

Construction Management Curriculum Transformation through Project-Based Learning: Part 2 of a Progressive Case Study

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In 2015, the Purdue University Building Construction Management Technology faculty decided to transform the entire construction management core curriculum to an integrated, project-based curriculum. This paper is the second of the series outlining the process of transformation. The first paper in this series described the work in the 2015-16 academic school year and is summarized here; while the work completed in the 2016-17 school year is explained. During this time, the curriculum committee grew and prepared to launch the new transformed curriculum for Fall 2017 incoming students. Several topics were either started, continued, refined, or finalized during, which included: outcomes, objectives, schedules, syllabi, handbooks, assessments, simulations, intercultural requirements, textbooks, project library, history, service learning, marketing, software integration, and work experience requirements. This paper provides an overview of this progress and next actions needed.

Key Words: student centered learning, competencies, project-based learning, integrated curriculum, curriculum development

Introduction

In 2015, the Purdue University Building Construction Management Technology faculty decided to transform the entire construction management core curriculum to an integrated, project-based curriculum. In 2017, the authors presented the first part of this curriculum transformation case study. This paper briefly summarizes part one and starts at its conclusion, the beginning of the 2016 fall semester, explaining the progress completed through to the end of 2017 summer. While transforming the curriculum, the department transitioned from Building Construction Management Technology (BCM) to the School of Construction Management Technology (CM). The purpose of the curriculum transformation is to integrate all BCM core classes into larger, project-based CM courses. This translates from the existing curriculum's (20) two – four-hour BCM courses into 11 CM courses: (1) three-hour course, (3) one-hour courses, (3) six-hour courses, and (4) nine-hour courses; Figure 1 provides the complete plan of study for CM students in the new curriculum. The six and nine hour courses are classified as pre-construction (class numbers ending in 0000) and construction (classes ending in 5000) content while utilizing spiral learning. Spiral learning presents topics several times over the student's academic education while increase in difficulty and complexity as the student advances through the curriculum. Figure 2 provides a visual representation of the core project curriculum with the spiral integration of pre-construction and construction topics for the semesters. It is vital to ensure that the classes tie horizontally (within year) and vertically (all pre-construction courses align together and all construction courses align together). The years are numbered, starting with freshman year along the bottom and moving up towards the senior year. The same topics listed across the top of the figure are covered in each connected semester and as mentioned, increase in complexity and difficulty as the student advances towards senior year. Although the outcomes and objectives are the same, or in some instances even improved, as the previous curriculum, one of the major differences is the basis of the content: authentic industry projects. Integrating topics such as mechanical, electrical, structural, and cost systems in the same course and from the same plans, specifications, and

documentation bolsters students' interdisciplinary skills and knowledge required to manage construction projects. These co-taught courses promote independent learning, critical thinking, and application of knowledge.

REVISED PROPOSED Plan of Study - 120 Total Credit Hours			
Fall First Year		Spring First Year	
3	CM 10000 Intro to Const Mgmt	6	CM 15000 Const Mgmt Fundamentals
3	MA 15800*	1	CM 11000 Const OSHA 10- HR Cert
3	English Composition Selective*	3	MA 16010*
3	TECH 12000*	3	Communication Foundation Selective*
2	CGT 16400	3	Free Elective
14	Total Credit Hours	16	Total Credit Hours
Fall Second Year		Spring Second Year	
9	CM 20000 Inter Pre-Con Mgmt	9	CM 25000 Inter Con Mgmt
4	PHYS 21800*	3	Free Elective
3	MGMT 20010	3	Lab Science Selective*
16	Total Credit Hours	15	Total Credit Hours
Fall Third Year		Spring Third Year	
9	CM 30000 Adv Pre-Con Mgmt	9	CM 35000 Adv Con Mgmt
3	Humanities Foundation Selective*	1	CM 39000 Const Work Exp I
3	Management Selective	3	MGMT 45500
		3	Free Elective
15	Total Credit Hours	16	Total Credit Hours
Fall Fourth Year		Spring Fourth Year	
6	CM 40000 Const Capstone I	6	CM 45000 Const Capstone II
3	ECON 21000 or AGECE 21700*	1	CM 49000 Work Experience II
3	Business Selective	3	Free Elective
3	Advanced COM or ENGL Selective	3	Global Selective**
		0	Intercultural Requirement**
15	Total Credit Hours	13	Total Credit Hours
*University Core Requirement		CM Required Courses	
**Polytechnic Requirement		ACCE Gen Ed Required Courses	

