols, concepts, and procedures disseminated in both directions. Open-ended survey responses from the years 2017, 2018, and 2019 were analyzed using the constant comparison method to allow themes to emerge from the data. The analysis of these data shows 1) Through the design and prior training of workers, it generated a psychologically safe learning environment for students in companies. 2) students recognize they establish a clear connection between the objectives of the course and the work within the companies, 3) The bridge built through a WIL experience between the companies and the course, allowed the students to impact the work of the companies becoming a win-win experience and 4) understanding the main student's barriers that must be minimized for a became full-participants and recommendations for the design and implementation of WIL experiences. The curricular integration of work experiences appears to effectively support the development of students into highly skilled construction engineers. This paper extends the knowledge base on WIL by identifying how students develop as brokers mediating the academic and professional communities, and tracing the bidirectional flow of information, concepts, procedures, and materials between the academic and professional communities.

Introduction

The construction industry faces new challenges that require engineers who have strong skills in collaborative work, time management, complex problem-solving, and critical thinking (Beichner et al., 2007; Díaz et al., 2017; Kolmos and de Graaff, 2014). The demand for graduate engineers with these skills has increased in recent decades (Kolmos and Holgaard, 2019). Various government initiatives have been developed to respond to this demand (e.g., ABET 2015; Engineering Council UK 2005; Engineers Australia 2019). Despite these initiatives' focus on increasing the number of engineers and the development of workforce skills, there are continued gaps between employers' expectations and the skills of graduate students in engineering (Markes, 2006; Ramadi E, Ramadi S and Nasr, 2016; Saeki and Blom 2011). This gap creates anxiety and frustration for recent graduates in the workforce (Jackson, 2014; Kolmos and Holgaard, 2019). Moreover, the construction industry demands for students to have more field experience before joining the workforce (Atkison and Pennington, 2012).

One strategy to bridge the gap is better integrating competencies developed in industry with the competencies developed in the universities. To better prepare graduates for the workforce, the industry-based competencies must be transferable and adaptable so that graduates can apply them to different scenarios. Construction engineering education programs must prepare students to make an effective transfer of tools, knowledge, capabilities, terminology, and skills to an industry setting (Bennett, 2002; Jackson, 2014). Addressing this imperative, we describe our approach to creating a transfer bridge from the classroom to a company, and report on our analysis of student perceptions of the course. We used the Work-integrated Learning (WIL) model to create an experience that places students in work environments early in their graduate studies, generating learning that is situated in practice and allowing early interaction with real environments and engineering professionals. We hypothesize that this design will facilitate and support students in the transition between higher education and industry (Jackson, 2014). In the next section, we will present a review of WIL and then describe how we used this model to establish a bridge between the curriculum and partnership companies that allow students to participate in real projects.

Theoretical Framework

Work- Integrated Learning

Work-Integrated Learning (WIL) is the intertwining of practical work experience with classroom learning (Jackson (2017). WIL forms a key interface between students and industry and allows students to practice applying their disciplinary knowledge in a supervised and enriching work environment. Students carry out an internship parallel to their academic studies, immersed in this work environment to complement and develop learning situated in a real engineering context.

This strategy has spread throughout the world, including Europe (e.g., Switzerland - Schedin and Hassan, 2016) UK (Ponikwer and Patel, 2021), North America (e.g., Canada - Dorland et al., 2020; USA- Jones et al., 2017), and South Africa (Bonnet, 2009), among others. While WIL requires establishing an articulation from universities to industries, the students do not necessarily become employees of the construction companies. This flexibility has allowed WIL experiences to be carried out in a variety of locations, including on-campus (e.g., Ponikwer and Patel, 2021), co-work spaces (Jackson, Shan, and Meek, 2021), and virtual contexts (E-WIL;

e.g., Hattinger and Eriksson, 2018), which allows applying WIL to BIM in Construction where students are connected to the companies without being employed by them.

