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Implementing Live Knowledge Transfer Based Pedagogy in CM Education through Faculty Externship

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Abstract

Consistent knowledge transfer of cutting-edge, industry best practices related to digital construction methods and virtual construction tools within traditional construction management (CM) curricula is often constrained by faculty resource expertise and the ability to engage professional development to broaden the knowledge base. Additionally, traditional course preparation and development procedures and standard curriculum review processes can delay the deployment of coursework containing training modules related to current industry trends and workflows for readily available software and hardware packages. This work-in-progress paper introduces a framework for more flexibility with course development and a more expedited way to interject dynamic curricular content into construction management program learning environments. Through a sponsored partnership or faculty externship with a construction management industry member and a faculty member's home academic institution, a course was created in which current industry project work was leveraged as curricular content and deployed, in real-time, within a combined lecture and lab classroom environment. The focus of the course was virtual design and construction tools, workflows, processes, and information technology for construction. In this model, a full-time faculty member was embedded in the industry to leverage a live knowledge transfer learning environment that draws from real-time industry experiences and training to bring direct career readiness and preparation into the classroom. Engaging this pedagogical model allowed the faculty member to introduce more focused student learning outcomes into the course while meeting the program's requirements and related accreditation. Additionally, the student learning outcomes were flexible enough to be tied to real-time case study projects conducted by the faculty member within the context of the industry partnership. This robust model of leveraging faculty professional development, industry partnerships, and dynamic course development and delivery methods sets a foundation for staying current with the fast-paced, digital construction environment without jeopardizing basic curricular requirements and faculty resource requirements within the context of traditional higher education construction management programs.

Keywords: Live knowledge transfer, Construction curriculum, Faculty Externship. VDC

Introduction

The construction management curriculum is a blend of courses requiring hands-on laboratories, software tools, theoretical lectures, and deeper learning on project management tools. These tools and techniques constantly upgrade with newer technologies, computing breakthroughs, and intensifications. The American Council for Construction Education (ACCE) establishes student learning outcomes (slos) to standardize construction education at 2-year, 4-year, and master's degree programs at different institutions. While ACCE focuses more on the core concepts and theories through its accreditation requirements, it is essential to understand that technological advancements have been pivotal in managing construction projects in recent years, specifically during and after the pandemic. Thus, students in this era must focus more on utilizing these tools

to track the progress and manage projects in the digital world right after graduation. To achieve this, the faculty must undergo new-knowledge training to upgrade their understanding of industry best practices and new technology implementation. This can be achieved through faculty-industry residency, industry-based seminars, conferences, and constructive conversations with industry practitioners and experts. In addition, academic units of construction management need to promote faculty knowledge upgrades which reflects on many different factors, including the increase in enrollment, establishment of new concentrations, and in-hand increase the revenue. In addition, the faculty members involved in this initiative would be going through professional development efforts, which can help in their promotions and tenure down the lane.

There are few opportunities for the construction faculty to do the internship/field experience during the full-time semester. However, every year, the Associated General Contractors (AGC) Faculty residency program provides opportunities for junior faculty to perform summer internships. Very few works of literature exist on the impact of faculty externships on construction education[1], [2]. This paper aims to lay out the strategies, course outcomes, and a knowledge transfer methodology utilizing the faculty residency performed in the summer semester. The paper also details how the construction management program offered an elective course for the faculty to "live knowledge transfer" the content practiced/learned on a day-to-day industry experience. The authors identify this as a unique opportunity and effort because of the timeliness of offering a new knowledge-sharing platform/course, which also guides the students on job expectations if they work as a co-op in the area of VDC in the immediate semester.