Figure 1: New Plan of Study

Part 1 Summary

Part 1 of the series of this case study focused on the overall preparation and planning stages of transformation. A thorough lit review was completed in this initial paper, justifying the case for transformation and analyzing what previous programs have attempted with integrating courses, albeit on a much smaller scale. The paper cited the many benefits of project-based learning (PBL) and spiral learning such as providing real world context, increased soft skills, and placing the student in an active learning environment as opposed to passive learning (Benhart, Cabral, Hubbard, Metzinger, Morgan, and Santon, 2017). Veladat & Mohammadi (2011) listed the goals of spiral learning as: “conceptualization, creativity, teamwork, individual work, to declare thoughts and achieve a hypothesis, to acquaint with terms, to apply images, knowledge, to interpret and criticize, learning, connect unfamiliar concepts with familiar ones, feeling trust, to extend information and the capability to maintain, pre-organizer, scientific thoughts” (pp. 1118 – 1120). Literature also helped to identify potential challenges the faculty and staff may

encounter in the transformation of curriculum and in co-teaching courses. For example, PBL requires more preparation time than lecturing and can therefore cause time-related stress for instructors (Chinowsky, Brown, Szajnman, & Realph, 2006; Frank, Lavy & Elata, 2003). Further, students typically prefer a passive learning environment that requires less effort on their part and are not familiar with an active, PBL environment (Frank et al., 2003). Groups provide their own challenges as well, such as members not participating, dominating members, pressure to accept differing ideas, and forceful conclusions (Gunderson & Moore, 2008). Recent literature has further justified the faculty decision to develop this new curriculum. Rokooei, Goedert, and Woldesenbet (2017) determined that active learning simulations increase knowledge retention. Further, students are aware of the increased retention and understanding (Lees, 2017). Validating that assessments actually evaluate student learning outcomes is an essential part any curriculum (Farrow, Good, Boyd, and Burt, 2017; Jiang, Flores, and Malek, 2017), especially when transforming curriculum.