Designing a Bridge to Connect Academia with Engineering Companies

Including a construction project internship in a course requires the design, development, and alignment of BIM objectives with the semester outline of a graduate course. The use of BIM for educational purposes while employed on an ongoing construction project has been previously reported (for example see: Herrera et al., 2021; Sotelino et al., 2020; Wang et al., 2020). The main challenge is developing a tight integration between the internship and the course learning objectives, so that students can immediately transfer what is covered in class to the work in the field experiences. Considering those challenges, our learning-teaching experience was developed based on three key components: 1) Design of relevant project tasks; 2) seamless alignment of problems in the field with the class content; and 3) effective communication with company workers.

Design of a WIL Relevant Project

Previous research has demonstrated that the use of authentic problems as class projects awakens curiosity, participation, and commitment of students (Aizman et al., 2017; Beichner et al., 2007; Chen, Kolmos, and Du, 2021; Díaz et al., 2017; Kolmos and de Graff, 2014; Shekhar and Borrego, 2017), fostering the development of professional and transferable skills. The use of authentic problems ensures that classwork will be relevant to the present and future life of students.

Therefore, the planned learning experience was built considering the ongoing construction work of several local companies where BIM was used. The companies were pre-selected by the instructor. This step requires ample time (3-12 months depending on individual companies) for planning and to establish connections with construction company outreach personnel. In this case, we arranged for internships in medium-sized projects within the city; both residential and industrial projects were represented. The students were organized into work teams and assigned to the participating businesses. The course assignments had the following premises: 1) the generation of an authentic, immersive experience for students, 2) team organization, 3) preference for unique or one-of-a-kind construction sites, and 4) sufficiently challenging for students.

The students were asked to create a basic BIM design to be used to monitor and evaluate the progress of the projects. Some companies also used complementary software to BIM (i.e. Naviswork), which allowed students to learn how to use more than one tool. Additionally, not all companies had the same degree of use of BIM; student teams placed at companies with low BIM use faced an additional challenge: having to show the advantages and benefits of implementing these tools on a construction site.

Site-Course Alignment.

Previous research has highlighted the need for close alignment between internship sites and the course. Carbone et al. (2020) performed an analysis of the WIL implementation in undergraduate engineering students. The feedback given by the participating students stressed the importance of seamless coordination between the class curriculum and career work. To address this goal, our course design started with creating a cohesive framework for content delivery with clear linkages that offer the students opportunities to transfer and practice their new class knowledge and skills in the workplace. To achieve that necessary, clear curricular connection, the recruitment of companies is essential, since we must find projects or learning environments that allow opportunities to transfer course knowledge. The stage and progress of the internship sites need to be aligned with the progress of the course (Jackson et al., 2019). Planning-stage or late-stage construction sites are not suitable because students need to observe physical buildings being constructed and model the progress using 3D BIM software.

Company-Student Interaction

An essential element of partnership between school and industry is the close interaction between students and company personnel. The fundamental pillar to ensuring the effectiveness of such a direct relationship are students who feel psychologically safe. Edmondson and colleagues (2004) defined psychological safety as “individuals’ perceptions about the consequences of interpersonal risks in their work environment” (p. 241). Participants who feel psychologically safe feel free to propose and discuss their ideas, take risks, and value other members ’skills and experience. For this reason, it was imperative to create safe spaces for participation.

The instructor was the first intermediary between the students and the companies, in seeking to ensure a psychologically safe space for the students throughout their participation. Each team was assigned an expert of the firm as point of contact and guide. This member received the students at the companies, gave them an induction, and presented the students within the nucleus of work on the project. Throughout the course and the internship, the assigned activities sought to give greater importance to students’ participation within the company, allowing them to advance towards a sense of membership and belonging in their construction environment and fostering their participation. The objective of the progressive activity design was that at the end of the course, the students had a sense of belonging in the company and that they could propose improvements for the work of the companies.

