

A Systematic Review of Research Papers on Construction Education and Research: 2000-2011

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Despite construction being a major contributor to the national economy of the United States, the discipline has received inadequate attention from researchers and scholars, except lately. Being a developing field, research endeavors in this field is constantly evolving. The paper reports the results of an eleven-year analysis of the IJCER technical papers. Based on content analysis of the technical papers published in IJCER from 2000 till 2011 utilizing the keywords as the recording units, this paper identified the major research topics of interest in this discipline. While the paper provided the scholars and practitioners a baseline understanding of the current research trend, it also highlighted the under-researched topics in this discipline.

Key Words: Qualitative research, Construction research, Construction education

Introduction

The construction industry plays a major role in the national economy of the United States (Abudayyah, et al., 2000), contributing in excess of $570 billion to the national gross domestic product (Census, 2011). In spite of supporting business of such magnitude, it is one of the least researched disciplines (Abudayyeh, et al., 2004). Traditionally construction is envisioned as a craft based discipline where "knowledge was gained by doing" (Oglesby, 1990), and consequently failed to attract adequate attention from the researchers and scholars. Recent shift toward higher education and research activities in construction has led to the exploration of new technologies, materials, and methods to improve the processes of construction, as well as improve construction education. However, being a developing field, research in construction is constantly evolving, and the best actions to take are constantly being challenged (Abudayyeh, et al., 2004).

The research efforts in construction cover a wide range of topics related to practice and education. The goal of this paper was to explore the trends of research in construction. With a base-line understanding of the research done so far, the researchers will be able to efficiently streamline their efforts to explore the less-investigated or novel topics. This paper has reviewed the research trends in construction practice and education by analyzing the scholarly papers published in the Associated Schools of Construction's International Journal of Construction Education and Research (IJCER) from 2000 to 2011. The IJCER, formerly known as Journal of Construction Education (IJCER replaced Journal of Construction Education in 2004 that was originally founded in 1996), is one of the premier publications in the field of construction, and has made significant contributions to construction practice and education. The journal was published thrice yearly from 2001 to 2004, when it became quarterly.

A content analysis method was adopted for the study to analyze the keywords of the individual publications to understand the trends in research. The goal of the paper was to report the trends from an unbiased perspective. The paper begins with a description of the content analysis approach followed by the data analysis results. From the analysis, the emerging trends were identified and finally the conclusions are stated.

Research Method

Content analysis was adopted in this paper for data analysis. "Content analysis came to prominence in the social sciences at the start of the twentieth century, in a series of quantitative analyses of newspapers, primarily in the United States" (Robson, 2002). Content analysis, a common approach to documentary analysis, is a method for making replicable and valid inferences from data to their context. It helps to examine large volumes of data and categorize them in a more methodological and systematic manner (Robson, 2002). According to Robson (2002) a content analysis can be developed through the following six steps: (1) start with a research question, (2) decide on a sampling strategy, (3) define the recording unit, (4) construct categories for analysis, (5) test the code on samples of text and assess reliability, and (6) carry out the analysis.

The question identified for this analysis: "What are the major topics of interest for the construction researchers and practitioners?" served as a starting point for the analysis presented in this paper. For this analysis, the sample consisted of all the publications of IJCER (for simplicity both IJCER and Journal of Construction Education are referred as IJCER in this paper) from 2000 to 2011, since they represent the construction research during the current century. The scope of the journal as stated in their website (http://www.ascjournal.ascweb.org/purpose.html) signifies that a wide range of technical papers are published in the journal, and it represents the state of the art of research pertinent to construction and practice.

Robson (2002) suggested the use of individual words as the simplest version of recording unit. He also stated that themes, characters, paragraphs and even whole items could be considered as recording unit as well. However, in context of this analysis the keywords provided by the authors of the technical papers were utilized as the recording units. In other words, the content analysis method was applied to the keywords. In doing so, it was assumed that the study of the keywords would provide sufficient perspective to the research trends. However, this method could not eliminate the biases of the authors of the respective technical papers in selecting the keywords. At the same time, it was recognized that the authors had the liberty to select as few (as three) and as many (as many as 10) keywords and this impacted the outcome of the keyword analysis.