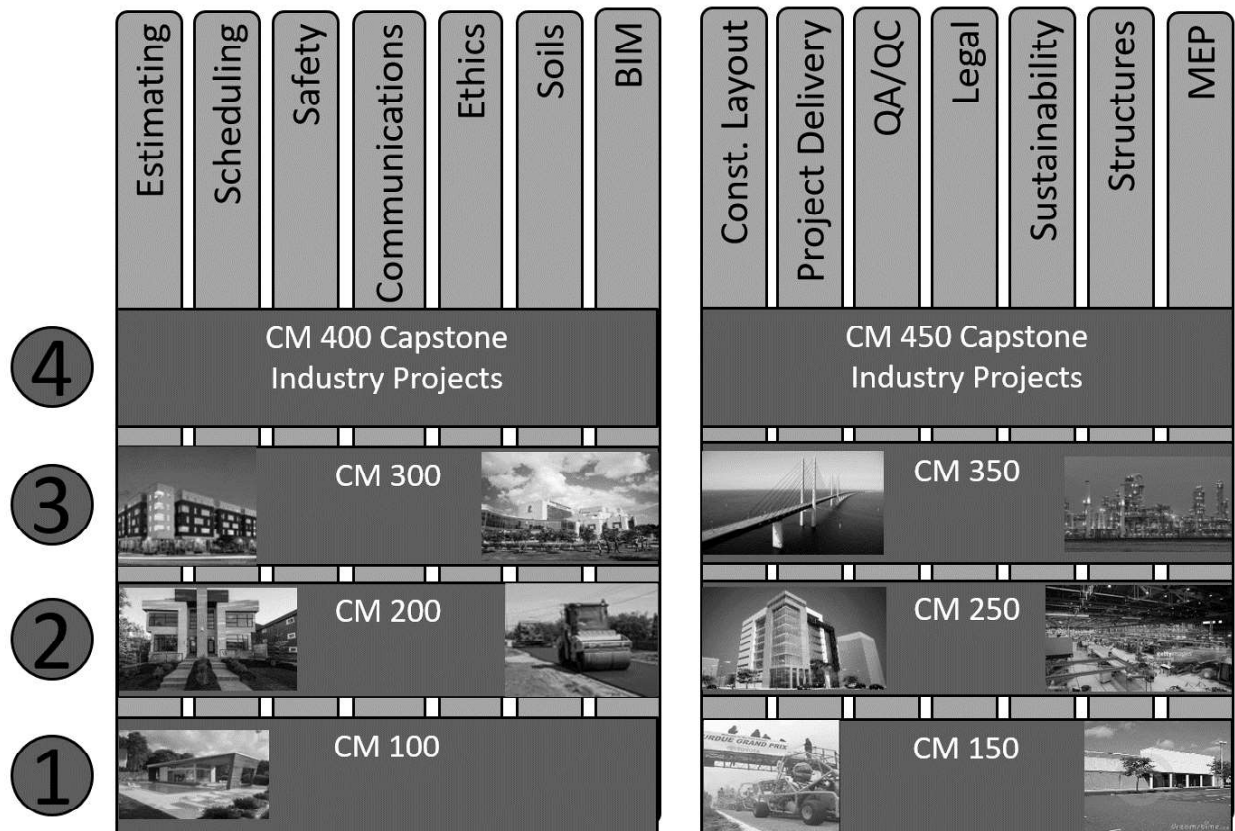


Figure 2: Visual Representation of the Spiral Learning Process for the New Curriculum

The faculty provided learning modules in their individual courses and identified where in the four-years each module would be best utilized and understood; this coming from the idea that even at a sophomore level course, for example, the beginning of the course is a summary of first year topics and by the end of the semester topics could develop to a senior-level objective. The curriculum committee arranged these modules based on the year and semester specified by the responsible faculty. This learning module distribution was the basis for the course objectives and served as a starting outline for the schedule for the semester. The committee also recognized the need for a “project librarian” who would solicit and manage the construction projects from the department’s industry partners. The projects are solicited based on industry-types (commercial, industrial, residential, or heavy civil) and

complexity. The original plan is for 16 total projects, four, one from each industry-type, for each year and in the future growing the library more to avoid the chance of student files and keep current with industry.

Due to signed plans of studies being a contract between the student and university, courses cannot be changed once a plan of study has started, therefore, two curriculum plans will be running simultaneously. One plan for the students who joined with the older version of the plan of study and then incoming students on the newer version. A transition schedule had to be created in order to determine the correct plan of study for students including graduation dates and schedule of offered courses. At the end of the 2016 summer, the curriculum committee planned to continue fine-tuning what they had accomplished, determine methods of assessing the new versus old curriculum, plan for the department American Council on Construction Education (ACCE) accreditation, further develop transformation schedule to prepare for overlapping instructional needs for new and old curriculum, faculty training needed for change management, and how to help faculty avoid slipping back into singular perspectives.

August 2016 Faculty Workshop

The August, 2016 faculty workshop was a two-day workshop focused on new curriculum outcomes and objectives and a tutorial on Bluebeam revu software. The first day of the workshop was led by Purdue University's Center for Instructional Excellence (CIE). Throughout the day, the workshop leaders introduced the faculty to ideas for the faculty to consider in their motivation, teaching style, student motivation, and what student success looks like at each year. The second day was a training session on Bluebeam revu software as this will be a software utilized throughout the curriculum for on-screen takeoff as well as PDF and plan mark-ups.

The first half of the day with CIE focused on instructional mechanisms and student motivation. The initial discussion revolved around transformation, not of just the curriculum, but within the classroom as well. In order to transform the curriculum and meet student needs, becoming aware of oneself is the first step. A Meyers Briggs test was administered to the faculty and discussed the following day. This allowed faculty to understand their own work techniques and those of their colleagues so that teamwork can be better leveraged. Various instructional techniques were examined such as "flipping" the classroom, active learning, student centered learning, hybrid courses, and online courses. These techniques will not be explained here as this paper's purpose is not to go into this detail, but it is important to recognize that several or even all of these techniques can be utilized within one course. CIE's overarching goal is to create student-centered, autonomous, supportive learning environments by utilizing the discussed instructional techniques. Further discussion was directed at the application of these techniques to reach CIE's goal within the classroom and throughout the department's curriculum. These techniques were also examined relative to the Meyers Briggs personalities so that faculty could determine techniques that best suited their natural tendencies. When this is accomplished, knowledge is applied, and positive student motivation increases as well as perceived value of education; thus increased performance in class.