Methodology

The first section of this paper offered a rationale for applying WIL in a graduate engineering course. To understand the impact of this learning experience on the students, data from student surveys were collected at the end of the course. Data from three semesters were analyzed from the BIM in Construction course. The instrument mostly has open questions around the axes of experience with On-site Visits, Company interaction, Site-course alignment, and Reflection on the course. Additionally, there were 2 closed questions, which were dedication and if they had had previous experience in on-site work.

A total of 76 students participated in this course in the years 2017 (30 students), 2018 (26 students), and 2019 (20 students). The analysis was approved by IRB (eIRB # 24449). Four central questions to be investigated were: 1) RQ1: Did the WIL environment allow the safe interaction of the students? 2) RQ2: Did students find a clear connection and opportunity to complement the learning objectives of the course with work in companies? Is this connection bi-directional? 3) RQ3: Does the connection company-course generated allow a win-win situation where students impact companies? and 4) RQ4: What are the key issues in designing a WIL experience in graduate engineering students? how can we minimized the barriers they faced to becoming full-participants?

The coding of the students' evaluations was carried out with the Taguette software using a combination of prior codes existing in the literature and an in vivo coding scheme devised by the author. For the selection of the a priori codes used, the studies/findings by capacities framework development Jackson (2020) and abilities by Ramadi et al (2016), both studies constructed based on the evaluation of supervisors in WIL. The evaluations of the alumni and students who participated in WIL (Ponikwer and Patel, 2021) and assessment of engineering students in a WIL experience off-campus (Carbone et al., 2020). An iterative process was used to code the transcripts using the constant comparative method (Glaser, 1964). We use this coding process until we reach the point of stability and saturation of the information Table 1 shows the final code and an example of students' statements assigned for each code

Code	Code-assigned	Transcript statement
A relevant Project	Discipline	*"The site visits helped understanding 4D, 5D well. I felt we touched upon all important BIM concepts " and "I learned how BIM is used in project management practics on field. What is the currents technology used in field as few as monitories and macking is carried like Laser scanner, virtual reality, point could"*
	Transversal	*"I learned so much about BIM and innovation in construction and This [course] really motivated, to get back in touch with Revit and BIM modeling"*
Company Interaction	psychological safety	*"The staff [Company staff] were very friendly towards us and provided good feedback to our ideas" and "Construction personnel were busy (even when we took prior appointments) something unexpected could always take place and I*

		did not feel comfortable disturbing them by going to the site unannounced and without many specific questions"
	Negative Interaction	*the actual construction seemed like it was going smoothly. Everyone looked busy and majority at tasks were on time*
Site course alignment	Connection	*This class is very practical as it gives the students an opportunity to apply what he/she learned in the field..*
	Disconnection	*"Course focused only on the basics of the software while working on a real project. Needed a lot of under studying " and They were all still old school sticking to construction drawings. The PM use an iPad, but no model was used.*
Suggestions	Hands-on session	*Less people in a team. Not collaboration in hands-on, more hands-on and use reading assignments*
	Lecture session	*Showed us videos of current innovations in the construction field*
	Company suggestion	*They must be willing to take more risks. 4D and 5D tools are an excellent resources for project coordination*

Table 1. Connection with code and course evaluation transcript

Result and Discussion

A WIL Relevant Project

The project was designed to offer a rich learning environment for the students. The evaluation of the students towards the learning that took place around this experience has a strong focus on the software, procedure, and disciplinary practices. For example, students stated: "*I learned so much about BIM and innovation in construction. This really motivated to get back in touch with Revit & BIM modeling."* and *"I learned about how the architecture and engineers use to Revit model to previsualize the scopes. Although, Revit model we received was incomplete but it helped us a lot while preparing the progress reports*"

This quote captures the general impression of the students. The assessment and evaluation by students of their own learning focused on the disciplinary knowledge, in particular the management of construction software (e.g., BIM and Navisworks). On the other hand, a smaller number of students refers to transferable learning skills learned, including coordination, solving real engineering problems, and presentation skills. Some comments exemplifying this focus follow: "*Informal presentation Skills and general professional interaction*" and "*New thing I learned was how coordination issues are dealt with on job site through coordination meetings. We did explain the ways used by project team for coordination.*"

Considering that the basis of this experience is the BIM in Construction course, these comments are aligned with the learning objectives of the course. This experience facilitates and manages to develop the skills involved for the use of BIM in situations of real engineering problems. The next challenge will be designing activities that allow the greater development of transferable skills.

