

Construction Curriculum of the Future: Changes and Challenges

Dr. Ihab Mohammad Hamdi Saad P.E., Northern Kentucky University

Dr. Ihab Saad is Professor of Construction Management and an alumnus of the University of Kentucky in Lexington where he received his Ph.D. in 1996 from the department of Civil Engineering and Construction. He has over 25 years of experience in the construction industry primarily in the civil/construction project management area. Dr. Saad received his Bachelor of Science and Master's degrees in Civil Engineering from Cairo University in his native country Egypt in 1984, and 1993 respectively, in addition to a higher diploma in construction project management (equivalent to another M.Sc. from Ain Shams University in Cairo, Egypt). He has worked for a top 10 worldwide project management firm, and offered training in Egypt, Kuwait, Saudi Arabia, the United Arab Emirates, Qatar, in addition to the United States. He has taught at his Alma Mater, the University of Kentucky, in addition to Bradley University in Peoria, Illinois, East Carolina University in Greenville, North Carolina, and most recently at the University of Cincinnati in Cincinnati, Ohio where he was voted "Faculty of the Year" by construction science students in June 2011. His work experience includes roles as a field engineer, cost engineer, senior scheduler, and project manager. His research interests include project sustainability, innovative project delivery systems, multimedia applications in project documentation, and construction organizations' behavior and lessons learned. He has published in peer reviewed journals and presented at national and international conferences.

Dr. Saad is a certified Project Management Professional (PMP) by the Project Management Institute (PMI) and a registered Professional Engineer in Egypt and Qatar. He has received university and national teaching awards and coached several 1st place winning teams in national and regional construction competitions.

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Dr. Ihab M. H. Saad, Ph.D., P.Eng., PMP
Professor of Construction Management
Northern Kentucky University

The construction industry is witnessing major changes ranging from a leadership generational change to the emergence of new techniques, materials, methods, and contractual relationships, all coinciding with domestic and international market instability. Construction academia is facing similar changes with a leadership change from seasoned faculty to a newer generation of junior faculty who recently completed their graduate studies, but in many cases lack the industry experience. The face of construction education will have to adapt to the changing environment by adopting and ideally leading the change in the industry. This paper represents the results of a survey of construction academics and professionals about the direction a construction management curriculum should follow in the next few years in order to play a proactive role in shaping the next generation of construction leaders. A Structured methodology of change management is prescribed to update construction management curricula periodically, with a complete cycle not exceeding six years to coincide with the programs' accreditation cycle. The paper addresses some of the challenges faced during the curriculum change, along with suggested solutions to ease the transition and provide a strong foundation for the change.

Keywords: Construction education, change management, construction leadership.

Introduction

The construction industry is one of the major contributors to the national US economy. In 2016, the industry employed 10.328 million people in the United States alone, with a payroll of approximately \$792.5 Billion. AGC estimates that an extra \$1 billion in nonresidential construction spending adds about \$3.4 billion to Gross Domestic Product (GDP) (AGC 2018). Preparing a qualified and well-trained workforce to manage construction projects is the responsibility of academic and vocational institutions. This effort is supplemented by the on-the-job-training provided by the industry. Currently, the industry is facing a severe shortage in qualified personnel at all levels: Management, field personnel, and skilled craftspeople. The face of the industry is changing rapidly with the introduction of new technologies in the form of new materials, construction techniques, and contractual relationships.

For an academic program to survive and prosper in the current and future environments, it has to adapt to change, and in many cases lead that change. From the author's experience and exposure to different academic programs, the quality of an academic program can be gauged through a quadrangle of elements, referred to in this paper by the acronym CAPE, which stands for:

- Curriculum, which answers the question "What is to be taught?"
- Assessment, which answers the question "Have our students got it? Can we document it?"
- Pedagogy, which answers the question "How is it going to be taught?"
- and Environment, which answers the question "What kind of experience did our students have?"