The second part of the day focused on defining successful students. Based on the outcomes, objectives, and learning modules per semester, the faculty applied verbs associated with Bloom's Taxonomy to describe advanced and baseline student performance. The faculty broke into groups and each group was assigned a semester to define. For example, if an objective is to "describe work sequencing", an advanced student will be able to critique a given sequence of work events and modify for optimization, while a baseline student can only create a sequence of events without considering optimization based on outside factors. This exercise was a practice in thought and somewhat theoretical as the more senior courses have not yet started development. The semester groups were tasked with meeting throughout the upcoming school year to further refine outcomes, objectives, and learning modules.

Work Completed During the 2016-17 School Year

Work on the curriculum transformation had a strong start thanks to the August faculty workshop. Course collaborations continued in an effort to develop co-teaching and instructional integration techniques, curriculum documents were submitted for university approval, project library was started, course teams were created, a more detailed transformation schedule was created, course teams met, and spring faculty workshop was completed. Transforming a curriculum with entirely new developed courses requires several levels of approval throughout the university. Thankfully, all documentation was completed and approved in time for the class starting in the 2017 fall to enter in the new curriculum plan of study. In January 2017, a staff member was hired to start building the project library, the cornerstone of the new curriculum. Draft assignments of course teams were created based on faculty expertise and content of each semester. Confirmation of when the students will start the new curriculum allowed for a detailed schedule to be created showing the phasing in and out of the new and old curriculum respectively, Table 1 provides this schedule.

The course teams met throughout the semester to continue refinement of objectives and outcomes for each of the semester CM courses. The groups met individually, horizontally (within the same year) and vertically (all pre-construction and all construction). Throughout the year, the teams focused on aligning the courses both with the other courses in their pre- or construction classification. It is imperative the alignment exist to seamlessly move through the semesters without the need for extraneous review and to avoid missing any topics. The spring faculty workshop was shorter and more focused on reviewing and sharing work that had been completed. Faculty broke out into groups per year and based on the work from the CM course groups, again further refined and aligned the courses through each year. After this was complete, all faculty came together and shifted the collaborative focus to both semesters from year two; defining what a successful and baseline student will look like. For example, the objective of safety: project planning, hazard analysis, and personal protective equipment, a baseline student will be able to identify safety hazards and an advanced student will be able to propose mitigation measures for those safety hazards. Six objectives were defined in this manner for each semester in year two.

Table 1 *Detailed Transformation Schedule*

Phase In	New Courses / Curriculum						
	Fall 2017	Spring 2018	Fall 2018	Spring 2019	Fall 2019	Spring 2020	Fall 2020
	CM 10000	CM 11000	CM 20000		CM 30000	CM 45000	CM 43300
		CM 15000	CM 25000		CM 35000	CM 49000	
					CM 39000		
					CM 40000		
					CM 23300		
Phase Out	Current Courses / Curriculum						
	Fall 2017	Spring 2018	Fall 2018	Spring 2019	Fall 2019	Spring 2020	Fall 2020
	BCM 10001		BCM 17500		BCM 21500	No Current Courses	
			BCM 11201		BCM 21601		
					BCM 27500		
					BCM 25001		
					BCM 28500		

Note: Semester listings are of first offerings of new curriculum courses and last offerings of current curriculum courses

Work Completed During 2017 Summer

Great strides were made over the 2017 summer because more faculty joined for work and curriculum was the main focus rather than teaching. Three people joined for summer work who were not part of the original committee. The summer group decided upon 15 tasks to either continue, start, or refine:

- Revise course outcomes, objectives, and schedules based on 2017 May workshop
- Create standardized syllabi for all courses
- Create student/faculty handbook
- Connect project library to learning modules
- Develop assessment tools
- Create simulation challenges for classroom use
- Finalize tracking for intercultural requirements
- Integrate history of construction into curriculum
- Define service learning projects
- Update website and marketing
- Determine textbooks
- Integrate Procore software
- Continue project library solicitation
- Develop work experience course
- Integrate technology simulations