RQ1: Company-Student interaction

In the analysis of the evaluations, 100% of the students felt welcome during their visits to the field. The students' evaluation of interactions with the company could be summarized as useful, informative, and positive. One student noted that "*Company was very welcoming and willing to teach us about the site. They were excited by the work, they did and toured us around the site every visit to view changes*." Another student said that: "*The company was generous enough to provide us with all the requisites for our weekly reports. We were welcomed by the company at the weekly meetings and felt involved*"

While students all felt welcome at work in the company, not all of them managed to achieve participation as full members. Some students mentioned that the workers were very busy, but had diverse reactions to this. One student said, "*The professionals are busy. [but t]he time that they gave was sufficient*". On the other hand, this student's statement about the discomfort of asking questions relates directly to one of the measures for psychological safety: "*Construction personnel were busy (even when we took prior appointments) something unexpected could always take place and I did not feel comfortable disturbing them by going to the site unannounced and without many specific questions.*"

It may be difficult for the site manager to have to dedicate several hours per week to this project. The participation of companies and workers is voluntary and they may believe that the internships will not have any direct benefit. The students' assessment of the work is very positive when the workers gave importance to the project and mentored them productively.

RQ 2. Site-Course Alignment

Students recognized the existence of an alignment between the course and the visits. The main connection axis mentioned was the use of software - BIM - at the construction site. Additionally, the students recognized the similarities and complementarity between the course and the visits: "*I liked the flow of content in this course. We started with the basics of Revit, Navisworks and got intense as the semester progresses. The site visits helped me to understand 4D, 5D well. I felt we touched upon all important BIM concepts*". Another student noted that "*The in-class exercise help understands different uses of BIM. This helped us implement on-site.*"

Students also noticed connections and disconnections produced by people or differences in practice. When they refer to people who failed to help connect, it is for example that the administrator or manager of the company did not have the knowledge or appropriate use of the tools that allow linking the site with the course: "*They were all still old school sticking to construction drawings. The PM use an iPad, but no model was used*." Other students recognized people who aided connections and were perceived as mentors: "*I felt my project manager is certainly one who could be able understand and guide me. I certainly look at project manager as a mentor*." On the other hand, the differences in practice were those in which the method of work, procedure, or tools that were used in the construction sites were different from those that were taught in the classes. Some students who mentioned this connection saw this as a challenge or problem to apply the knowledge: "*Course focused only on the basics of the software while working on a real project. Needed a lot of under studying*." while others saw it as an opportunity to learn some complementary tools: "*As a member on job site, I had certain questions and concerns about BIM, which I could solve with the bridge provide by this course. Also, there were new construction techniques which I was not aware of and I learned by being a member on Job-site.*"

RQ3. Company Impact

The course was designed to help students become full participants in the company and project they were involved in. The analysis showed that some students managed to achieve this goal. Some students developed a contribution that was seen as interesting, and the company workers voiced interest in adopting it: "*We propose 4D schedule to improve their approach in preparing their baseline schedule. They also could improve their site planning in terms of logistics as better safety on site. The engineers on site were very impressed with the proposal. They agreed that 4D BIM for site logistics could help them save a lot of re-work in-time and improve efficiency*." and "*We did present our idea of using 4D BIM (Navisworks) & we used color coding to track progress so they admired the idea & definitely willing to invest in this idea*." Along these lines, other students generated suggestions for the performance of the company.

These phrases are a reflection of the sense of belonging and the impact that the participants can have. The use of an experience that can be developed for a longer time or with greater time commitment could have allowed a greater number of students to make more significant changes to the companies. This can be accomplished by increasing the credit hours of the course and/or extending this experience by complementing the work of two consecutive courses that consider complementary activities. These experiences could be integrated into a course that has the same focus as this course, or a topic that is different but that allows students to work on the same construction sites, possibly on different activities. The proposals to develop this could be in courses currently offered, such as Construction Project Management, Construction Safety Management, and Construction Productivity.