Faculty-Industry residency program

The Associated General Contractors (AGC) established a faculty residency program in 2011 to promote junior faculty members in the construction management programs to pursue faculty residency opportunities during the summer term. This residency helps the junior faculty members of the program to gain some industry knowledge and can implement that in their classes. AGC sponsors 5-7 construction faculty members annually to perform the residency with a contraction firm of their choice. This initiative involves three parties where the faculty gets a stipend of the maximum of $30000 for a 12-week residency, and the cost is equally split by the institution the faculty work full-time, the contracting firm that supports the residency program, and AGC. In this case study, one of the authors performed a faculty residency in the summer of 2022 and also developed a course through a new "live-knowledge transfer" pedagogy. Most faculty members who perform industry residency in summer focus on gaining knowledge through the contracting firm and utilize the knowledge in their future semesters. The uniqueness of this faculty residency performed by one of the authors is that the author was able to transfer knowledge gained to the students weekly while working on the residency. It helped the faculty resident to pre-plan the course before the beginning of the summer semester since the AGC applications are usually approved around January of every year, and the applications detail the 12-week learning outcomes. The author was able to develop the course syllabus and outline based on the application learning outcomes. As a new course elective, the author, who is also a faculty resident, was able to decide on the course topics and outcomes months before the beginning of the summer semester.

Faculty Externships

Technical universities within the United States usually focus on bringing cutting-edge technology into education without compromising the quality of learning outcomes. The faculty members of various degree programs serve as the backbone of the institutions to implement high-quality education and provide transformative student experiences. The educators of these institutions provide focus through classroom and laboratory knowledge-sharing strategies and thus help students with their learning outcomes by various means. It helps the industry hire those students and thus reduces their time and effort in training them in cutting-edge technologies. However, this is not true in most cases.

In recent years, the construction industry's technology adaptation has undergone a paradigm shift. Industry practitioners and experts rely on productive tools to ameliorate the construction process and alleviate gaps and challenges. This evolution in the industry serves as the primary motivation for this research manuscript. With the established ACCE slos, most construction management academic units set a standard of education that the construction industry requires. However, with the recent shift towards digital twins and construction cyberspace, students will need a core understanding of digitalization in the construction industry. It is possible only if the educators of these students understand the need for this shift in classroom education.

Researchers and scholars utilized various pedagogical approaches to integrate cutting-edge technologies and computing into construction education [3]–[7]. Some educators utilize construction gaming simulations, and others utilize project-based learning with technology integration [8], [9]. The pedagogical approaches have been constantly changed with realistic classroom education requirements. With recent social media engagement, students' focus perspectives and knowledge retention have been enormously altered in the classroom. Many researchers develop studies on new pedagogical approaches to overcome classroom education and assessment challenges through technological integration, expert mentoring, and service-learning opportunities [10], [11]. Most educators try to adopt pedagogies that blend learner-centered and educator-centered pedagogical approaches [12], [13]. [14] and [15] evaluated the benefits of teaching construction management courses through flipped classroom approaches. Similarly, researchers evaluated project-oriented pedagogical models for teaching construction engineering, sustainability construction, and culturally responsive education [10], [16], [17]. In addition, [12] addressed the challenges faced during the curriculum changes in one of the institutions, and [18] measured the value of assessment through simulation games. Thus, various researchers and educators with proven success have constantly utilized pedagogical changes in construction education. This served as a motivation for this research.

Research Objectives

The objective of this research includes:

1. Leverage faculty professional development (summer externship) to develop a CM elective on Virtual, Design, and Construction (VDC).

2. Develop a course syllabus and assessment criteria based on the faculty externship's new knowledge transfer.

3. Map the ACCE student learning outcomes with the CM elective created.

Course development Process

The focus of the course was virtual design and construction tools, workflows, processes, and information technology for construction. In this model, a full-time faculty member was embedded in the industry to leverage a live knowledge transfer learning environment that draws from real-time industry experiences and training to bring direct career readiness and preparation into the classroom. Figure 1 details the process of developing a live knowledge transfer-based pedagogy. The course that was developed is titled "Engaging Technologies in Construction Project Management." Students enrolled in this course are junior-level students who take 14 credits of courses in the summer semester and then perform co-op in the Fall semester. Thus, the course on VDC and advanced technologies provided the latest knowledge base for these students before they do co-op in the Fall semester.