The four elements of this quadrangle are inter-related, with some overlap among them. For example, the curriculum will dictate the material to be taught (Blueprint reading, estimating, scheduling, etc.), whereas the pedagogy determines the mode of delivery of instruction (face-to-face versus hybrid or fully online, lecture-based or experiential, etc.). Assessment of the students' learning can be quantity-based (how many hours were dedicated to each curriculum topic) versus outcome-based (what did the students learn and retain and what can they apply and demonstrate). The Environment addresses students' experience while learning and can be demonstrated through project-based learning, student competitions, and the availability of laboratory facilities and group space. Several efforts have been directed towards defining and measuring the impact of these four elements on construction education, however, the focus was primarily on Curriculum (C) and Pedagogy (P), with some relatively recent work on Assessment (A) and Experience (E).

Examples of these efforts include Abdelhamid (2003) who addressed the evaluation of teacher-student learning style disparities in construction education, Bernold (2005) and Bernold et al. (2000) who emphasized the need for flexibility and adaptation in construction curricula, and Holt et al. (2018) who discussed the learning styles of undergraduate students in construction in the US. Wang (2009) and Tinker et al. (2004) addressed specific content topics focusing on sustainability and greening of the curriculum. Levitt (2007) and Becerik-Gerber et al. (2011) emphasized the role of construction engineering and management research and its applications to the curriculum in keeping pace with technological innovations. Saad (2018) and Saad (2014) addressed the importance of assessment and curriculum mapping and realignment around the student learning outcomes and objectives. Ahn et al. (2012) and Haupt (2012) addressed the experience element by focusing on the key competencies that the industry is looking for in construction graduates and the role of cooperative education in developing these skills.

For a curriculum to excel, it has to display a combined quality in all aspects of CPAE. This paper addresses the first element of CPAE; the curriculum, including suggested changes, the change process, and obstacles to the change including some suggested remedies.

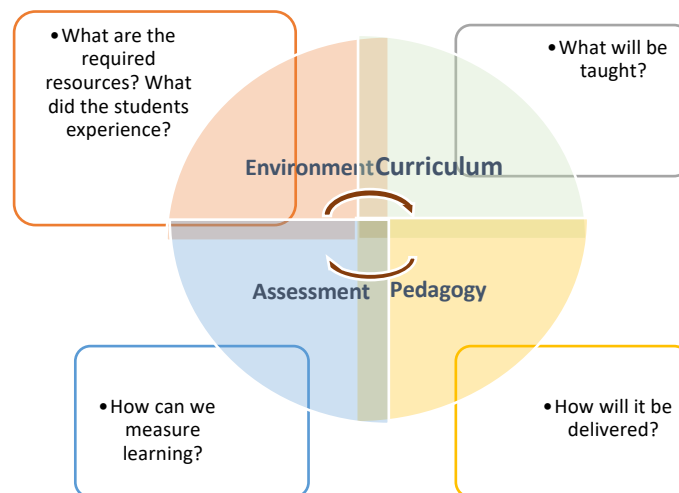


Figure 1 – CAPE Model

Problem Statement

Designing a curriculum for the next generation of construction professionals faces a lot of challenges, as the face of the industry is changing at a very fast pace. New concepts are introduced, and new technologies are shifting roles from individuals to machines that can perform some of the tasks more efficiently, at a higher quality, and with a reduced exposure to accidents. Established construction programs have to recognize, embrace, and lead this change in order to prepare their graduates to successfully interact with the changing aspects of the industry. This paper is attempting to answer the following questions based on the responses to a survey sent to a large number of construction academics and professionals:

- What concepts are likely to remain unchanged in the next five to ten years and what concepts will drastically change?
- Are the current curricula adequate to address such challenges and changes?
- What could be the areas of improvement in existing curricula?
- What are the most important skills an employer looks for in a construction program graduate?
- Which skills are likely to be replaced in the future by a machine?
- Which new technologies will become mainstream and which will become obsolete?
- How to implement the change to the program? And what are the obstacles to this change?

Research Method

A survey was designed and disseminated online through the Qualtrics platform. The survey was circulated to the Associated Schools of Construction (ASC) mailing list that contains the emails of about nine hundred construction professionals, both academic and practitioners. The latter group consisted mostly of industry professionals serving on the Industry Advisory Boards (IAB) of these programs, thus possessing both the professional experience and the exposure to the academic program intricacies and details. The survey contained questions related to demographics and the roles of the respondents, their years of experience in construction education or the construction industry, as well as their opinions on different topics and technologies used in construction education. Responses were received from 139 respondents representing about fifteen percent of the polled pool. The results of the survey were analyzed and grouped as shown in the following discussion.

