Evaluating Computer Technology in Construction Education: Hardware and Software

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The primary purpose of this study was to discover if there are common hardware and/or software used by construction programs; secondary purposes were to determine the educational degrees offered, professional certifications pursued, and funding sources of construction computer labs. The surveyed audience was the Associated Schools of Construction (ASC). Construction Management was the most typical construction-related degree. Professional certifications pursued by graduates from the class of 2013 varied depending on the school, but the most pursued was Associate Constructor followed by LEED Green Associate and the Fundamentals of Engineering certification. Dell® computers and Intel® processors were the most common. The primary software used in preliminary planning/cost estimating was MS Excel®. Autodesk® products were the primary design authoring software. In the cases in which coordination (clash detection) software was employed, the most used was Navisworks Manage®. Primavera®, MS Project®, and MS Excel® were the primary scheduling software programs used by respondents. Analysis (energy & structural) software was less used and varied in the type used with "no software used" being the primary response. Funding for software came primarily from operations funds. Overall, most respondents would like improvements to their facilities, hardware upgrades, software improvements in variety and type, and building information modeling (BIM) upgrades. Future work could include repeating the survey annually to baseline and assess improvements in construction school computer labs and certifications.

Key Words: Computer Technology, Professional Certifications, Educational Degrees, Survey.

Introduction

The primary purpose of this study was to discover if there are common hardware and/or software used by construction programs. Hardware information includes computer manufacturer, processor manufacturer, hard drive size, random-access memory (RAM) size, and monitor size. Software information was focused on design, estimating, and scheduling software. The secondary purpose of this research was to determine the educational degrees offered, professional certifications pursued, and funding sources of construction universities. Respondents' general school information includes educational degrees in construction along with graduating class size. Professional certifications provide a standardized way to evaluate learning outcomes from a variety of curricula and help determine the graduate's ability in corresponding areas. Professional certifications evaluated Fundamentals of Engineering, Associate Constructor, LEED Green Associate, Project Management Professional, and Associate Design Build Institute of America. Since a variety of funding sources provide computer software at universities, this research sought to determine the most common source.

Literature Review

Computers are becoming more common in both education and industry; therefore software variety and overall volume of computers is increasing exponentially. In a 2007 study, over 20,000 patents, about 15% of all patents, were issued for software development (Bessen & Hunt, 2007).

Education is the basis which professionals rely on while gaining experience. In a study conducted at North Carolina Central University, the authors concluded that for the United States to remain competitive in the global economy, it is important that young employees are adequately prepared in both current and future technology proficiencies (Grant, et al., 2009). Grant also stated that, "in order to build and sustain information technology proficiency, people

must have formal and informal opportunities to interact with computers" (2009, p. 142). For the construction industry, it is also important to ensure that students are using cutting edge technology and methods. According to Crumpton and Miller, construction programs began implementing new technology like building information modeling (BIM) into their curriculum in 2005 to respond to industry advancements (2008). Those schools then make their students more competitive in an increasingly competitive industry job market by teaching the new improvements in technology industry is currently implementing into construction.

Construction managers are improving project development and operation management by using increasingly sophisticated technology. A new technology, BIM, is being incorporated more frequently in both private industry and government projects (Sabongi, 2009). Just as calculators replaced slide-rules, computer-aided drafting pushed hand-drawn plans to the side. The future may hold the same for BIM replacing computer-aided drafting. With new technologies emerging at an ever increasing rate, it is intuitively important for schools to keep up on both new hardware and software to make their graduates more successful. Therefore, by offering the latest technologies, universities have the potential to increase enrollment.

A similar survey on software in education was conducted by researchers at the University of Florida in the fall of 2010. Their paper, "Implementation of Building Information Modeling into Accredited Programs in Architecture and Construction Education", focused on BIM integration in construction programs (Joannides, et al., 2012). They surveyed architecture programs which are members of the Association of Collegiate Schools of Architecture (ASCA) with a 36% response rate and construction programs which are members of the American Council for Construction Education (ACCE) with a 54% response rate (Ibid.). Other areas of interest to their survey included demographics, other software used, and an in-depth focus on BIM. The in-depth survey on BIM focused on how schools implement BIM into their undergraduate curriculum, who teaches BIM to students, and the industry perception of BIM knowledge (Ibid.). Overall, Joannides found that 93% of architecture schools and 73% of construction schools said BIM was either "important" or "very important" to the construction industry (Ibid.). The results of this research will be compared to the Joannides paper in the discussion section.