RQ 4: Course Time Requirements

Through a closed question (scale 1-5), students evaluated the time required by this course compared to another course of equal credit. Most of the students (55.3%) declared that the course was slightly heavier, 22.4% felt it was very heavy, and 15.8% that it was similar (see table 2).

	2017	2018	2019	Total
Very Heavy	2	7	8	17 (22.4%)
Slightly Heavier	16	15	11	42 (55.3%)
About the same.	8	3	1	12 (15.8%)
Slightly Lighter	2	1	0	3 (3.9%)
Very Light.	1	0	0	1 (1,3%)

Table 2. Distribution of time-dedication responses by year

Over 77% of students felt that this course requires a greater time commitment. This poses a challenge and the need to re-design for reduced course load. From the open-ended questions, we identified several reasons for the heavy workload. These included logistical challenge (i.e., transportation to and from work site), the number of tasks, and lack of prior experience in handling BIM. The logistical issue can be addressed by establishing a maximum travel radius of 30 minutes from the university. Instructors should prioritize the search for companies that are located within that range. If there are not enough construction projects near-by, instructors might increase the number of team members to a maximum of 4 members to require fewer companies. Company assignment and team building could also consider access to own transportation and location preferences.

Conclusion and Future Work

This research focuses on the description of the design, implementation, and evaluation of the implementation of a Work-integrated Learning experience around the BIM in construction course for engineering graduate students. The analysis of the evaluations of the students who participated during 2017, 2018, and 2019 in this experience, allowed us to gather opinions that complemented the design of this course. Through the analysis of the results, it was found that the internship offered a safe experience for the students' work. All the students declared that they felt welcome in the workplace, but not all of them were able to establish participation that was additional to the tasks assigned. The barriers that the students had were the time of the students and the time of the workers of the company.

Second, the connection/disconnection between classroom activities and the workplace is directly related to the appraisal of the student experience, but also offers the opportunity for students to complement their learning. Additionally, connection and disconnection can be generated by alignment in practice as well as by students, teachers, or company workers.

Systematic work in workplaces was shown to have a two-way impact. One towards the preparation of the students, but also some students report producing an impact towards the work of the companies

Finally, the factor of time of dedication and time in the semester was a barrier mentioned by the students. Future WIL integration experiences should consider advancing in improving the effectiveness of this experience that allows the experience to fit the expectation of dedication of the subject.

The next work will consist of building an evaluation model of the experience that includes the evaluation of workers, teachers, and alumni. A longitudinal analysis is proposed with the alumni and workers of the company to evaluate the impact of this experience in the medium-long term (2-4 years). These retrospective evaluations, after some time working, can be compared to the students' positive impressions at the end of the course: "*I felt this course is very enriching in gaining practical Knowledge about BIM and selected advantages. I am glad I was in this class and I am taking away in my professional life. Thank you*"

References

ABET. (2015). CRITERIA FOR ACCREDITING ENGINEERING PROGRAMS Effective for Reviews During the Engineering Accreditation Commission

Atkinson, H., & Pennington, M. (2012). Unemployment of engineering graduates: The key issues. Engineering Education (Loughborough), 7(2), 7-15. https://10.11120/ened.2012.07020007

Beichner, R., Bernold, L., Burniston, E., Dail, P., Felder, R., Gastineau, J., Gjertsen, M., & Risley, J. (1999). Case study of the physics component of an integrated curriculum. American Journal of Physics, 67(S1), S16-S24. https://10.1119/1.19075

Bennett, R. (2002). Employers' demands for personal transferable skills in graduates: A content analysis of 1000 job advertisements and an associated empirical study. Journal of Vocational Education & Training, 54(4), 457-476. https://10.1080/13636820200200209