Results and Discussion

Participants included Owners/Owner representatives (17 or 8.25%), Architects/Engineers/Designers (16 or 7.73%), Construction Managers (33 or 17%), General Contractors (33 or 16.5%), Specialty Contractors/Subcontractors (8 or 4.12%), Suppliers/Manufacturers (1 or 0.52%), Insurance/Surety (1 or 0.52%), Academics/Researchers/Instructors (78 or 39.18%), and Other [Developers, Consultants] (13 or 6.19%). Some respondents checked more than one box as their responsibilities included more than one of the above-mentioned categories. The range of experience for the participants included 94 participants with 16 or more years, 18 participants with 11 to 15 years, 15 participants with 6 to 10 years, and 12 participants with less than 5 years of experience in the construction industry.

When asked about the most important skills the employer is looking for in a graduate from a Construction Management program, the respondents ranked soft skills such as communication skills, problem solving, and teamwork as the most sought-after skills. These skills were followed by safety awareness, creative thinking, and standard hard skills such as electronic collaboration, scheduling, and estimating. Other desired skills included contract administration, CAD and BIM fluency, sustainability awareness, and surveying and layout. The skill that came at the bottom of the desired skills with less than 5 out of ten on the scale of importance was Structural analysis/Design. This ranking indicates a focus on generalities more than specifics, as creative thinking, communication, and problem-solving skills can easily adapt to new environments/technologies.



Figure 2 – Ranking of expected skills (Most important to least important)

Figure 2 shows the respective scores for the abovementioned skills. It is noteworthy that the order of these skills complies to a large extent with the latest standards for accreditation by the American Council for Construction Education (ACCE), including the 20 learning outcomes sorted and ranked according to Bloom’s taxonomy.

After ranking the required skills, the respondents answered a question that addressed the susceptibility of these skills to be completely automated, with machines or computer systems replacing humans in performing the tasks associated with these skills. There was a clear distinction between two different groups of tasks: creative and judgment tasks that relied on the performer’s creativity and would drastically vary from one user to another, versus repetitive and tedious tasks that relied on rigid rules and are not subject to multiple interpretations. The first group was represented by skills such as problem solving (13%), contract and claim administration (7%), sustainability (15%), scheduling (36%), and some field operations (26%). Whereas the second group included tasks such as structural analysis and design (66%), estimating and costing (62%), surveying and layout (83%), and virtual construction and Building Information Modeling (BIM) (66%). Figure 3 provides a graphical representation of the respondents’ views. This is a further proof of the importance of creativity and problem solving as essential skills in the new generation of project and construction managers.

A follow up question enquired about the adequacy of current academic programs in addressing the future challenges and/or opportunities. The respondents' opinions were predominantly positive, stating that current academic curricula are extremely adequate (3.94%), or somewhat adequate (62.99%). The neutral or negative opinions were neither adequate nor inadequate (21.26%), somewhat inadequate (10.24%), and extremely inadequate (2%).

When asked to rank the deficiencies on a scale of 1 to 10 with 1 being the least deficient and 10 needing the most improvement, the respondents again cited soft skills at a higher-ranking including communication skills (7.59), creative thinking and problem solving (7.4), and teamwork (6.75) as the three top skills needing improvement. Figure 4 represents, in a descending order, the scale of deficiency and need for improvement. It is also noteworthy that the most desired skills are the same ones needing most improvement.