Another round of revisions of outcomes, objectives, and schedules for the courses in years 2, 3 and 4 of the curriculum were completed as well as finalized for year 1 to ensure compliance with accreditation and cohesion. The faculty responsible for developing these courses in the upcoming months and years will utilize the spreadsheets that were created this summer to tie the outlined objectives and outcomes to content such as classroom activities, assessments, construction projects from the library, integrated history, and writing components. The most pressing goal, however, was finalizing year 1 as the new curriculum was starting in the fall. The three-hour 100 level course is an introductory course open to all students within the university and no major changes were made to this course. The next year 1 course, CM15000 is the first major, integrated course the students will encounter and will be available 2018 spring. This course combines three main content areas: materials and methods, surveying, and contract administration. In order to plan this course faculty utilized several 3'x9' sheets of paper and hundreds of color-coded post-it notes, each with a specific content area per each note, which allowed easy modification of the schedule. At the end of the semester, the schedule was complete enough to create an electronic schedule which faculty teaching the course in the spring could easily share and start to create lesson plans.

A draft of a standardized syllabus and student/faculty handbook to be used in all new courses was completed. Resistance is expected from faculty, as with any organizational change, however, holding our faculty accountable is the best way to show the level of professionalism we are expecting of our students. Moreover, the syllabus and handbook have complete transparency with the entire faculty and will have faculty approval before implementation.

A review of the current construction projects in the library was completed. At the end of the summer, 19 projects had been committed with already receiving documents for 11 of those projects. An additional 27 projects have been collected from various student competitions. As objectives and outcomes continued to be refined, these were compared to the projects in determining the best fit for these projects. This was also necessary to determine what projects still are needed for the library. Course content cannot be properly developed without having projects to tie activities.

In collaboration with Kiewit, assessment tools were developed. These tools were developed in order to allow collaboration between industry and academia. These tools were coordinated to address student-learning outcomes prescribed by both ACCE and ABET (Accreditation Board for Engineering and Technology) construction management accrediting bodies. For example, their assessment tool titled "Estimating Risk Analysis (Guide 4 of 6)" meets ACCE outcome #4 and ABET outcome H: Estimating.

Creating simulations for the students prepares them for more situations that they will encounter. These simulations will be presented via both virtual reality and in-person during class activities. Virtual simulations will be administered live and online. In-class simulations of challenges will develop problem-solving skills and increase interpersonal communication and conflict resolution strategies. Initial challenge ideas include:

- Safety issues on site
- Various inspections
- Subcontractor incomplete work
- Material does not show up or is short
- Error on plans discovered on site
- Gender and/or race issues
- Disgruntled employee
- Hiring / firing issues
- Unskilled worker
- Dealing with harassment
- Stealing / drinking / substance abuse
- Taking gifts
- Bid shopping
- Backdating document

However, it is not enough just to produce the simulation; it is the faculties' hope to record the student reaction to these challenges. A record of the even can be reviewed with the students as well as use them as case studies in other courses. A debrief immediately after the challenge with the student will explain it was a planned part of the lesson; this is especially imperative when dealing with challenges dealing with sensitive issues.

Purdue University Office of Globalization has created an intercultural requirement for the university. Each student is required to self-report their own progress toward their chosen level of Global awareness and Intercultural Competency, which requires minimal, if any, effort by the CM instructors. However, there is a new requirement with the implementation of the transformed curriculum: Pre- and Post-Intercultural Development Inventory (IDI) Assessment and the Pre- and Post-Beliefs, Events, and Values Inventory (BEVI) into the coursework. The pre work will be completed in the required TECH 120 course and the post work will need to be integrated into the senior capstone courses.

While redeveloping the curriculum, faculty took the opportunity to integrate related topics into the courses. One such topic is construction history. A committee was formed to develop history integration and worked separately from the summer curriculum committee. The selection of historical projects was based on the ability of multiple analytical approaches and scope of impact in not only construction, but socio-economics, politics, and culture. Articles, videos, and podcasts will be utilized to provide information about the project and will be presented at relevant times throughout the course. For example, the Brooklyn Bridge will be presented in the CM 200 course and the Empire State Building will be presented in CM 400. Topics such as planning, financing, processes, innovations, and overcoming any challenge will be investigated by the students.