Categories of analysis in content analysis, according to Robson (2002) can be as varied as subject matter, goals, methods, etc. In the context of this paper, subject matter of the technical papers was considered as the category of analysis. The objective was to analyze the keywords mentioned in the technical paper to develop an understanding about the research trend pertaining to construction practice and education. All the keywords from the technical papers were first identified and their frequencies determined in order to create categories based on clusters of keywords. The categories were named based on the selected common root word or the more commonly used keyword.

The next step of content analysis as suggested by Robson (2002) involves testing the codes on samples of texts. As the keywords were put forward by the authors of the individual papers, they were considered representative of the contents of the respective papers. Once all the keywords were identified and listed, the words with similar meanings were clustered to create the categories. These categories provided an insight about research trend in construction practice and education. While analyzing the keywords, occasionally the abstracts of the technical papers were referred to confirm the categorization of the keywords.

Findings

There were a total of 167 technical papers published, of which 50 (30%) were written by single authors, and the rest 117 were written by multiple authors. Out of the 117 technical papers, only one was written by five authors. Majority of the authors were affiliated with higher education institutions, with only 14 affiliated to industry. The abstracts and keywords of all the 167 technical papers published in IJCER from 2000 till 2011 were analyzed. A total of 728 keywords were identified, averaging 4.33 keywords per paper. As mentioned previously, the keywords were clustered under major categories based on their root meanings. The frequencies of the individual categories were computed as shown in Table 1. The category of 'Construction Education' had the highest frequency consistently throughout the period selected for the analysis. This was probably due to the focus of IJCER on construction education. On the other hand, papers related to 'Technological Improvements' appeared more frequently lately, reflecting the recent trend of the industry.

Table 1

Frequency of keyword categories in IJCER technical papers from 2000-2011

Year	Construction Education	Construction Processes	Management Aspects	Asphalt & Transportation	Technological Improvements	Construction Cost	Contracting & Delivery	Occupational Safety	Risk Management	Productivity	Research Methods	TOTAL
	N (%)	**N (%)**	**N (%)**	**N (%)**	**N (%)**	**N (%)**	**N (%)**	**N (%)**	**N (%)**	**N (%)**	**N (%)**	**N (%)**
2000	60 (59)	18 (18)	7 (7)	-	2 (2)	1 (1)	4 (4)	2 (2)	4 (4)	3 (3)	-	**101 (14)**
2001	25 (36)	18 (26)	8 (12)	-	6 (9)	-	1 (1)	1 (1)	4 (6)	6 (9)	-	**69 (9)**
2002	20 (42)	4 (8)	2 (4)	9 (19)	6 (13)	-	2 (4)	-	3 (6)	-	2 (4)	**48 (7)**
2003	33 (75)	-	6 (14)	-	-	4 (9)	0	1 (2)	-	-	-	**44 (6)**
2004/05	7 (18)	10 (25)	5 (13)	-	5 (13)	8 (20)	5 (13)	-	-	-	-	**40 (5)**
2006	20 (33)	15 (25)	5 (8)	-	-	-	-	10 (16)	11 (18)	-	-	**61 (8)**
2007	10 (18)	10 (18)	6 (11)	9 (16)	2 (4)	-	5 (9)	5 (9)	3 (5)	5 (9)	2 (4)	**57 (8)**
2008	24 (37)	21 (32)	6 (9)	4 (6)	-	-	-	8 (12)		1 (2)	1 (2)	**65 (9)**
2009	10 (13)	30 (39)	3 (4)	5 (7)	7 (9)	7 (9)	8 (11)	2 (3)	4 (5)	-	-	**76 (10)**
2010	22 (25)	15 (17)	10 (11)	18 (21)	4 (5)	4 (5)	9 (10)	4 (5)	1 (1)	-	-	**87 (12)**
2011	19 (24)	19 (24)	10 (13)	-	10 (13)	15 (19)	2 (3)	-	2 (3)	-	3 (4)	**80 (11)**
TOTAL	**250 (34)**	**160 (22)**	**68 (9)**	**45 (6)**	**42 (6)**	**39 (5)**	**36 (5)**	**33 (5)**	**32 (4)**	**15 (2)**	**8 (1)**	**728 (100)**

Construction Education - 34%

This category contains a wide variety of keywords related to curriculum development, pedagogical approach, distance learning, and various other facets of education in the construction programs. Considering the focus of IJCER's predecessor on education, the high frequency of keywords belonging to the education cluster is understandable. The higher frequency indicates the importance of construction education as perceived by the scholars and practitioners belonging to the construction industry.