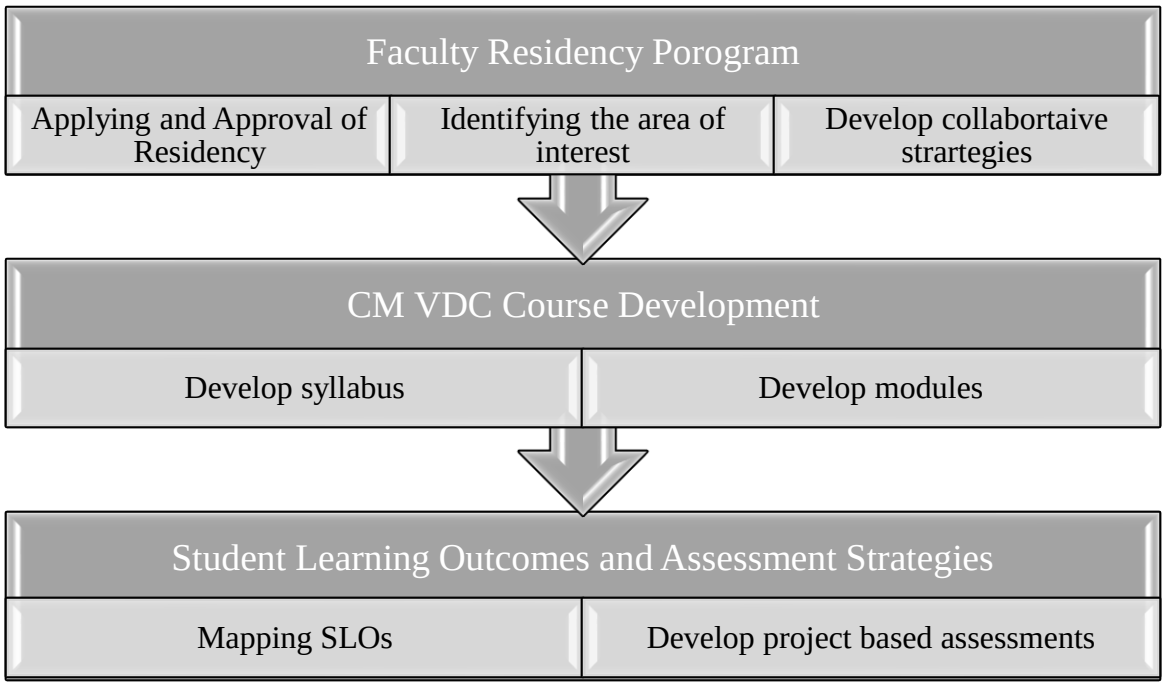

Figure 1 Course Development Process

Additionally, the student learning outcomes were flexible enough to be tied to real-time case study projects conducted by the faculty member within the context of the industry partnership. Figure 2 details the timeline of the course development process. As mentioned, the approval timing for the faculty resident was one of the compelling reasons to develop this course in the summer. The AGC approved the faculty residency application around January, giving ample time for the faculty resident to develop the course outline, learning outcomes, and essential materials. During the application process, the faculty and the industry participant must decide on

the primary duties and responsibilities of the faculty resident to learn, observe and participate at an assistant project engineer level. It guided the faculty resident to develop a course on VDC.