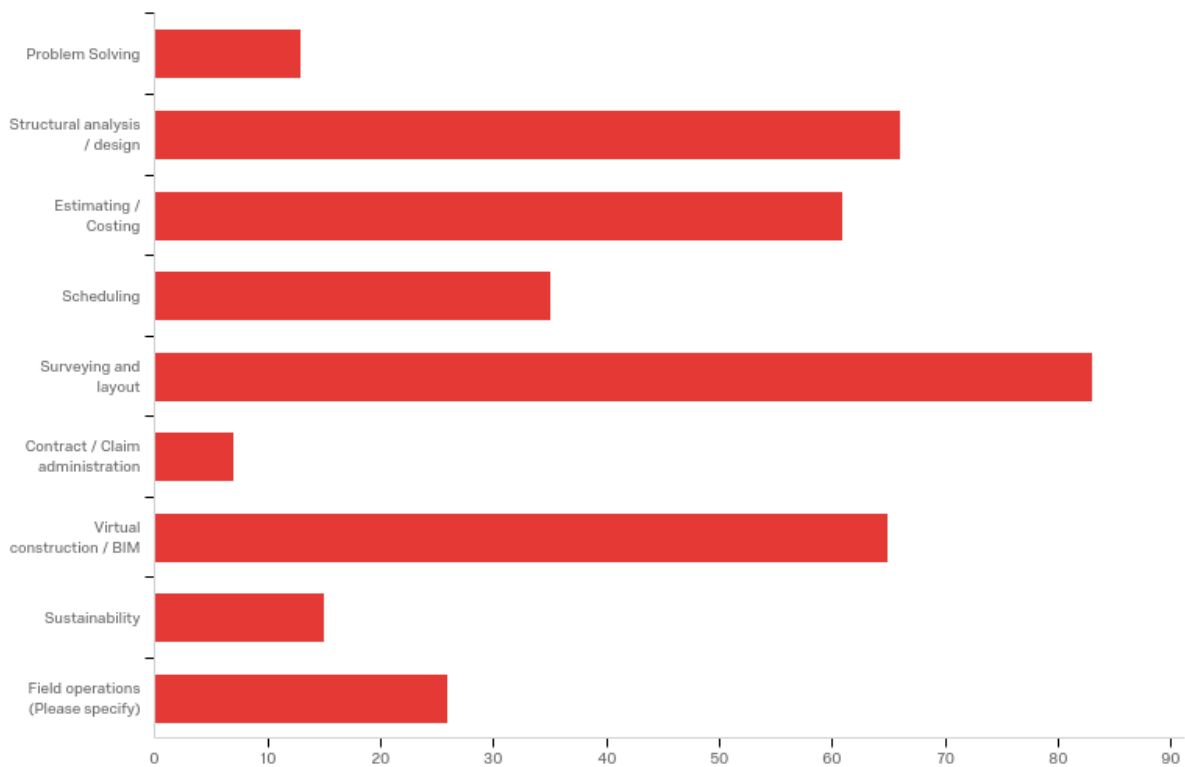


Figure 3 – Susceptibility to being replaced by a machine



Figure 4 – Skills deficiency and need for improvement

The following question probed the respondents’ opinion on which concepts/technologies will become mainstream over the next decade, and which might run their course and become obsolete within the same timeframe. Respondents were asked to qualify their answers on a Likert scale ranging from strongly agree to strongly disagree. The answers to the statements are shown hereunder and reflected in Table 1 below:

- On the first statement: “Most cutting-edge technology available today will be mainstream in the next 10 to 20 years”, the responses were predominantly in agreement with a total of 84.38% ranking it between somewhat agree and strongly agree. The unsure or general disagreement was a total of 15.62% with 0% “Strong disagreement”.
- The second statement: “Most cutting-edge technology available today will be obsolete in the next 10 to 20 years” was trying to gauge the respondents’ perception of the longevity of the current cutting-edge technology. The responses were mixed, as a total of 42.19% gave a positive response, whereas the unsure and negatives added up to 57.81%.
- The third statement: “Mastery of a concept is more important than mastery of a tool” showed a clear bias towards confirmation, as a total of 79.69% responded in the affirmative, and only 20.31% were either unsure or in disagreement.
- The fourth statement: “Problem-solving is the most important skill a graduate has to be equipped with” showed even more congruence as 89.07 were in general agreement with the statement, whereas only 10.93% were either unsure or disagreed. It is noteworthy that there was no “strong disagreement” with either statement three or four.
- The fifth statement: “It is more important to know the Why than the How” showed another trend towards agreement with a total of 72.65% generally agreeing with the statement and 27.35% either unsure or in general disagreement.