Methodology

A survey was developed through Survey Monkey® and sent out using the Associated Schools of Construction list server. Results were collected for three weeks beginning 23 August 2013 and ending 13 September 2013. After the initial solicitation email, a follow up email was sent a week before closeout. The survey consisted of 28 questions requesting information in the following categories:

- General information (school, number of graduates from 2013, and construction-related degrees).
- Professional certifications (Fundamentals of Engineering, Associate Constructor, LEED Green Associate, Project Management Professional, Associate Design Build Institute of America, and other).
- Computer information (hardware).
- Software used (preliminary planning/cost estimates, design, coordination, scheduling, and analysis).
- Other information (ergonomics, other software, software funding, desired improvements, and other outstanding features).

The survey received 94 initial "hits". Of those, 56 surveys were mostly completed for a 60% survey completion rate from the initial hits. There are 150 schools in the ASC list server; therefore, because 56 schools completed the survey, 37% of construction schools responded to this survey. The survey consisted of free answer, "choose all that apply," and 5-pt Likert scale questions. The focus was on programs conferring bachelor's degrees.

Results

General Information

Respondents from the survey are shown on a map (see figure 1) illustrating their geographic distribution. The average graduating class size from 2013 was 60 with the minimum being 5 and the maximum being 250. Some of the degrees offered by respondents had different names but were separated into these primary categories: Construction Management, Construction Engineering Technology Management, Civil Engineering, Building Construction, Architecture, Environmental Engineering, and Other. Construction management was the most numerous with 70% of respondents offering this major (see figure 2).
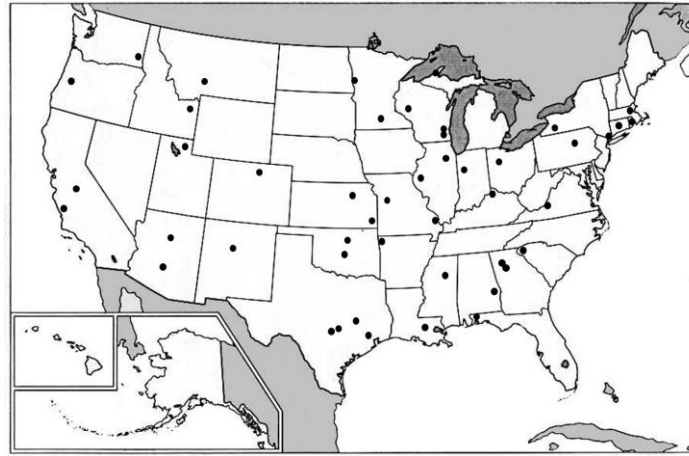

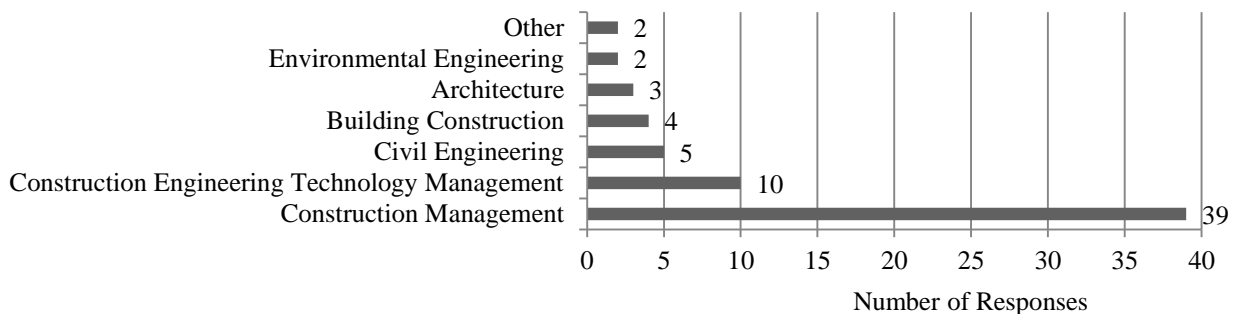*Figure 1:* Location of respondents to the survey.

Figure 2: Undergraduate construction related degrees.

