A/E/C Integration: An Education and Training Program

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Abstract

Globalization, increasing project complexity, and emerging technologies are among the major drivers affecting the Architecture, Engineering and Construction (A/E/C) industry. These changes are overtaking the A/E/C industry and are forcing formally fragmented groups to work together to create a more efficient, economic and sustainable product. The organizations that will move ahead in this climate understand and embrace these changes. More importantly, they are led by individuals who possess the skills and foresight needed to successfully meet these challenges and incorporate change. The goal of this paper is to present a summary of discussions and ideas generated from a workshop at the Georgia Institute of Technology on how to prepare an integrated education program in two core areas: (1) cultural and organizational changes affecting the industry; and (2) the industry's current and future technological needs. Cultural change refers to establishing a mindset based on teamwork, collaboration, and empathy for the differing roles and responsibilities of various stakeholders involved in the industry. Technology need refers to the specific IT tools used in the A/E/C industry, such as Building Information Modeling (BIM). It also includes training in delivery systems, process management, telecommunications, shared work environments, and other innovations.

Keywords

Education, Training, A/E/C industry, Integration

1. Introduction

In the past decade, the Architecture, Engineering and Construction (A/E/C) industry has undergone tremendous changes as a result of globalization, increasing project complexity, and emerging technologies. These changes are overtaking the A/E/C industry and are forcing formally fragmented groups to work together to improve efficiency and reduce costs, while adopting principals of sustainability. The organizations that will move ahead in this climate understand and embrace these changes. More importantly, they are led by individuals who possess the skills and foresight needed to successfully meet these challenges and incorporate change. Universities are in a unique position to help meet the growing demand for professionals who can lead the A/E/C industry toward seamless integration and become innovators and change agents within the field. However, training students on basic management practices or new technologies alone isn't sufficient to prepare them for managing the diversity and complexities of the A/E/C workplace. Thus, a unique approach to A/E/C education is needed.

This article is based on the results of an A/E/C Integration Workshop held at Georgia Institute of Technology by the Construction Resource Center in 2007. The purpose of the workshop was to gain an understanding from industry professionals and academicians concerning Architecture, Engineering,

Construction, and Planning (A/E/C) Integration. The workshop focused on a number of issues, such as the factors driving integration and those preventing the construction industry from achieving integration, as well as the types of tools or processes needed to enhance integration. The purpose of the workshop was to generate ideas that will help the College of Architecture at the Georgia Institute of Technology (Georgia Tech) create a curriculum centered on A/E/C integration, with application for other institutions. Based on these discussions, an integrated curriculum trains and prepares students in two core areas: (1) cultural and organizational changes affecting the industry; and (2) the industry's current and future technological needs. Providing training in these core competencies will produce graduates who can manage diverse teams, have the skills and mindset for effective integration and automation of project processes, have engineering, design and construction knowledge, and fundamental knowledge of information technology, management and financial principals.

2. A/E/C Workshop

This paper reports on the discussion and ideas generated from a workshop held at the Georgia Institute of Technology, in which members of industry and academia met to discuss the need for an integrated curriculum, and the types of themes and courses which should be central to the development of the curriculum. A small number of experts from different sectors of the A/E/C industry, representing both the private and public sector, as well as academia, were invited to participate in the event. The workshop was organized in four parts: Part I centered on defining integration; Part II focused on factors driving and preventing integration; Part III centered on the tools to enhance A/E/C Integration; and Part IV included a discussion on how universities can best respond to industry needs for A/E/C integration and the types of courses and issues that should be included in curricular study. A summary of each of those discussions follows.

2.1 Defining Integration

In the first part of the workshop, each member of the panel was asked to provide a definition of A/E/C integration. Definitions varied greatly depending on the professional background and perspective of the panelist. Panelists defined integration as a 'Team Approach' to project execution, in which each project requires collaboration and integration and all parties, such as owners, contractors, and subcontractors, are involved throughout the course of the project; this team approach is also reliant on open information sharing and relationship building, in which all decisions are made in the best interest of the project. Integration was also considered dependent on leadership and project/program management, in which individuals had core competencies for AEC project. Integration was also defined as being technology-based, with BIM and CAD seen as unifying technologies linking people and processes together. Integration was also seen as a necessity in the face of industry trends toward consolidation.