Bernold, L. E., Alarcon, H., & Mora, C. (2017). Introduction to Engineering : a STEM -PBL approach Introduction to Engineering: a STEM-PBL approach

Bernold, L. E., & Felipe González Böhme, L. (2017). STE(A)M: Art, design and architecture in the formation of engineers at UTFSM

Blom, A., & Saeki, H. (2011). Employability and Skill Set of Newly Graduated Engineers in India American Psychological Association (APA). https://10.1037/e596532012-001

Carbone, A., Rayner, G. M., Ye, J., & Durandet, Y. (2020). Connecting curricula content with career context: The value of engineering industry site visits to students, academics and industry. European Journal of Engineering Education, 45(6), 971-984. https://10.1080/03043797.2020.1806787

Chen, J., Kolmos, A., & Du, X. (2021). Forms of implementation and challenges of PBL in engineering education: A review of literature. European Journal of Engineering Education, 46(1), 90-115. https://10.1080/03043797.2020.1718615

Dorland, A., Finch, D. J., Levallet, N., Raby, S., Ross, S., & Swiston, A. (2020). An entrepreneurial view of universal work-integrated learning. Education & Training (London), 62(4), 393-411. https://10.1108/ET-11-2019-0260

Engineering Council, U. K. (2005). EUR-ACE Overview: Accreditation Procedures and Criteria for Engineering Programmes in Europe

Engineers Australia. (2019). Engineers Australia Accreditation Board for Engineering Education Programas

Glaser, B. G. (1964). The constant comparative method of qualitative analysis. Social Problems, 12, 436 – 445.

Hattinger, M., & Eriksson, K. (2018). Co-construction of knowledge in work-integrated E-learning courses in joint industry-university collaboration. International Journal of Advanced Corporate Learning, 11(1), 10. https://10.3991/ijac.v11i1.9152

Herrera Rodrigo, F., Muñoz-La, R. F., & Vielma Juan, C. (2021). Interaction networks within student teams learning building information modeling (BIM). Journal of Civil Engineering Education, 147(1), 05020008. https://10.1061/(ASCE)EI.2643-9115.0000032

Jackson, D. (2014). Factors influencing job attainment in recent bachelor graduates. Higher Education, 68(1), 135-153. https://10.1007/s10734-013-9696-7

Jackson, D. (2017). Developing pre-professional identity in undergraduates through work-integrated learning. Higher Education, 74(5), 833-853. https://10.1007/s10734-016-0080-2

Jackson, D., Fleming, J., & Rowe, A. (2019). Enabling the transfer of skills and knowledge across classroom and work contexts. Vocations and Learning, 12(3), 459-478. https://10.1007/s12186-019-09224-1

Jackson, D., Shan, H., & Meek, S. (2021). Enhancing graduates' enterprise capabilities through work-integrated learning in co-working spaces. Higher Education, , 1-20. https://10.1007/s10734-021-00756-x

Jones, F. R., Mardis, M. A., McClure, C. R., Ma, J., Ambavarapu, C., & Spears, L. I. (2017). Work-integrated learning (WIL) in information technology. Higher Education, Skills and Work-Based Learning, 7(4), 394-407. https://10.1108/HESWBL-08-2017-0046

Kolmos, A., & de Graaff, E. (2014). Problem-based and project-based learning in engineering education: Merging models. In A. Johri, & B. M. Olds (Eds.), Cambridge Handbook of Engineering Education Research (pp. 141-160). Cambridge University Press. https://10.1017/CBO9781139013451.012

Kolmos, A., & Holgaard, J. E. (2019). Employability in engineering education: Are engineering students ready for work? In S. H. Christensen, B. Delahousse, C. Didier, M. Meganck & M. Murphy (Eds.), The Engineering-Business Nexus: Symbiosis, Tension and Co-Evolution (pp. 499-520). Springer International Publishing. https://10.1007/978-3-319-99636-3_22

Markes, I. (2006). A review of literature on employability skill needs in engineering. Null, 31(6), 637-650. https://10.1080/03043790600911704

Pierre Bonnet. (2009). Development of a competency-based work-integrated learning program to facilitate science, engineering and technology retention in south africa as a developing country. Asia-Pacific Journal of Cooperative Education, 10(2), 65. https://search.proquest.com/docview/2231273518

Ponikwer, F., & Patel, B. A. (2021). Work-integrated learning: A game-based learning activity that enhances student employability. Journal of Chemical Education, 98(3), 888-895. https://10.1021/acs.jchemed.0c00919

Psychological Safety, Trust, and Learning in Organizations: A Group-level Lens (2011).