Professional Certifications

After general information, respondents were asked about student pursuit of professional certifications from the class of 2013. The majority of schools (70%) did not have any students taking the Fundamentals of Engineering (FE) Exam (see table 1). Conversely, the majority of schools (70%) had students pursuing Associate Constructor (AC) with nearly half (40%) of schools having almost all of their students pursuing becoming an AC (see table 1). The professional certification most commonly sought (78% of schools had students take the exam) was LEED Green Associate (see table 1). Two-thirds of the schools stated that about a quarter of their students pursued becoming a LEED Green Associate. The least pursued (80% of schools had none) professional certifications were the Project Management Professional (PMP) and Associate Design Build Institute of America (DBIA) (see table 1).

Table 1

Percent of construction schools where students pursued professional certifications

	None	*<25%*	*~50%*	*75%*	*~100%*
Fundamentals of Engineering	70%	12%	4%	8%	6%
Associate Constructor	30%	18%	12%	0%	40%
LEED Green Associate	22%	66%	10%	2%	0%
Project Management Professional	80%	18%	2%	0%	0%
Associate Design Build Institute of America	80%	18%	2%	0%	0%

Other professional certifications pursued include Occupational Safety and Health Administration (OSHA), Construction Management Association of America (CMAA), American Concrete Institute (ACI), and National Association of Home Builders (NAHB). Less than 5% of schools had students pursue the OSHA professional certification. Only one school (2%) had students pursue any of the other certifications listed.

A weighted average of professional certifications was conducted. The weighted average is the percent of respondents' graduates pursing the professional certification multiplied by their graduating class size divided by the cumulative number of graduates from all the respondents. This method yielded a comparative chart of the professional certifications sought after by students in the construction field (see figure 3). Associated Constructor was the most pursued (42.4%) certification with LEED Green Associate (22.0%) and Fundamentals of Engineering (16.9%) making up the majority of the other certifications pursued.
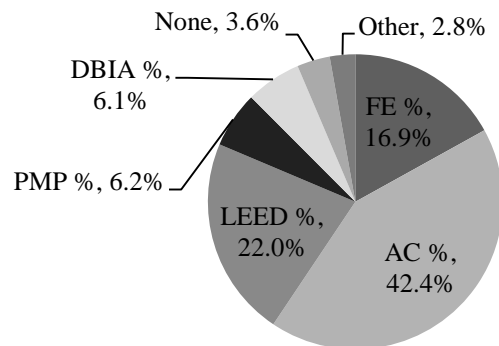

Figure 3: Weighted average of professional certifications pursued by construction students.

Computer Information

After professional certifications, respondents were asked about the current hardware they provide for student use in their department. The average number of computers owned by the department and available for student use, either lab computers for classroom use or general use, were 52 computers with a minimum of 0 computers (usually laptop campuses) and a maximum of 200 computers. The average was 1.17 computers per graduate with a minimum of 0 computers per graduate (usually laptop campuses) and a maximum of 5.83 computers per graduate. The average computer lab was used for 9 hours a day on an average day. The majority (60%) of computers used by departments were Dell® with HP® (21%) and Lenovo® (11%) as the other most used computer brands.

The overwhelming majority (91%) of processors were a variety of Intel® models. IBM® processors comprised the rest (9%) of the category. Random-access memory (RAM) varied in size from 4 GB to 32 GB. The most common (70%) was 8 GB and the average was 11 GB. Hard drive size varied from 40 GB to 1+ TB. The most common (52%) was 500 GB and about a third (32%) were 1+ TB. The average being just over 640 GB. Graphics cards varied in model, but just over half (54%) were NVIDIA® and just under half (46%) were AMD®. Computer monitor screen size excluded projectors, screens, and televisions. The average screen size was 21" with the minimum size being 14" and the maximum size being 28". About a quarter (24%) of the respondents offered dual screens and the size of these screens ranged from 17" to 28".