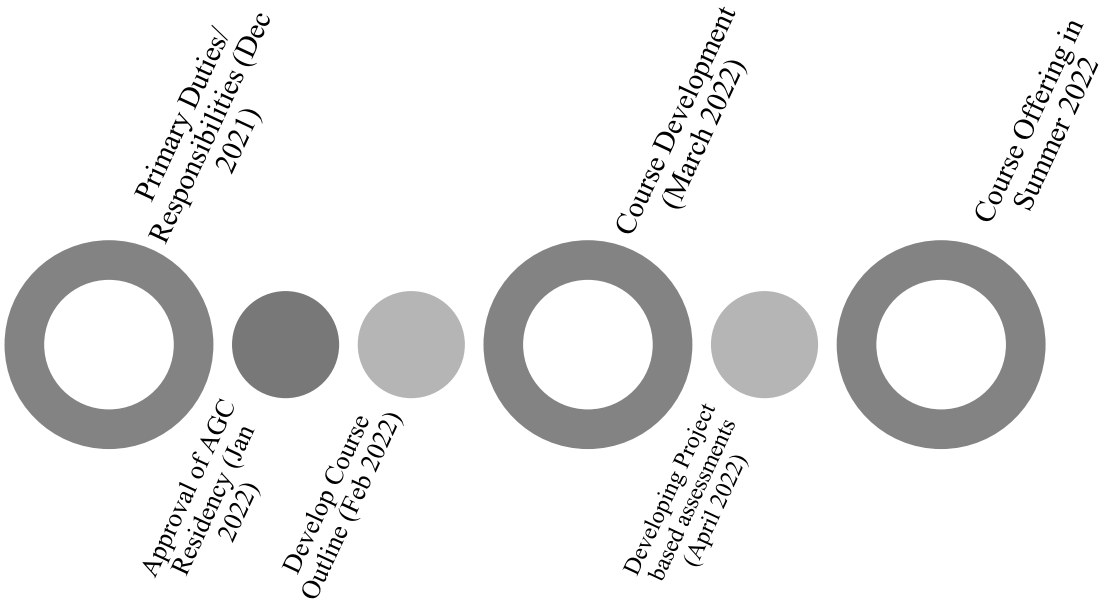

Figure 2 Timeline of the course development process

This robust model of leveraging faculty professional development, industry partnerships, and dynamic course development and delivery methods sets a foundation for staying current with the fast-paced, digital construction environment without jeopardizing basic curricular requirements and faculty resource requirements within the context of traditional higher education construction management programs.

Course Deployment

The faculty member who developed this course is a full-time faculty at the construction management program in one of the institutions in the New England region. The faculty member possesses a Ph.D. In a related field and applied for faculty residency for the summer of 2022. The institution, the contracting firm, and AGC approved the faculty residency application. The faculty and the contracting firm designed the following aspects of training during the VDC Residency program.

1. MEP coordination and clash detection
2. Site logistics and Construction Bidding
3. Drones, Laser scans, and developing point clouds for as-built conditions.
4. Using immersive tools to develop 4D, 5D, 6D, and 7D BIM strategies.

Based on these training objectives, the course descriptions and student learning outcomes are derived for the CONM 3800 elective. In addition, since this is a CM elective course, the number

of students enrolled in the course is only 14. It is also because the students in the program had the flexibility to choose other CM electives offered. The students enrolled in this course are junior-year students who possess the introductory knowledge of BIM through their introductory classes on construction graphics and plan reading. The faculty performed residency during the weekdays from 7 am – 3 pm and utilized the knowledge base to deploy materials in the following week in classroom education. The course was offered twice weekly on Tuesdays and Thursdays from 5 pm – 6:20 pm. It is another reason for the course enrollment reduction since most undergraduate students do not prefer evening classes because of their personal and professional commitments.

Faculty Workload

The uniqueness of this course offering depends highly on balancing the faculty workload. The faculty resident had to go through the process of learning, documenting, and delivering the knowledge at different locations daily. While the course was offered only on Tuesdays and Thursdays, the faculty was able to manage the workload by pre-planning the course, as detailed in Figure 2. The faculty spent 1-2 hours per week during the pre-planning phase, around 34 hours at the contracting firm, and 5-7 hours on course preparation and deployment. The preparation time during residency was significantly reduced since the faculty could engage in activities and document immediately during the learning process. Thus, the faculty was able to manage the workload irrespective of learning and deployment at different locations.