Service learning is important to students as it gives them the opportunity to gain hands on experience while giving back to the community. Individual courses and student organizations have completed service learning projects on somewhat random basis, depending on the instructor's connections. The goal of the transformed curriculum is to establish a long-term community relation so that every course can have a consistent organization to plan service learning projects. The summer was spent actively looking for organizations to establish this relationship.

ACCE accreditation has been at the forethought of this transformation, it is critical to abide by these regulations, even in marketing and the department website. The faculty took this time to not only update for ACCE requirements, but to improve the quality and information provided by the department site. Information regarding the new curriculum and a new major, Construction-Design-Integration (DCI), have been included on the site. Further, Public Disclosure Requirements for the department site have been reviewed as well.

When evaluating the diversity of instructional levels throughout the learning modules, it became apparent that textbooks would become an issue. Instead of being able to buy or rent a few books a semester and sometimes returning them after, in the new curriculum, one book could be referenced throughout all four years. This would

result in a student spending nearly \$1900 on all of their CM books at once during their freshman year and keeping them for four years. In typical curriculum, this cost is spread over eight semesters, making the price seem more palatable. Further, book rentals last anywhere from three to six months, making rentals a less cost effective method for this new curriculum. Several ideas have been considered, including a combination of ideas, such as utilizing free information (YouTube, online articles, journals, etc.), providing information from books under the *Fair Use Law*, utilizing older additions of books (thereby less expensive), and library books. As of yet, a reasonable solution has not been determined by the faculty, but will continue to be examined.

In maintaining relevant processes and technologies from industry, the faculty decided to integrate Procore Construction Project Management Software in the new curriculum. It was discovered that nearly two-thirds of the department's construction industry advisory council uses Procore in their daily operations as well as several peer CM programs. Procore offers free use for Universities without storage restrictions and free certification training for students to include on their resume and LinkedIn profile. The summer curriculum committee completed certification training; the same certification will be required in the freshman year as one of the assessment projects. The committee also utilized the software throughout the summer to coordinate information, as many members were not on campus during the summer and to better acquaint with the program. Procore will be utilized throughout the entire curriculum to organize and provide access to the documents in the project library. Similar to the project library, one faculty member will manage the software, create the projects for the faculty to develop their course, add or remove students and faculty to the appropriate projects and update accessibility permissions every semester, and provide software support and training throughout the department.

The last items managed over the summer were the new one-hour courses. In the old curriculum, students received their 10-hour OSHA certification in CM 175. In the new curriculum, there will be a one-hour course in year 1 to provide this certification. Due to OSHA regulations, there is a limit of 40 students per class. It was determined that the course will be compressed to five weeks, with two sections offered each semester, and scheduled on Fridays, outside of the regular CM course schedule. The next two one-hour courses focus on industry work experience. The new curriculum will continue the 800 hours of industry experience required to graduate. However, in years 3 and 4, a one-hour reflective course will be required. During this course, each student will complete oral and written communication assessments based on their summer work experience. A draft of an internship handbook was also created in conjunction with the work experience course. This handbook outlines requirements and resources for this course they will take after their summer experience. This handbook will provide a guide for employers and students alike.

Conclusion and Next Steps

The curriculum committee along with the rest of the faculty have spent countless hours transforming the CM program and preparing for its launch for the 2017-18 school year. Each semester, more faculty become involved in development and bring their creativity and problem solving skills for the steps needed to fully transform the curriculum. As there is no roadmap to follow for a transformation of this size, the faculty has been forced to create this change based on ingenuity. As this transformation progresses, new challenges and solutions arise, such as the need for a standardized syllabus and the issue with textbooks. Outside analysis and feedback is crucial in this process as well. Feedback from the 2017 ASC annual meeting has been actively reviewed and incorporated where applicable. It is anticipated that there will be some unforeseen issues once the new program starts, especially while offering both plans of study simultaneously. However, this has not deterred the productivity and motivation of the faculty. Items will continue to be refined and finalized through the next year. Year 2 development will start in the 2017-18 school year, as it will launch in the following year. Additional faculty workshops will occur focusing on teamwork, providing constructive feedback to peers, and potential expansion to the Polytechnic Institute and entire University. Two new faculty members will start in the 2017-18 school year, and up to another three will be hired for the following year. There is also a need to hire adjunct faculty to instruct while both plans of study are offered. As the new curriculum starts, more excitement arises from academia and industry. This transformation will continue to prepare top professionals in the construction industry.

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