Technical papers related to construction education published in the early part of the 21st century focused on a wide variety of topics. The papers published in the early part of the 21st century focused on the evaluation and assessment processes of the construction programs (Al-Khafaji and Seckler, 2000, Auchey, et al., 2000) as well as the faculties (Al-Khafaji and Rebholz, 2000, Senior, 2000). Scholars also looked into the faculty development processes (Ciesielski, 2000) and the pedagogical aspects of preparing class websites (Ryan, 2000) and motivating students'

performance (Hall, 2000). With time, the focus of the scholars shifted towards distance learning in construction with the assistance of latest technologies (Aziz, et al., 2010, Ellingson, 2002, Holley, 2006, Ryan, 2008, Sawhney, et al., 2001) curriculum development (Adcox, 2003, Senior and Hauck, 2001, Tinker and Burt, 2004-2005) and assessment of various pedagogical styles (Berryman, et al., 2004-2005, Choudhury, 2002, Gunderson and Moore, 2008, O'Brien, et al., 2003). The transformation of the construction industry from a craft based industry to more technically sound was reflected in the growing emphasis on research on several occasions (Amaratunga and Senaratne, 2009, Hartman et al., 2010) as well as exploration of the need for higher education in construction (Gunderson, et al., 2002, Pace and Danali, 2002). A general trend of lesser number of technical papers pertaining to education was noticed since 2004.

Construction Processes – 22%

This category contains the smaller clusters of construction processes, construction equipment and materials, and sustainability. All these small clusters have been included within the bigger cluster of construction processes as they are the integral part of the construction industry. The technical papers related to the construction processes looked into various aspects of residential construction (Hutchings and Christofferson, 2004-2005, Nguyen, et al., 2008) dealing with the pertinent issue of shortage of craft laborers (Kashiwagi and Massner, 2004-2005). An equally pertinent topic of construction equipment, which is one of the largest investments for a company, was evidently not investigated much, as apparent from fewer technical papers published in the IJCER. In the study by Clapp et al. (Clapp, et al., 2007), they conducted a survey among the members of Associated General Contractors of America and various concrete pavement trade associations to analyze the equipment acquisition process.

Technical papers pertaining to concrete have appeared sparingly, primarily focused on improving performance by altering the constituents. For example, Berryman et al. (2006) found that increasing the content of fly ash in concrete for reinforced concrete pipe, did not deter the performance of the concrete pipes under standard testing procedures. Another study by Muszynski and Gulas (2001) cited the fire resistance capability of insulating concrete forms.

Unlike construction equipment, sustainability has been a topic of much interest among the scholars in the recent past. As estimated by the American Institute of Architects (2007), nearly 50% of all the greenhouse gas emissions are generated by buildings and their construction in terms of the energy used during the production of materials, transportation of materials from production factories to construction sites, as well as energy consumed during the operational stage. Thus, it is easily understandable that building construction significantly contributes towards energy use, carbon emission and waste generation. The scholars responded to the growing interest on sustainability by investigating different topics starting from indoor air quality (Hepner and Boser, 2006) to implementation of BIM for sustainability analysis (Azhar and Brown, 2009). IJCER technical papers have also investigated the carbon emission during transportation of building materials (Palaniappan, et al., 2009), compared different sustainability rating systems (Reposa, 2009), and how to reduce potable water usage (Glick and Guggemos, 2011). Environmental impacts of transportation project (El-Gafy, et al., 2010) as well as warm mix asphalt (Hassan, 2010) using life cycle analysis has also been investigated.