Software Used

After computer hardware, respondents were asked about their computer software. The overwhelming majority of universities (96%) used MS Excel® as their preliminary planning/cost estimates software (see figure 4). Software that was listed, but not used by respondents, included e4Clicks®, Onuma Planning System® (OPS), Paces®, and Tokmo®. Note that respondents were able to select and/or list multiple software types.
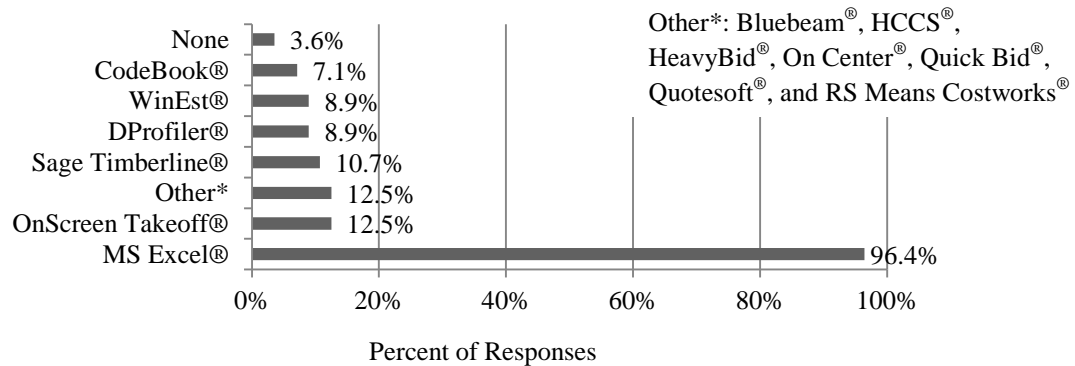

Figure 4: Software used in preliminary planning/cost estimates.

The majority of universities (84%) used various Autodesk® products for design (see figure 5). Software listed, but not used by respondents, included Rhino® and Vectorworks®. Note that respondents were able to select and/or list multiple software types.
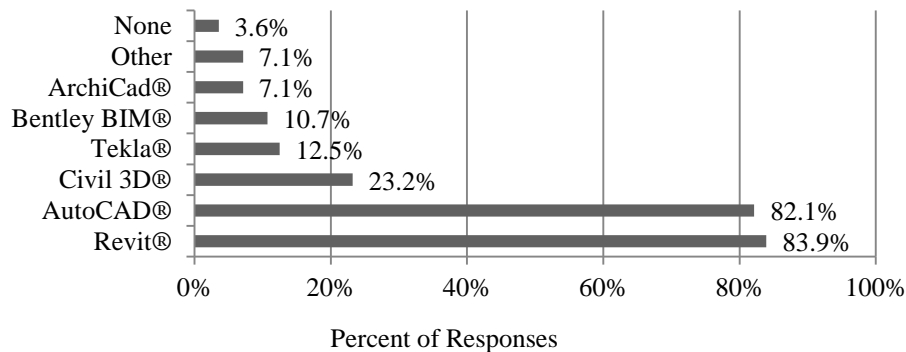

Figure 5: Software used in design.

The primary software (66%) used in coordination (clash detection) was Navisworks Manage® (see figure 6). However, nearly a third (29%) of universities did not use any software for coordination. Software listed, but not used by respondents, included EPM Model Server®, Horizontal GI®, and Solibri Model Checker®. Note that respondents were able to select and/or list multiple software types.
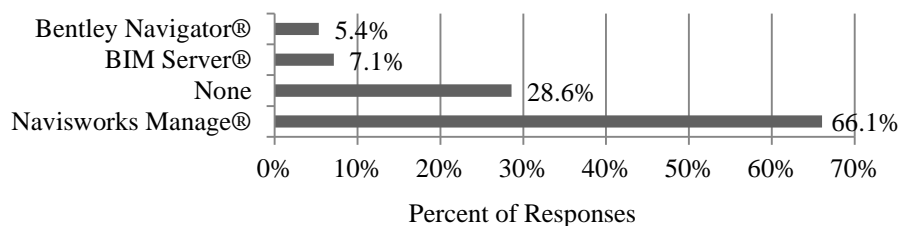

Figure 6: Software used in coordination (clash detection).