Course: Engaging Technology in Construction Project Management

Technology is transforming the modern landscape of the construction industry. Issues related to productivity on (and off) job sites, safety and complex site logistics, coordination of multiple trade design and installation, project management processes, and turnover requirements are explored through the engagement of software, hardware, and advanced technology workflows. This course aims to provide knowledge on managing construction projects in this digitalized environment through technologies, models, and software in all phases of construction sites. The course also emphasizes introducing advanced construction methods and technologies to prepare students as a technology-skilled workforce for the construction industry in the mere future. Students will learn through each module and be assessed through quizzes, reading assignments, projects, and presentations. In addition, the course aligns with SLO 10 of ACCE undergraduate student learning outcomes, including applying electronic-based technology to manage the construction process. At the end of the semester, the students must be able to achieve the following course learning outcomes:

- Analyze different technological options for the construction process.
- Create written communications related to the construction discipline.
- Understand the sequence of construction projects and technologies used in them.
- Analyze the capabilities and limitations of different technologies regarding cost and productivity.
- Explain the advantages and drawbacks of utilizing technology in small and mid-size construction companies.

- Select construction equipment, software, and technology based on project requirements.

Weekly modules

Table 1 below details the weekly modules and how they integrate with the faculty residency training every week. The faculty performed a ten-week residency with a blend of office and site experiences, and Table 1 details how the faculty residency aligns with the weekly course modules.

Course Phases

As Table 1 indicates, the courses are divided into three phases. In addition, the table also details the weekly training for the faculty in the industry and weekly course modules and their related course assessments. Phase 1 is the introduction phase, where the faculty do the basic orientation in the construction firm, and students understand the expectations and learning outcomes of the course. Phase 2 is the pre-construction phase, where faculty trains on the pre-construction tools and provides learning materials and projects for the students. Phase 3 is the construction phase, where the faculty performs site visits and trains on managing projects during the construction phase. The students also perform site visits and learn tools to utilize immersive tools. Phase 4 is the post-construction phase, where students understand 6D BIM and look at other advanced technologies in this phase. The faculty at this phase review the overall experience of the faculty residency, evaluate what went well, and documents things that require improvements for future reference.

Phase 1: Introduction: Week 1 – Week 4

Week 1 – Week 4 is the introduction phase of the course. Week 1 is an introductory week with an overview of the course syllabus and installation software required for this course. The faculty resident during this week will be setting up the system, understanding the company culture, and the need for VDC in that specific firm. This helped the faculty to understand the need for VDC for a construction firm that does institutional and commercial buildings. Week 2 to Week 4 will be a refresher time for the students on Revit and how to use Revit for VDC workflows. The faculty resident went through handling construction projects and getting familiar with the advanced Revit systems.

Phase 2: Pre-construction: Week 5- Week 7

Phase 2 includes the pre-construction phase of the course. Week 5 starts with understanding the utilization of technology in the pre-construction phase. The faculty resident underwent rigorous training on utilizing VDC for estimating, scheduling, and project management. The students during this phase are introduced to projects to implement these tools in their projects. Some content of this phase is taught during the next phase because of holidays and exams during the middle of the semester.

Table 1 Mapping of weekly modules and faculty training

Module	Weeks	Faculty Residency Training Topic	Course Topic	Assessments
Introduction	1	Introduction to VDC. System setup and Software installation	Introduction, Course Syllabus Review, Benefits of BIM in Construction Management	Pre-test
			Importance of Cutting-edge Technologies in Construction Projects	Quiz 1 – BIM in CM
	2	Utilizing Autodesk Revit as a VDC tool and learning Enscape	Reviewing Plans and Markup using Bluebeam	
			Advanced Revit Modeling Part 1	Homework 1 – Restaurant Project Revit Model
	3	Develop immersive site logistics using Revit models	Advanced Revit Modeling Part 2: VDC workflow using Revit	Quiz 2 – Reviewing Plans
			Reviewing Construction Specifications	In-class exercise- 1: Reviewing Specs using Bluebeam
	4	Imaging and Laser Scanning tools	Integration of Revit and Enscape to develop interactive site logistics	Quiz 3: Reviewing Specifications
Pre-Construction Phase			Develop Office projects and a 360 immersive experience using Enscape	Homework 2; Develop an immersive experience for a residential housing project
	5	4D Estimating using Autodesk Assemble	Introduction to Technology and Pre-Construction	N/A
			Point clouds of existing projects using laser scans: Part 1	Homework 3: Review materials and write a 1-pager on technology utilization in pre-construction
	6	5D scheduling using Revit, twin motion, and Synchro	Utilizing point clouds to develop Revit models for as-built conditions: Part 2	Reading Assignment: Review Materials for Exam 1
			Exam 1	N/A
	7	Construction Coordination and Clash Detection	4D Estimating using Autodesk Assemble Part 1	
			Quantity take-offs using Assemble	Group work: Reviewing real projects from the contracting firm using Autodesk Assemble
	8	Utilizing Autodesk Navisworks for Clash Detection	5D scheduling using Synchro Part 1	N/A
Construction			5D scheduling using Synchro Part 2	Homework 4: Estimate quantity using Autodesk Assemble and Revit Model