Management Aspects – 9%

This category includes the keywords related to management practices as well as team building, and leadership skills. Since management practices are at the heart of any construction projects, IJCER technical papers have investigated the suitability of different management practices with a predominant focus on the residential construction companies. In two separate surveys conducted by Hutchings and Christofferson among the residential contractors, they found that most of the home builders focused on systems to improve office management and customer relationship (Hutchings and Christofferson, 2004), and rated quality workmanship, honesty, customer communication indispensable for company success (Hutchings and Christofferson, 2005). Another study identified few management practices such as written business plans and formal start-up training for employees to be important predictors of success for small volume residential contractors (Hutchings and Eggett, 2006).

Successful management practices entail quality leadership characteristics among the personnel and effective team building. Technical papers published in IJCER covered a wide array of pertinent topics related to team building (Achor and Achor, 2000) highlighting the importance of cross cultural training (Choudhury, 2001) due to the

increasing internationalizing of the construction industry. Badger et al. (2009) discussed a participatory technique of profiling leadership styles of students by the use of a 52-action-card-game. In a follow up study by Badger et al. (2010), the scholars addressed the leadership transition needs among the project managers with a second set of action card game. The overarching question whether leadership characteristics could predict team performance was investigated by Sumner and Slattery (2010), and in a subsequent study Slattery and Sumner (2011) extended an unique finding that tangible leadership skills such as enabling others to act and challenging the status quo were highly valued than soft skills such as encouraging and inspiring subordinates.

Asphalt and Transportation – 6%

Based on the trends of the technical papers published, IJCER has primarily been a platform to present work related to construction education and building construction. The discipline of infrastructure and heavy civil has not featured prominently among the technical papers. The scholars have looked into few aspects related to asphalt pavement such as life cycle economic performance of hot mix asphalt pavement (Shuler, et al., 2010), using coarse aggregate asphalt mix interlayer to control reflective cracking in asphalt pavement (Chen and Jiang, 2008), and determine probable causes responsible for edge cracking of asphalt pavement in residential subdivisions (Shuler and Nobe, 2007).

Technological Improvement – 6%

This category encompasses the keywords related to technology, modeling and simulation. Historically the construction industry has been fragmented in nature exhibiting poor interoperability. With a declining productivity, construction industry is perceived as arcane, complex, paper based, and inflexible. To increase the accuracy, productivity, and interconnectivity of the industry, it is of utmost importance to bring in new technological improvement. Over the years, technical papers published in IJCER have investigated various technological advancements that have been/ could have been embraced by the construction industry for better performance. For example, studies looked into the impact of new surveying instruments (Arumala, 2000), database technology (Duvel and Schmidt, 2002), voice recognition (Williams, 2001), and how these technologies could be embedded in the construction curriculum to educate the future professionals. Use of radio frequency identification tags for tracking tools in the job site (Goedert, et al., 2009), as well as to assist in document management (Shehab, et al., 2009) have been explored by the scholars. In addition, a prominent use of technology to assist in the bidding process was also noticed (Du and El-Gafy, 2011, Lenin, 2011).

Alongside the technological advancements, the construction industry has embraced the use of modeling and simulation lately (Fuller and Davis, 2003, Nassar, 2002). The technical papers demonstrated that building information modeling (BIM), perceived as the future of the construction industry is being utilized by the industry for various purposes, such as virtual safety training (Fuller and Davis, 2003) and sustainability analysis (Azhar and Brown, 2009). Being a new tool, the adoption of BIM has not been equally adopted by the entire construction industry giving rise to varying level of expertise. Ku and Taibet (2011) summarized the experience and expectations of the construction companies in regards to BIM by conducting a survey among the companies listed in Engineering News Record's top contractors' list.

Construction Cost – 5%

This category contains the larger cluster of estimating and construction economics. Published papers related to estimation have tried to bridge the gap between industry and education. Published papers have investigated method for teaching estimation and specifications that emphasized the parallel usage of drawings and specifications to extract project information for estimating and bidding (Mcfarland, 2010). On a similar note, Jackson (2004-2005) assessed the extent to which estimation was taught as a part of design-build project delivery. As mentioned previously, published papers demonstrated a prominent trend of using technology to assist in the bidding process (Du and El-Gafy, 2011, Lenin, 2011).