2.2 Factors Driving and Preventing Integration

In the A/E/C industry, there are factors both driving and preventing integration. Members of the workshop panel identified several driving factors, including: demands of the market which is forcing collaboration; global competition and pressure; increasingly complex projects which require the involvement of more trades and disciplines; and re-conceptualization of the meaning of 'value.' Owners' objectives, along with client demands and needs, have also expanded; both expect seamless delivery of a product, which is dependent on integrated work teams and integrated solutions. Litigation, along with industry consolidations, which have required the pooling together of limited resources and people, has also contributed to the need for enhanced integration. The availability of new technologies, particularly Building Information modeling (BIM), which allows for virtual collaboration and construction, was named as an important factor driving and facilitating integration among project teams.

Some of the factors preventing the industry from achieving integration, as identified by workshop participants, include a lack of trained personnel, as well as the attitudes of professionals who are entrenched in traditional mindsets and ideas of roles and responsibilities. A lack of unifying industry standards, as well as the lack of a singular software platform, has also prevented widespread industry integration.

Though technology was seen as a driving force, the fear of technology was also identified by participants as a factor preventing integration; the rapid introduction of new technologies, which are evolving faster than individuals and organizations can adapt, was also seen as a prohibitive factor. Participants also noted the dangers of over-relying on technology, as opposed to forming human relationships, and stated that the initial cost of bringing new technology on board were preventing true and seamless integration.

Interestingly, one of the factors preventing integration, as identified by the workshop participants, involved fragmentation of disciplines in the university setting. The separation of disciplines at the university level later leads to adversarial relationships within the different fields in the A/E/C industry, as discussed by participants. Institutional barriers that begin at the undergraduate level persist in the professional environment, particularly since there is no single professional or trade organization that represents the industry as a whole; instead silos are first formed, then maintained within the workforce.

2.3 Enhancing Integration

Panelists discussed the general tools that can be utilized to enhance integration in the third part of the workshop. Some of the items discussed included: innovations in procurement and project delivery systems; development of standardized processes; gathering industry feedback on their needs and concerns; and creating an educational environment in which integration is central to learning. Technology, namely BIM, 4D and CAD, was also seen as another tool to enhance integration; participants stated there was a need to improve existing software and to develop more partnerships between universities and industry to test and develop new platforms.

2.4 Skills Needed and the Roles of Universities

The fourth part included a discussion of the role of Georgia Tech, and other universities, in promoting A/E/C integration at the college level. According to the panelists, there are several core competencies which were critical for future graduates, including: financial and business skills; problem-solving skills; leadership training; technical expertise; and more exposure to the various disciplines. Panelists also discussed some of the specific ways Georgia Tech and other universities can move toward a more integrated curriculum, including: development of jointly-taught courses; joint lecture series with other colleges; open dialogue with other college on strategies for closer cooperation; and development of new degree programs. There was also discussion concerning the importance of involving the industry in the planning and development of an integrated curriculum, in an effort to ensure students are exposed to the latest trends and issues.

Panelists emphasized the need to remove silos between the disciplines, and to shift attitudes and teach respect and understanding of other disciplines. For example, there was a suggestion to require construction majors to take courses in design, and for architecture students to take courses in construction management. In Georgia Tech's College of Architecture, freshmen are automatically enrolled in the Common First Year (CFY), which is a group of three courses which all entering undergraduate students are required to take. CFY provides introduction to design and construction; students still have core competency in one discipline but are provided with the language and agility to move between disciplines. However, there is recognition that more must be done to integrate the disciplines at more advanced levels. There is also recognition that Engineering ("E") education and emphasis is significantly missing from dialogue concerning integration. Future initiatives on the part of the College of Architecture at Georgia

Tech are needed to begin a dialogue with representatives from the College of Engineering in order to develop a truly integrated curriculum.

3. Designing an Integrated Curriculum

Based on the discussions with members of industry and academia, recommendations emerged concerning the development of an integrated A/E/C curriculum at the undergraduate level. Integration is dependent upon both collaboration, or an extended understanding and empathy of value of various participants and stakeholders, as well as dependent upon language, in which there remains a need to create a common language which is understood by architects, builders and owners; software can be a form of language and communication. Thus, a curriculum centered on A/E/C integration provides a foundation in: 1) Culture; and 2) Technology. A description of each of these elements follows

3.1 An Integrated Curriculum: Culture

Culture refers to establishing a mindset based on teamwork, collaboration, and empathy for the differing roles and responsibilities of various stakeholders involved in the industry. An advanced knowledge of the processes and responsibilities of architects, engineers and builders will be essential in managing multi-disciplinary teams and complex projects. Having managers with the required technical skills plus expertise in business management, marketing, law, finance and accounting is a necessity within the integrated A/E/C workplace. Emphasis must also be placed on managing diverse educational, cultural and economic multi-disciplinary teams, particularly in an increasingly global workplace.