#	Question	Strongly Agree	Agree	Somewhat agree	Neither agree nor disagree	Somewhat disagree	Disagree	Strongly disagree
1	Most cutting-edge technology available today will be mainstream in the next 10 to 20 years	9.38%	39.06%	35.94%	7.03%	7.03%	1.56%	0.00%
2	Most cutting-edge technology available today will be obsolete in the next 10 to 20 years	6.25%	11.72%	24.22%	20.31%	26.56%	8.59%	2.34%
3	Mastery of a concept is more important than mastery of a tool	28.13%	36.72%	14.84%	11.72%	6.25%	2.34%	0.00%
4	Problem-solving is the most important skill a graduate has to be equipped with	28.13%	35.94%	25.00%	5.47%	3.91%	1.56%	0.00%
5	It is more important to know the "Why" than the "How"	14.06%	26.56%	32.03%	14.06%	10.16%	2.34%	0.78%
6	Construction management education should move more from generalization to specialization (MEP, Residential, Commercial, Heavy Civil, Industrial)	4.72%	18.11%	13.39%	14.17%	23.62%	18.90%	7.09%
7	Teaching software skills and techniques is more important than teaching the underlying theory	1.57%	7.09%	10.24%	11.02%	24.41%	32.28%	13.39%

Table 1- Opinions on Current and Future Trends

- The sixth statement: “Construction management education should move more from generalization to specialization...” showed a total of only 36.22% in general agreement, whereas the unsure or general disagreement was 63.78%, with a relatively large 7.09% in strong disagreement.
- The seventh and last statement: “Teaching software skills and techniques is more important than teaching the underlying theory” showed a strong trend towards disagreement, with a total of 81.1% either unsure or disagree, including 13.29% who strongly disagree. On the other hand, agreement with the statement was limited to 18.9% with only 1.57% strongly agreeing.

The following question was “Which of these technologies do you see flourishing and becoming mainstream in the next 10 to 20 years”. Among the suggested technologies/concepts, modularization and preassembly ranked highest as the top concept with 24.8% of the respondents ranking it as the most important concepts becoming mainstream. This concept has its impact on prefabrication, especially in MEP (Mechanical, Electrical, and Plumbing) construction. This was followed by both robotics and virtual/augmented reality at 12% each. In third place came analytics/big data and unmanned aerial vehicles with 8% each. It is worth mentioning that many of these latter technologies are primarily tools for established courses such as construction graphics/visualization, statistical analysis, and surveying. The complete tally of the answers to this question is listed in table 2 hereunder, showing the percentage of respondents ranking the different technologies on a scale of 1 to 10 with 1 being the most likely to flourish and 10 being the least likely or having the lowest priority.

#	Technology/Concept	1	2	3	4	5	6	7	8	9	10
1	Robotics	12.0%	10.4%	5.6%	19.2%	10.4%	14.4%	9.6%	7.2%	8.0%	3.2%
2	3D Printing	4.0%	12.0%	12.0%	11.2%	16.8%	10.4%	19.2%	8.0%	5.6%	0.8%
3	Analytics / Big Data	8.0%	15.2%	12.8%	10.4%	14.4%	11.2%	11.2%	6.4%	9.6%	0.8%
4	Machine Learning / Artificial Intelligence	7.2%	9.6%	13.6%	11.2%	8.0%	9.6%	12.0%	15.2%	12.0%	1.6%
5	Computer Vision / Pattern Recognition	1.6%	5.6%	11.2%	8.8%	10.4%	18.4%	16.0%	19.2%	8.8%	0.0%
6	Virtual / Augmented Reality	12.0%	8.8%	8.0%	12.8%	13.6%	8.0%	7.2%	12.8%	13.6%	3.2%
7	Unmanned Aerial Vehicles (Drones)	8.0%	16.0%	16.8%	9.6%	9.6%	10.4%	9.6%	11.2%	6.4%	2.4%
8	Modularization / Preassembly	24.8%	13.6%	9.6%	5.6%	10.4%	8.0%	3.2%	8.8%	8.8%	7.2%
9	Autonomous vehicles / equipment	7.2%	7.2%	9.6%	11.2%	6.4%	9.6%	12.0%	9.6%	25.6%	1.6%
10	Other (Please specify)	15.2%	1.6%	0.8%	0.0%	0.0%	0.0%	0.0%	1.6%	1.6%	79.2%

Table 2 - Future trends for current and emerging technologies including percentage of ranking

The change process

The American Council for Construction Education (ACCE) is the main body accrediting construction management programs in the US. Accreditation can initially be obtained upon meeting prescribed criteria (currently 20 Student Learning Outcomes), in addition to other institutional, financial and administrative requirements. The renewal of accreditation occurs on a 6 year cycle, and accreditation can be renewed for up to 6 additional years each cycle.