The technical papers related to construction economics explored the best practices for dealing with price volatility in commercial construction (Weidman, et al., 2011), compared economic development for four most competitive economics in the world, and effect of prevailing wage structure on construction efficiency (Duncan, et al., 2009).

Contracting and Delivery – 5%

This category contains the smaller clusters of project delivery and contracting strategies. Different delivery methods have been the point of discussion for long in the construction industry and considerable attention has been directed at ways to make the traditional delivery method more efficient and cost effective. While the preferred delivery method used in the construction industry has been Design-Bid-Build, Design-Build and Construction Management at Risk has also become popular among the owners due to their capability of sharing the burden of risks. In addition, the last two methods also facilitate collaboration among the project participants much earlier in respect to the project timeline. Similar point of view has been expressed by the different technical papers published in IJCER, where the scholars have suggested the need to integrate Design-Build project delivery in the course curricula. In a survey conducted by Jackson (2004-2005) it was found out that a majority of the Associated Schools of Construction (ASC) member universities taught components of Design-Build project delivery at some level in their undergraduate curricula. Scholars have also suggested educating the students about Design-Build via internet class (Batie and Connell, 2000) and interdisciplinary studio environment (Geva, 2001). While the public transportation projects have been more inclined towards the traditional Design-Bid-Build delivery method, in the last two decades Design-Build and Construction Management at Risk, and Job Order Contracting have been utilized. Among the alternative methods, Design Build was found to be the most popular based on quality, cost, and timeliness (Rizk, et al., 2007). Other technical papers pertinent to this area highlighted the common practices in the project delivery methods adopted by foreign automobile companies setting up plants in the US (Ahn, et al., 2009), role of architects in the evolving environment of integrated design and construction model (Burr and Jones, 2010), and similarly the ability of the contractors to work in the interdisciplinary teams (Sumner and Slattery, 2010).

In comparison to delivery methods, technical papers focusing on the contracting strategies are very few in numbers and lack a central theme. One of the technical papers summarized the legal theories that could come into play when the owners had made changes to the extent of "destruction of the contract" (White, 2006). These changes come with new liabilities for the project stakeholders, and revised payment structure.

Occupational Safety and Health Hazards – 5%

Improving safety in construction remains a priority in almost every country around the world, because the construction industry stands out among all other industries as the main contributor to severe and fatal accidents. The scholars have offered number of solutions and visions to relieve this chronic problem as evident from the technical papers published in IJCER. Scholars have put forward suggestions for utilizing the principles of Total Quality Management to develop a model safety plan that could be adopted by any construction companies (Shahbodaghlou and Haven, 2000) or training the workers on occupational safety with the aid of the latest available technologies (Fuller and Davis, 2003) or reducing postural instability from working on sloped roofs (Choi, 2008). Technical papers have also looked into different temporary lighting systems being employed commonly in the construction work sites and compared them with the minimum standards set by OSHA (Smith, 2008). With the ageing work force, the US construction industry is experiencing a growing population of Hispanic workers who are sometimes faced with communication challenges. Construction being a dynamic industry with interdependent tasks, gap in communications can cause havoc in terms of safety and health hazards. In response to this concern, McConnell's (2006) study concluded that there was no significant relationship with occupational injuries and English proficiency of the workers. The construction industry have been proactive in eliminating the communication barriers among the Hispanic workers by implementing hands-on training, English as a second language courses, appointing bilingual trainers, vocabulary cards, and arranging social gatherings (Lavy, et al., 2010). Improving current safety situation, as always has been a major focus of the construction industry, and that has to be instilled in the future professionals as well. Ciesielski (2006) conducted a longitudinal study and found that number of students receiving OSHA cards in the higher education institutions had increased, and the programs had incorporated safety adequately in their curricula.