Scheduling software had a variety of software used (see figure 7). The most used (75%) is Primavera®. Two-thirds (66%) of respondents used MS Project® and just over a third (38%) used MS Excel®. Software listed, but not used by respondents, was Bentley Navigate®. Note that respondents were able to select and/or list multiple software types.
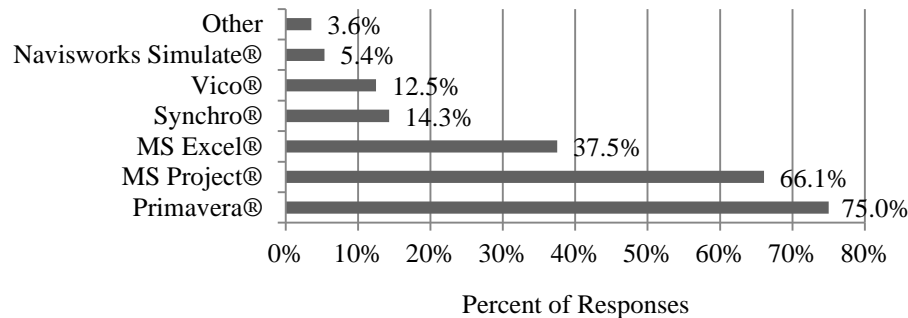
Figure 7: Software used in scheduling.

The majority of universities (63%) do not use any software in analysis (energy and structural) (see figure 8). Respondents who used analysis software typically used more than one software type. Software listed but not used by respondents was TAM®. Note that respondents were able to select and/or list multiple software types.
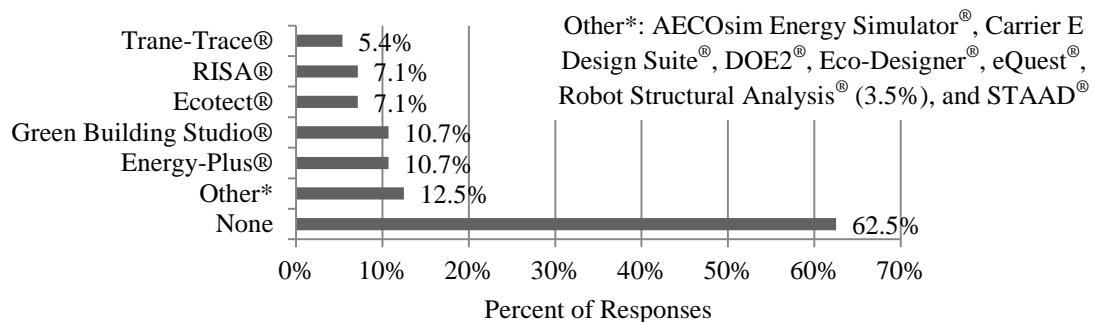
Figure 8: Software used in analysis (energy and structural).

Respondents were also asked if students were allowed to download software for personal use. The majority (53%) said "yes" and just over a third (37%) said "no". The rest of the respondents (10%) said "yes and no". The "yes and no" answers were mostly caveated with if it was possible for the students to download the software then they were allowed, but it depended on the software license agreement.

Other Information

Software funding came primarily (80%) from operating funding from either the university or the department (see figure 9). Other primary sources included donations (24%) and additional student fees above tuition (20%). Note that respondents were able to select and/or list multiple funding types.
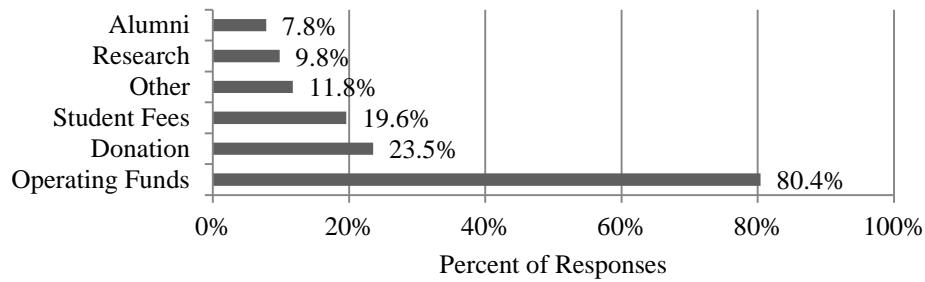
Figure 9: Software funding sources.

"Desired improvements to computer facilities" was a free answer question. The most common answers included: BIM lab and/or BIM upgrades, more software, upgraded computers, upgraded infrastructure ranging from building/space improvements to equipment like printers/plotters, more open lab hours, and a virtual reality environment. "Outstanding features" was also a free answer question. The most common answers included: a 24/7 computer lab, laptop only campuses (personal computer with required minimums or school acquired but student owned computers), reconfigurable space, and fostering a collaborative environment.