It would be imprudent to start the change process beyond the third year in the cycle, as there would be limited time to make the change, collect data, assess the change, and report on the assessment within the remaining three years. The timing to start the change process, if needed, should immediately follow securing accreditation for a new cycle.

Different methodologies can be implemented to achieve the desired changes. Among these methodologies, this paper suggests the Kotter (1995) 8 step model, as it has proven its efficiency in managing change in other industries. Kotter's model follows a structured approach to realize the change and its steps can be summarized as follows:

- 1- Establishing a sense of urgency within the academic program that change is impending or has to happen. Smart leaders will recognize the triggers for this change. As Kotter suggested, examining market and competitive realities will enable the academic program to establish benchmarks to meet and identify its strengths and weaknesses while contemplating the opportunities and threats that it is facing.
- 2- Creating a guiding coalition. Internally, the academic program must empower change champions to form a team overseeing the development steps needed to obtain the buy-in from different stakeholders, including faculty, students, administration, advisory boards, and the industry at large.
- 3- Developing both a vision and a strategy for change: A vision may include expanding to new areas, establishing new programs, or creating new courses. The strategy will translate this vision into long-term steps to be taken to achieve the vision.

4- Communicating the vision through internal dialogue within the program. This communication can use both the push and pull modes: push to close and influential stakeholders and pull to the general public and other less crucial stakeholders by posting the vision for change on the program's website to attract new talent. Transparency, timeliness, and openness are key features leading to the success of this communication, explaining the available opportunities, the expected obstacles and steps to overcome them.

5- Empowering others to act on the vision by reducing or removing any obstacles that could derail the change process. New behaviors will have to be learned, new processes will have to be developed, and teams will be encouraged to take risks and adopt non-traditional ideas, activities, and actions. Key faculty affected by the change will have to be shown "what's in it for me", and "what's in it for the program". Addressing the concerns of the affected faculty will help reduce the resistance and pave the way for the change to settle-in.

6- Confirming that the change is going in the right direction by planning for and creating short-term wins. Visible and measurable performance improvements should be assessed and documented, while rewarding the faculty and the change team members involved in these improvements. The low-hanging fruit should be targeted and success results such as improved student performance, successful deployment of new systems, or introduction of new concepts or technologies should be shared with all stakeholders. These early wins will encourage faculty to follow the change roadmap hoping to achieve the full benefits of the vision and the strategy.

7- Gains from the sixth step will facilitate the seventh step which calls for consolidating improvements and producing more change. The short-term wins result in increased credibility of the change initiative and help beget more successes as skeptics will start seeing the results of the change. By this time, change has developed its own momentum that needs to be maintained by further education, coaching, and development of the faculty to increase the number of active change agents.

8- Finally, the eighth step culminates the change process by institutionalizing the new approaches and reinforcing them so that they become the new program culture. Activities that can help this reinforcement include articulating the connections between the new and modified behaviors and the program success. Promoting the change agents to leadership positions and entrusting them with the decision-making power for the program will accomplish the transition from one change cycle to another.

Applying this model has its obstacles that can derail its successful implementation, and these include:

1- Allowing too much complacency, which would be the opposite of the urgent need for change. If the team is satisfied with the status quo and does not see the need for continuous improvement, that can lead to gradual program deterioration.

2- Failure to create a sufficiently powerful leading team which would be contrary to the guiding coalition. Support from the administration can pave the way for program leadership to implement the change.

3- Underestimating the power of vision, by not properly and clearly articulating that vision. In many cases, external facilitators providing a fresh eye can serve as catalysts for the change.

- 4- Failure to clearly and timely communicating the vision. This can result in either missing opportunities or succumbing to stagnation.
- 5- Permitting the first obstacles to block the new vision, thus preventing the quick successes. The persistence of the change champions would help overcome this problem.
- 6- Failure to create the short-term wins, thus losing momentum and weakening morale. Aim for small wins that can keep growing as the whole team coalesces around the change initiative.
- 7- Declaring victory too soon before the change has been reinforced and institutionalized. Continuous monitoring and assessment can emphasize the achieved gains.
- 8- Neglecting to anchor the changes firmly in the organizational culture and the corporate best practices. It is the role of the team leadership to document the achieved successes and formalize them into processes and standard operating procedures.