Risk Management – 4%

This category includes two other smaller clusters namely construction risks and legal issues related to construction projects. Poor performance of construction projects in terms of cost, time, and safety can be attributable to

unforeseen events. Although uncertainty is an inherent feature of the construction industry due to the very nature of the tasks and their interdependence and complexities, risk management has not been adequately practiced (Panthi, et al., 2009). Lack of risk management in the industry is reflected in the dearth of technical papers being published in this area. The handful of papers related to risk management investigated methodology to incorporate risk management in order to allocate contingency funds (Panthi, et al., 2009), explored risk management arising due to unexpected foreign exchange fluctuations (Ahn and Holley, 2009), and risk related to capital equipment acquisition (Clapp, et al., 2007). As a natural corollary of the uncertainties involved and the interdependence of the construction tasks, legal mediation is often required to settle contending stakeholders. However, the dearth of technical paper in this area did not support the perceived importance of the topic. Two technical papers were located pertaining to legal issues such as inadequate capitalization of construction firms (Jensen and Adcox, 2001), and enforceability of liquidated damage clause by the United States court system.

Productivity – 2%

The US construction industry has demonstrated decline in productivity per human hour invested over the past forty years, when other engineering fields have dramatically increased their productivity during the same time. Thus it was expected that the scholars would have been exploring this topic with much vigor to identify methods to improve productivity. In the contrary, scant number of papers has been published in IJCER that looked into the topic of productivity. A study by Choi (Choi, 2007) explored potential areas for productivity improvement in roofing construction, and claimed that better planning, scheduling, and communication were instrumental in improving productivity. In a similar study focused on highway construction, Jiang and Wu (Jiang and Wu, 2007) conducted statistical analysis and found that highway construction production rates were affected by weather conditions, location, types of project, and contractors.

Conclusions

The study started with the goal of exploring the research trends in construction practice and education. The goal was accomplished by analyzing the technical papers published in IJCER, one of the prominent platforms to showcase scholarly works related in the field of construction. All the technical papers published in IJCER from 2000 till 2011 were considered for this study, and content analysis was used as the preferred method of data analysis. Using the keywords provided by the authors as the recording units, the following categories were formed containing keywords with similar meaning (see Figure 1). The varying frequencies of the categories over the years depicted the changing focus of the construction industry to address current needs.

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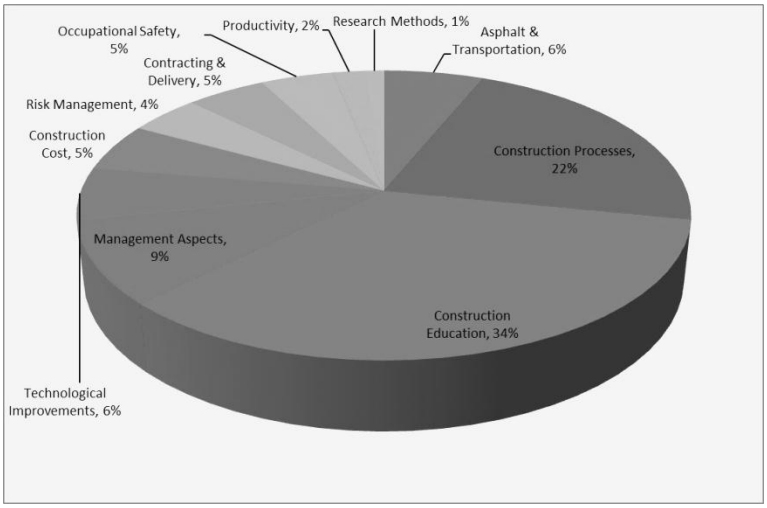

Figure 1: Keyword categories and their % contributions to IJCER keywords from 2000-2011

Subsequent to computing the frequencies of each of the keyword categories, relevant papers were identified in order to support the discussions. The keyword categories identified in this paper are believed to represent the major research topics of interest in the field of construction practice and education. The findings presented in this paper will provide the scholars in the field of construction with a baseline understanding of the trend in research, and help explore areas that were under-represented. While identifying the under-represented topics was a logical step to perform after the analysis and discussion, the space constraints did not allow the authors to include that within the scope of this paper.

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