3.2 An Integrated Curriculum: Technology

Technology refers to the specific IT tools used in the A/E/C industry, such as Building Information Modeling (BIM). It also includes training in delivery systems, process management, telecommunications, shared work environments, and other innovations. However, rather than teaching a single technology or software, students should have hands-on experience with various emerging technologies. The intent is not to train them on a single system or process, that may become outdated, but to arm them with the critical thinking and analytical skills that can applied to various challenges they will encounter throughout their careers.

Education and training of innovative digital technology is the cornerstone of the AEC integration. An article by the Engineering News-Record (Post, 2008), describes digital design and construction technologies, such as Building Information Modeling (BIM)-enabled integrated project delivery, as the best chance for change in the A/E/C industry. Virtual collaboration allows hundreds of AEC members to work on various components. BIM is a very powerful asset for planners, architects, engineers, constructors, and facility managers. It allows both visual integration of information and virtual collaboration. Therefore, there is a direct relationship between levels of digital systems with AEC integration. Symeon Christodoulou (2004) likewise touts the importance of incorporating information technology into the curriculum; in his article on educating civil engineers, Christodoulou recommends an academic sequence, in which students take courses in civil engineering, project management and IT, as an effort to provide a more comprehensive education in "fully integrated and automated project processes" (p.91).

The current economic turmoil is another reason for application of digital technology for cost reduction. Such a system will reduce multiple data entry, reduce errors, enhance collaboration, and help ensure smart business decisions. It is a new business process and employees need training to make the process work. It allows for recreation of design and construction process and minimizes risk of project delivery. BIM is

more than just a 3-D design. It is an integrated process built on coordinated and reliable information about design, engineering, construction, and operation.

4. A/E/C Integration: A Holistic Education

Education in the AEC integration curriculum heavily depends on a holistic education. In this education system, each student finds identity, meaning, and purpose in life through connections of AEC to the community, to the natural world, and to spiritual values, such as compassion and peace. What distinguishes holistic AEC education from other forms of education are its goals, its attention to process integration, experiential learning, and the significance that it places on relationships and primary human values within the learning environment.

The concept of holistic education indicates that all the properties of AEC study cannot be determined or explained by the sum of its component parts. Instead, the system as a whole determines how its components (A, E, and C) behave. A holistic way of thinking tries to encompass and integrate multiple layers of architecture, engineering, and construction knowledge and experience rather than defining possibilities narrowly. Holistic education aims at helping students be the most that they can be. It seeks to engage students in the practical work process and encourages collective responsibility and relationships.

5. Conclusions

The discussion from the workshop yielded a number of recommendations regarding the development of an integrated A/E/C curriculum and the need for the development of both degree programs in integration and more partnering, training and collaboration among disciplines at undergraduate and graduate levels.

Although universities have contributed to the dichotomous separation among disciplines which persists in the private and public sector, they have the opportunity – and a responsibility – to reverse this trend and create an integrated environment in which students learn respect for and appreciation of other disciplines at the undergraduate levels. As discussed by members of both industry and academia, there is a need to establish a culture of collaboration from the onset.

Universities should teach students to view projects within the wider environment and provide them with a framework in which the interconnectedness of projects is seen as a way to foster and promote integration. There are several key recommendations on how to offer a more holistic education, including providing more inter-disciplinary research opportunities for students and seeking partnerships with multiple disciplines, as well as formal partnerships with industry. For example, participants suggested offering courses with semester-long activities that integrate the disciplines, such as construction management, urban planning, civil engineering, law, public policy, and architecture.

There is also a need to focus more on training students to be adaptable and flexible to better cope with changing industry, and to focus on teaching critical thinking skills as a way to promote integration. A framework for offering an integrated A/E/C curriculum, one centered on both "culture" and "technology", is a step toward providing students with the tools to lead the industry toward seamless integration. In short, this curriculum will produce professionals armed with the necessary skills to move the A/E/C industry forward.

6. Acknowledgments

7. References

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