Understanding these obstacles before the start of the change initiative, while following the prescribed solutions, will enable the change team to devise mechanisms and metrics for their avoidance.

Conclusions

Construction education will witness major changes in the next decade. Academia, together with the construction industry, will have to regularly and periodically revisit and reassess the construction curricula to make sure the latter are meeting the demands of the technological and conceptual changes. Lifelong learning becomes a necessity as the curriculum covered in an undergraduate degree will have an increasingly shorter shelf-life, which necessitates regular retooling and retraining. It is imperative to focus on the foundational concepts rather than the evolving technologies representing the manifestation of these concepts, as the answer to the question “why” is more important than the “how”. A certain level of specialization is desired, however, curricula should provide a good foundation of general knowledge and practice allowing for lateral moves of the graduates among the different industry segments (residential, specialty, commercial, heavy, and industrial) if and when needed.

A repetitive cycle for program design, delivery, assessment, and review should coincide with the standard 6 year cycle of accreditation by ACCE. The first three years are used to design, deliver and collect data, whereas the second three years are used to review the collected data, assess it against the intended goals/objectives, and make proper adjustments to the program. The change process follows the repetitive and iterative cycle: unfreeze, modify, freeze, deliver, assess, retain or discard, repeat.

Faculty should assume complete ownership of the curriculum, and program leadership should secure faculty buy-in in the process. Faculty will be taken out of their comfort zone, therefore the proposed gains should be highlighted, and fast wins should be celebrated. Following one of the standard methodologies for change management will provide a clear roadmap to be followed in order to achieve the change.

References

AGC Construction data (2018). <https://www.agc.org/learn/construction-data>

Abdelhamid, T. S. (2003). Evaluation of teacher-student learning style disparity in construction management education. *Journal of Construction Education*, 8(3), 124–145.

Bernold, L. E. (2005). Paradigm shift in construction education is vital for the future of our profession. *Journal of Construction Engineering and Management*, 131(5), 533–539.

Bernold, L. E., Bingham, W. L., McDonald, P. H., & Attia, T. M. (2000). Impact of holistic and learning-oriented teaching on academic success. *Journal of Engineering Education*, 89(2), 191–199+247-248+251

Holt, E., Chasek, C., Shaurette, M., & Cox, R. (2018) The Learning Styles of Undergraduate Students in CM Bachelor's Degree Programs in the U.S., *International Journal of Construction Education and Research*, 14:1, 4-21, DOI: 10.1080/15578771.2017.1342718

Wang, Y. (2009). Sustainability in Construction Education. *ASCE Journal of professional issues in engineering education and practice*, Vol. 135, No. 1, 21-30.

Tinker, A., & Burt, R. (2004). Greening the construction curriculum. *International Journal of Construction Education and Research*, 1(1), 26-33.

Levitt, R. (2007). CEM research for the next 50 years: maximizing economic, environmental, societal value of the built environment. *ASCE Journal of construction engineering and management*, Vol. 133, No. 9, 619-628.

Becerik-Gerber, B., Gerber, D. J., & Ku, K. (2011). The pace of technological innovation in architecture, engineering, and construction education: integrating recent trends into the curricula. *Journal of Information Technology in Construction (ITcon)*, 16(24), 411-432.

Ahn, Y. H., Annie, R. P., & Kwon, H. (2012). Key competencies for US construction graduates: Industry perspective. *Journal of Professional Issues in Engineering Education and Practice*, 138(2), 123-130.

Haupt, T. (2012). Student attitudes towards cooperative construction education experiences. *Construction Economics and Building*, 3(1), 31-42

Saad, I. (2018). Towards an assessment of SLO 9: Working in a multidisciplinary team. *Journal of the American Constructor/American Institute of Constructors*, Spring (March)

Saad, I. (2014). Mapping the curriculum around student learning objectives and assessment, 151st International Conference and Exhibition, American Society of Engineering Education ASEE, Indianapolis.

Kotter, J. (1995). Leading Change: Why Transformation Efforts Fail, Harvard Business Review, March-April