Discussion

The most interesting trend to note from the general information section is that 70% of respondents offer construction management as an undergraduate degree (see figure 2). Since this is a survey sent through the ASC list server, it stands to reason that construction related degrees should be in the majority.

Interesting information from the professional certifications section is that 42% of students from the respondents schools pursue an Associate Constructor certification, 22% LEED Green Associate certification, and 17% Fundamentals of Engineering certification (see figure 3). Associated Constructor (AC) is the entry level certification for Certified Professional Constructor (CPC), similar to Fundamentals of Engineering (FE) is to Professional Engineers (PE). Since this survey was sent to the Associated Schools of Construction (ASC) and the majority of undergraduate degrees were construction management, it makes since that the majority of respondents said their students pursued becoming Associated Constructor.

Hardware information showed Dell® as the primary computer manufacturer and Intel® as the overwhelming processor manufacturer. Models of both computers and processors varied from respondent to respondent. Another data point is the average number of computers per graduate is 1.17.

The software section had the overwhelming results from the respondents being Autodesk® products as the primary design and coordination software (see figures 5 and 6 respectively). Similarly Microsoft® products were dominant in preliminary planning/cost estimates (see figure 4), and Primavera® led the way as the primary scheduling software (see figure 7). This information would be interesting to compare to the industry standards to better evaluate education's alignment with industry.

In the BIM article by Joannides, the primary software used for design was Revit®, the primary scheduling software was Primavera®/Suretrack® and MS Project®, and the primary estimating software was Timberline® and MS Excel® (2012). These results align with the results of this survey with regards to Autodesk® products being the primary design software. A difference between this survey and Joannides' survey is scheduling and estimating software. Joannides' article lists Primavera®/Suretrack® as the primary software; however, this survey found Primavera® and MS Project® as the most used scheduling software (2012). The other difference is Joannides survey listed Timberline® and MS Excel® as the primary estimating software; however, this survey found by far MS Excel® as the preliminary planning/cost estimates software (Ibid.). Differences between the two surveys include the surveyed audience (ACSA and ACCE vs. ASC) and time (2010 vs. 2013). Because of the time difference and the surveyed audience, this survey more accurately depicts the software used by construction programs in the Associated Schools of Construction.

Lastly, the survey's free answer section had some notably reoccurring answers. Most respondents understandably wanted to upgrade both their hardware and software. However, more interesting was the trend of respondents to upgrade their lab to use and integrate BIM technology into current and future course work. The desire to use BIM technology by some construction schools indicates either a potential industry growth area or an educational response to industry progress. In the Joannides survey, 93% of architecture schools and 73% of construction schools said BIM was either "important" or "very important" to the construction industry (Ibid.). This survey provides further data that substantiates BIM as a priority area for construction programs to develop to better meet industry needs because of the common free answer response stating a BIM addition or BIM upgrades as a "desired improvement."

Conclusion

The data showed that there were trends in the types of hardware or software used by construction schools and the professional degrees students pursue. This survey showed the current trends in the hardware and software used by construction schools. Hardware trends include average computers per graduate of 1.17, average RAM size of 11 GB, and average hard drive size of 500 GB. Software trends indicated extensive use of Microsoft® products and Autodesk® products. The last highlight is the most pursued (42%) professional degree was Associate Constructor.

A comparison of this survey with Joannides' BIM survey yielded similar results in design software in Autodesk® products. Conversely, Joannides found Primavera®/Suretrack® as the primary scheduling software where this survey found both Primavera® and MS Project® as the principal scheduling software. Likewise, Joannides found Timberline® and MS Excel® as the main estimating software but this survey found MS Excel® as the overwhelming estimating software (2012). These differences may have been a result of time and/or surveyed audience. It is assumed the results of this survey are representative of the construction management field due to the use of the ASC list server and the response of 37% of the ASC list server schools.

Future work could include performing the same survey on an annual or bi-annual time table to provide longitudinal data. The same survey could also be performed on a different target audience such as engineering schools or architecture schools. The survey could be modified and sent out to construction firms comparing what software construction firms use with what software construction programs teach. Other research areas could include investigating the implementation of BIM into computer labs, the use of technology in different classes, and/or research into the age and replacement rate of computers. This research was important because it assessed computer technology and provided a baseline of computer software and hardware for construction programs in 2013. Results presented can be referenced by construction education programs when they consider curriculum design or computer upgrades.

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