Ramadi, E., Ramadi, S., & Nasr, K. (2016). Engineering graduates' skill sets in the MENA region: A gap analysis of industry expectations and satisfaction. European Journal of Engineering Education, 41(1), 34-52. https://10.1080/03043797.2015.1012707

Schedin, S., & Hassan, O. A. B. (2016). Work integrated learning model in relation to CDIO standards. Journal of Applied Research in Higher Education, 8(3), 278-286. https://10.1108/JARHE-11-2014-0104

Shekhar, P., & Borrego, M. (2017). Implementing project-based learning in a civil engineering course: A practitioner’s perspective. The International Journal of Engineering Education, 33(4), 1138-1148.

Sotelino, E. D., Natividade, V., & Travassos Do Carmo, Cristiano Saad. (2020). Teaching BIM and Its Impact on Young Professionals American Society of Civil Engineers (ASCE). https://10.1061/(asce)ei.2643-9115.0000019

Suleman, F. (2018). The employability skills of higher education graduates: Insights into conceptual frameworks and methodological options. Higher Education, 76(2), 263-278. https://10.1007/s10734-017-0207-0

Wang, L., Huang, M., Zhang, X. X., Jin, R., & Yang, T. (2020). Review of BIM Adoption in the Higher Education of AEC Disciplines American Society of Civil Engineers (ASCE). https://10.1061/(asce)ei.2643-9115.0000018

Appendix A: Course Evaluation BIM in Construction course.

In this course, you had to visit a construction site on a regular basis to complete your assignments and project.

Experience with On-Site Visits

Was this your ***first*** experience visiting a construction site multiple times as part of a class?

i. If yes, what did you learn from this experience?

Yes

ii. If not and you had previously worked (intern, co-op and/or full-time) at a construction site:

a. Please briefly describe what you did.

No

b. Compare those earlier experiences to your experience in this class, focusing on what you learned (e.g., management practices, scheduling, project controls, etc.).

Company Interaction

2. How was your interaction with your company?

   a. Describe it.

   b. Did you feel welcomed?

   c. Do you have any suggestions on how to improve the experience on the construction site?

3. All companies have agreed to spend extra time with you if you wanted. Did you spend extra time (not related to assignments and project) with the company and/or onsite to gain more experience/interact with them? Yes No

   a. If so, please explain what you did and your experience.

   b. If no, why?

   c. If you wanted to spend more time but did not, is there anything the instructor can do to help future students to spend more time on jobsite if they wanted?

4. Suggest some ideas to improve construction productivity at the site you observed, and/or for the construction industry in general.

Site-Course Alignment

5. Please identify areas where the course lectures and exercises **aligned well with actual practices** on the construction site by giving examples:

6. Please identify areas where the course lectures and exercises were **very different from actual practices** on the construction site by giving examples:

Reflections on the course

7. Please reflect on hands-on sessions [i.e., given by industry lecturers and TA] and lecture-based sessions [i.e., given by Dr. Han]. What are advantages and disadvantages of each?

Activity	Advantages	Disadvantages
Hands-on Sessions		
Lecture-based Sessions		

Any suggestions on how to best sequence the mix of hands-on and lecture-based sessions?

8. What would you suggest to improve this course?

9. How was the workload compared to other 3 credit hour courses?

a) Very heavy (b) Slightly heavier (c) About the same (d) Slightly lighter (e) Very light

f) Feel free to add your open response here: