

Leveraging Mobile Applications to Promote ACCE Student Learning Outcomes

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Mobile technology usage is proliferating in the construction industry, yet to date, little research has been published regarding its usage in the construction management curriculum. The construction industry is also inherently mobile and in order to prepare the incoming workforce, exposure to mobile technologies should be a part of the curriculum. Taking this into consideration, the underlying purpose for this research study was to create a connectedness between student learning outcomes and the need to fortify their learning experiences with mobile technology. Hence, in this research study, mobile applications were reviewed for functionality and cross tabulated with the twenty American Council for Construction Education (ACCE) student learning outcomes in order to support the purpose of this research. The results of the analysis indicated vast opportunities to utilize mobile applications within the construction management classroom, especially in the areas of field operations, project management, and virtual design and construction. Moreover, the analysis highlighted opportunities to utilize mobile applications across multiple courses and encourage collaborative exercises. Future research into mobile technology usage across accredited construction management programs is suggested along with further development of course activities where mobile technologies are utilized to promote specific course learning outcomes.

Key Words: Mobile technology, Construction education, Active learning

Introduction

Changes within the construction industry, such as the introduction of sustainability standards, increased safety protocols, and the use of building information modeling (and other technologies) present environments where creative thinking and resourceful problem solving differentiate firms with increased competitive advantage and enhanced project success. Collegiate construction management programs should meet the industry's charge by fostering critical thinking and creative problem solving throughout the curriculum. Unfortunately, construction programs in the United States are somewhat structurally challenged to meet this obligation and are not well suited to teach students of the 21st century (Peterson, 2010, Cardullo, 2015). Students need learning environments that foster active learning above traditional passive learning models in order to achieve higher order learning and a deeper understanding of the course outcomes.

The usage of mobile technologies, such as ultra-portable laptops, tablet devices, and smart phones in higher education settings have been shown to provide greater benefits to students (Evans and Johri, 2008). Mobile devices and their associated applications (apps) have enormous potential due to their increasing popularity and their widespread use among students (Yang et al., 2015). For example, courses taught in Engaged Active Student Learning (EASL) spaces can be designed with the incorporation of mobile devices (and relevant apps) as active learning tools (Cardullo, 2015). A key differentiator of the EASL classroom is the encouraged use of mobile devices, which have perennially been viewed as distractions in the classroom. Students are encouraged to take ownership of their own learning with all the available technologies, while the instructor becomes a facilitator to the learning activities, as opposed to the sole proprietor of information (Cardullo, 2015). Students gain knowledge through the completion of collaborative "micro learning" activities (Echeverria et al., 2011, Yang et al., 2015) where app capabilities are described by the instructor then utilized by the students to complete a task associated with a course learning objective.

Opfer (1993) posits that the construction industry is a mobile environment, where most participants are not confined to a single location, as is the case for the manufacturing industry. The construction site is *dynamic* and not *static*, and mobile technologies offers an opportunity to support the construction industry (Opfer, 1993). Therefore, addressing the need to educate students in ways more befitting of the 21st century that aligns with the needs of the construction industry's usage of mobile technologies is paramount. To date, limited research has been completed that addresses how construction management programs accredited by the American Council for Construction Education (ACCE) leverage mobile technology to facilitate meeting student learning outcomes (SLOs). The balance of this paper describes the author's initial review of pertinent construction-related apps, specifically their functional characteristics, and how these functional characteristics align with the twenty ACCE SLOs. The methodology of how the app functional characteristics were categorized is described, along with a methodology for how the app characteristics were aligned with the ACCE SLOs. Limitations of the research are described, along with future research opportunities.

Research Objective and Methodology

The main objective of this study was to determine what currently available mobile applications (apps) could be utilized to promote ACCE SLOs. The methodology for this research included three sequential steps:

1. Condense the twenty ACCE SLOs into categorically unique core areas of construction management education
2. Functionality review of pertinent apps
3. Categorization of relevant apps into core areas of construction management education along with a cross tabulation of those categories with ACCE SLOs

Research Findings

Step 1. Condense the twenty ACCE SLOs into categorically unique core areas of construction management education

The authors developed a core area matrix of the primary components of construction management education based on a review and abridgment of the twenty ACCE SLOs. Considering that multiple ACCE SLOs could be matched to a single course, the authors concluded that identifying the connectedness between apps and course learning objectives would be more understandable if they were associated with commonly defined core areas in construction management education. In addition, the naming convention for these core areas are useful search terms for gathering the list of relevant apps for this research study. Eight core areas of construction management (CACM) were identified and are defined in Table 1.

Table 1. *Core Areas of Construction Management (CACM) education*

Core Area (Abbreviation)	Definition
Plan Management (PLAN)	The management of the construction plans, specifications, addenda and supplemental instructions, inclusive of managing versioning, distribution and changes to these documents. Distribution may include early subcontractor solicitations for pricing as well as plan distribution during construction activities.
Field Operations (FLD OP)	Management and tracking of daily record keeping of construction related activities. Tracking may include journaling of events, recording of quantities and work-in-place, photography, documenting visitors and special events and the tracking of construction equipment and tools.
Accounting (ACT)	Recording, processing and reporting of all financial aspects of a construction project, often including time tracking, invoice approvals, payment application processing and requests for payment.
Safety (SAFE)	Detection, management and reporting of issues, conditions and activities that affect the well-being of individuals and property on a construction project.
Virtual Design and Construction (VDC)	Planning and management of the design and constructability of a construction project, often employing the use of a 3D building information model (BIM). May also include a visual schedule (i.e., 4D BIM) along with construction estimated costs (i.e., 5D BIM) assigned to the elements contained within the BIM.
Project Management (PM)	Management of the various facets of the building process, with the intent of reducing risk. Some facets include processes that manage submittals, requests for information, approvals for changes, punch list, close-out, coordination issues and general project documentation/reporting.
Scheduling (SCHED)	The management, reporting and updating of work tasks required to complete a construction project.
Estimating (EST)	A system to manage, prepare and forecast the anticipated construction cost for a construction project based upon a quantity survey (i.e., quantity takeoff).

The authors cross tabulated each of the 20 ACCE SLOs with the CACM, the results of which are shown in Table 2. To summarize, 13 of the SLOs categorized to *Plan Management*, eight of the SLOs categorized to *Field Operations*, four of the SLOs categorized *to Accounting*, seven of the SLOs categorized to *Safety*, seven of the SLOs categorized to *VDC*, 10 of the SLOs categorized to *Project Management*, seven of the SLOs categorized to *Scheduling*, and eight of the SLOs categorized to *Estimating*. It should be noted that five of the twenty SLOs (2) Create oral presentations appropriate to the construction discipline, (6) Analyze professional decisions based on ethical principles, (12) Understand different methods of project delivery and the roles and responsibilities of all constituencies involved in the design and construction process, (13) Understand construction risk management, (17) Understand the legal implications of contract, common, and regulatory law to manage a construction project did not categorize with any of the CACM used in this research.

Table 2. *Crosstab of ACCE SLOs with CACM*

	PLAN	FLD OP	ACC	SAFE	VDC	PM	SCHED	EST
SLO 1	✓	✓	✓	✓		✓	✓	✓
SLO 2								
SLO 3	✓			✓				
SLO 4	✓				✓	✓		✓
SLO 5	✓	✓			✓	✓	✓	
SLO 6								
SLO 7	✓	✓		✓	✓	✓	✓	✓
SLO 8	✓	✓		✓		✓	✓	✓
SLO 9	✓							
SLO 10	✓	✓	✓	✓	✓	✓	✓	✓
SLO 11	✓	✓						
SLO 12								
SLO 13								
SLO 14			✓			✓		✓
SLO 15	✓	✓				✓		
SLO 16	✓	✓	✓	✓	✓	✓	✓	✓
SLO 17								
SLO 18	✓							
SLO 19	✓				✓			
SLO 20	✓	✓		✓	✓	✓	✓	✓
Totals	**14**	**9**	**4**	**7**	**7**	**10**	**7**	**8**

Note: Full listing of ACCE SLO descriptions is provided in Appendix A.

Step 2. Functionality review of pertinent apps

In February 2017, the authors used the keyword search feature in Apple's App Store to populate a listing of mobile apps using each of the CACM (Table 1) as search terms. The initial results of this search provided over 200 results. The authors determined additional app features should be used to limit the search results, which included (1) apps must have been updated to work with the latest version of the Apple operating system, (2) the app was not "new" to the market to ensure viability of the app (meaning released for the first time after January 2017), and (3) the apps were coded to either the "business" or "productivity" category in the App store to ensure appropriateness of the app's functionality (i.e., construction-related games would not be pertinent.). Forty-one apps were found to meet all search criteria, hence were satisfactory for functional analysis and categorization.

Step 3. Categorization of relevant apps into core areas of construction management along with cross tabulation of those categories with ACCE SLOs

Each of the 41 pertinent apps were downloaded to a departmental iPad. The authors individually reviewed the functionality of each app, and categorized each app's functionality based on the CACM. The authors found (based on functional categorizations): 19 apps aligned with core area 1. *Plan Management*, 31 apps aligned with core area 2. *Field Operations*, 13 apps aligned with core area 3. *Accounting*, 12 apps aligned with core area 5. *VDC*, 12 apps aligned with core area 6. *Project Management*, 11 apps aligned with core area 7. *Scheduling*, and 10 apps aligned with core area 8. *Estimating*. It should be noted that 37 of the 41 apps have functionality to address more than one of the core construction management education areas. Only four of the 41 apps addressed a single core area of construction management education. Each of the 41 apps were cross tabbed with the eight core areas of construction, and each of the 20 ACCE SLOs. A portion of the cross tabbing is shown in Table 3. The full cross tabbing results are provided in Appendix B.

Table 3. *Partial results of cross tabbing apps and core areas of construction management education/ACCE SLOs*

		PLAN	FLD OP	ACC	SAFE	VDC	PM	SCHED	EST
1	AutoCAD 360™	✓	✓			✓	✓		✓
2	A360™	✓				✓			
3	BIM 360 Docs™	✓	✓			✓	✓		
4	BIM 360 Field™	✓	✓		✓	✓	✓	✓	
5	BIM 360 Glue™	✓	✓			✓			
6	BIM 360 Layout™	✓	✓			✓			
7	BIM 360 Plan™	✓	✓			✓	✓	✓	
8	BIMx™	✓				✓			
9	Bluebeam Revu™	✓	✓			✓	✓		✓
10	Bluebeam Vu™	✓	✓				✓		✓

Discussion of Research Findings

The results of the SLO categorization based on the core areas of construction management education (Table 2) show the SLOs moderately and evenly span across all eight of the CACM, however, there is greater concentration on the areas of plan management, project management, and field operations, with the highest numbers of SLOs covering these three core areas (14, 10, and 9, respectively.) These results align with the overarching intent of mobile technology utilization, where those individuals working outside of the traditional office setting (i.e., in the field) can leverage technology to enhance their daily work tasks by using mobile devices.

The results of the cross tabbing of available apps with the CACM (Table 3, Appendix B) show there is vast opportunity for using mobile devices to promote the ACCE SLOs in construction management curricula, specifically in the areas of field operations and project management. 76 percent (31 of the 41) of the apps reviewed as part of this study were found to have functionality that aligns with field operations, and 54 percent (22 of 41) apps were found to have functionality that aligns with project management tasks. Specific course exercises in courses where field operations and project management are a focal point, could be developed, where specific course learning outcomes (that inherently align with ACCE SLOs) would be promoted through the usage of apps identified in this research. Moreover, students could gain hands-on exposure to specific tasks, such as document coordination, that are critical to project success, and an essential part of the daily work activities of field personnel and project managers. This active and hands-on exposure can help prepare students for internship and full-time employment.

The results shown in Table 3 and Appendix B also highlight the opportunity for mobile applications to be used across courses in construction curricula. For example, courses may be included in an overall undergraduate or graduate curriculum to address VDC and field operations or project management separately. As shown, several apps, such as those included in the suite of tools available from Autodesk provide functionality across these core areas. The same app can be used simultaneously in different courses with distinct exercises to facilitate the teaching of the separate student learning outcomes. The cross-course use provides advantages to instructors regarding the student's mobile learning potential and may foster collaboration between courses or among students at different levels within a program.

Conclusions and Future Research

Incorporation of more active learning-focused exercises and course designs, such as those that are positioned around mobile technologies, greatly enhance student learning potential. The use of mobile devices and their associated apps, can greatly promote the achievement of specific SLOs. Hence, the opportunities to utilize mobile devices in construction management curriculum are vast, as little incorporation of such technologies has occurred to date. Furthermore, this research study serves as a platform from which to begin examining specific apps and how effectively they can be assimilated into construction management courses.

The methodology and results described in this document provide the initial steps to developing course exercises centered on the use of mobile technologies in the construction management curricula. Future research into the use of mobile technologies should be focused on two separate areas: (1) opening of a dialogue between ACCE-accredited construction management programs to discern how mobile technologies are currently being utilized, and what the current impediments are (e.g., cost, capabilities, past results) to incorporating mobile technologies, and (2) development (and testing) of course activities where mobile technologies are utilized to meet specific course learning outcomes and ACCE SLOs. This research study was limited to apps that were available at the time of this survey on the Apple's App Store. There are other outlets available that provide app capability for mobile devices not a part of the Apple domain. For instance, Google and Microsoft have competing marketplaces and their inventory too should be examined in future iterations of this research.

References

Cardullo, V. M., Wilson, N. S., & Zygouris-Coe, V. (2015). Enhanced student engagement through active learning and emerging technologies. Handbook of Research on Educational Technology Integration and Active Learning, 1–18.

Echeverria, A., Nussbaum, M., Calderón, J., Bravo, C., Infante, C., and Vásquez, A. (2011). Face-to-face collaborative learning supported by mobile phones. Interactive Learning, 19 (4).

Evans, M., and Johri, A. (2008). Facilitating guided participation through mobile technologies: designing creative learning environments for self and others. Journal of Computing in Higher Education, 20 (2), 92-105.

Opfer, N. D. (1993). Mobile Computing in the Construction Industry. In ASC Proceedings of the 29th Annual Conference.

Peterson, P. E. (2010). Saving schools: From Horace Mann to virtual learning. Harvard University Press.

Yang, X., Li, X., & Lu, T. (2015). Using mobile phones in college classroom settings: Effects of presentation mode and interest on concentration and achievement. Computers and Education, 88, 292–302.

Appendix A

Listing of ACCE SLOs

1. Create written communications appropriate to the construction discipline.
2. Create oral presentations appropriate to the construction discipline.
3. Create a construction project safety plan.
4. Create construction project cost estimates.
5. Create construction project schedules.
6. Analyze professional decisions based on ethical principles.
7. Analyze construction documents for planning and management of construction processes.
8. Analyze methods, materials, and equipment used to construct projects.
9. Apply construction management skills as a member of a multidisciplinary team.
10. Apply electronic-based technology to manage the construction process.
11. Apply basic surveying techniques for construction layout and control.
12. Understand different methods of project delivery and the roles and responsibilities of all constituencies involved in the design and construction process.
13. Understand construction risk management.
14. Understand construction accounting and cost control.
15. Understand construction quality assurance and control.
16. Understand construction project control processes.
17. Understand the legal implications of contract, common, and regulatory law to manage a construction project.
18. Understand the basic principles of sustainable construction.
19. Understand the basic principles of structural behavior.
20. Understand the basic principles of mechanical, electrical and piping systems.

Appendix B

Cross tabbing of apps with core construction management education areas – complete list

		PLAN	FLD OP	ACC	SAFE	VDC	PM	SCHED	EST
1	AutoCAD 360™	✓	✓			✓	✓		✓
2	A360™	✓				✓			
3	BIM 360 Docs™	✓	✓			✓	✓		
4	BIM 360 Field™	✓	✓		✓	✓	✓	✓	
5	BIM 360 Glue™	✓	✓			✓			
6	BIM 360 Layout™	✓	✓			✓			
7	BIM 360 Plan™	✓	✓			✓	✓	✓	
8	BIMx™	✓				✓			
9	Bluebeam Revu™	✓	✓			✓	✓		✓
10	Bluebeam Vu™	✓	✓				✓		✓
11	Buildertrend™	✓	✓	✓			✓	✓	✓
12	BusyBusy Time™		✓	✓					
13	BusyBusy Equipment™		✓	✓			✓		✓
14	CCS Safety (HSE) ™				✓				
15	CoConstruct™	✓	✓	✓			✓	✓	✓
16	Construction Manager™	✓	✓	✓			✓		✓
17	Construction Master Pro™		✓						✓
18	Corecon Mobile™		✓	✓			✓	✓	✓
19	Fieldwire™	✓	✓				✓	✓	
20	FormIt 360™					✓			
21	FotoIn™		✓		✓		✓		
22	GenieBelt™		✓				✓	✓	
23	HCSS Field™		✓	✓					
24	iAuditor™		✓		✓		✓		
25	iNeoSyte™		✓				✓		
26	InfraWorks 360™					✓			
27	JobSnaps™		✓				✓		
28	Mobile Field Manager ™		✓	✓			✓		
29	PlanGrid™	✓	✓		✓		✓		
30	Plexxis Foreman™		✓	✓					
31	Procore™	✓	✓	✓	✓		✓	✓	
32	Prolog Mobile™	✓	✓		✓		✓	✓	
33	Quiicker™	✓	✓	✓	✓		✓	✓	
34	Raken™		✓		✓			✓	
35	Safesite™				✓				
36	Safety-Reports™				✓				
37	Safety Meeting™				✓				
38	SmartBid™	✓							✓
39	SmartReality+™					✓			
40	Time-Equipment		✓	✓					
41	Tsheets™		✓	✓					
	Totals	**19**	**31**	**13**	**12**	**12**	**22**	**11**	**10**