	9	Site Visits	Construction Coordination Part 1	Quiz 4 – 4D Estimating
			Construction Clash Detection Part 2	Group Work: Find the missing elements using Navisworks walkthrough
	10	Utilizing hololens to manage construction projects	Bid Management	N/A
			Site Visit 1	Quiz 5: Bid Management Tools
	11	Overview of the faculty residency program and final presentation to the contracting firm	Exam 2	N/A
Post-Construction and Other Technology Phase			Virtual and Augmented Reality	
	12		Construction Safety and MEP Coordination	Preparing Assignment: Prepare for the project presentation
			Project Presentation: Site logistics, Quantity takes-offs, scheduling, and Clash detection	N/A
	13		Construction Quality Control Part 1	
			Site Visit 2	Quiz 6: Quality Control
	14		Robotics and Automation	Homework 5: 1-pager on Automation and Robotics
			Study Day	N/A
	15		Final exam period	

Phase 3: Construction: Week 8- Week 11

In this phase, the faculty resident is trained to manage construction projects, identify issues and understand the documentation process. The faculty in this phase utilizes Autodesk Navisworks to understand the clash detection process in MEP coordination and also understands the overall bid management processes. The students learn how to utilize Navisworks, perform walkthroughs and clash detection, and create reports on clash detection. The students also take their second exam on the project's construction phase.

Phase 4: Post Construction: Week 11-Week 15

In the final phase of the course, the students understand the overall technological advancements in the construction industry and learn how to use VR/AR in the classroom. The faculty residents developed a report on their residency and assessed student performances. The students also presented their work since most of their homework is mini-project submissions on the specific tool they utilize.

Discussion and Future Work

The uniqueness of the process, as mentioned above, is the simultaneous professional development engagement for a full-time faculty member alongside the deployment of real-life case studies and projects for student understanding of industry expectations upon entering the workforce. Offering a course during the learning process helps the faculty resident learn by doing and sharing the knowledge during the same timeframe, helps retain knowledge, and gain confidence in the subject matter. The course can be re-offered in future semesters. However, the paper focuses on first-time deployment during the faculty residency timeframe. The proposed process allows construction management programs to coordinate with industry sponsors to deploy current case study content in the classroom with a seamless trade-off for both visibility of the company and transparency of types of career paths offered within the company for similar projects. Additionally, this allows the faculty member to explore and test a new process and pedagogy for knowledge transfer and course development in real-time, where the course becomes a pilot for potential concentrations/specializations or core-curriculum coursework within the program once refined.

The future work and extension of this research would be on analyzing the student learning outcomes of the students enrolled in the course. In addition, 8 of the students have an A grade, 5 have a B grade, and 1 has a C on this course. The author would offer the course again with upgraded materials and collect data on the grades and performance, along with the student feedback, to analyze and improve the course deployment strategies. Also, the authors would identify the potential to involve the industry advisory board to develop a system to help faculty members of the program develop an industry-based curriculum. It is also essential to understand and learn from the strategies of other faculty residents. Thus, analyzing the faculty externship/residents' experiences and their knowledge transfer strategies will also be one of the future works of this research.

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