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Incorporating Software Instruction into a Civil Engineering Curriculum

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By

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This paper contains the results of a survey of almost 43% of all the private civil engineering firms and government agencies in the state of Mississippi. The survey was focused primarily on the use of software and their thoughts on the software knowledge of new college graduates hired at each place of business. There were three key issues the survey focused on: computer programs used, software proficiencies of new college graduates, and the benefits of prior software knowledge. The paper presents the survey results and analyzes the trends in order to discover what civil engineering firms do and want. Also in this paper, methods of integrating software into a typical civil engineering curriculum are explored. Overall, it was found that several programs were constant in all of the firms, and that even though software knowledge is not required to land a job, it certainly is beneficial.

Key words: computer software, curricula, engineering education

DEDICATION

This paper is dedicated to those who supported me in my educational journey.

To my wife, who has been by my side these college years keeping me on the right track, and encouraging me when things got tough.

To my family, who instilled in me, the desire to challenge myself and to realize the importance of getting an education.

And to my friends, who made life at college an enriching experience and probably taught me more about life than school ever could.

TABLE OF CONTENTS

LIST OF TABLES

CHAPTER I

INTRODUCTION

According to the Accreditation Board for Engineering and Technology, Inc. (ABET), “students must be prepared for engineering practice through a curriculum culminating in a major design experience based on the knowledge and skills acquired in earlier course work and incorporating appropriate engineering standards and multiple realistic constraints (ABET, 2011). In this vastly different, ever changing society, are the engineering institutions adapting and educating future engineers to meet the standards? Not just the standards set forth by ABET, but also the expectation of practicing engineers whom are hiring new college graduates. According to a survey published in CE News magazine, only about 38% of practitioners felt that entry-level civil engineers were actually prepared for their jobs (Fauerbach, 2010). This paper explores what these engineering employers expect of new graduates, specifically, their required knowledge of engineering software when they emerge from the world of academia.

Technology is growing at a significant rate, and the way businesses operate have adapted to this growing trend. Computer software has allowed businesses to streamline processes, track inventory, and increase productivity significantly, so why not use it? The same goes for a civil engineering business using software. If the firm cannot produce a product effectively and efficiently, they will not survive. The current economic climate is harsh and employers are not hiring as they have in the past. When a new engineer is hired, they want them to produce services that will benefit the company. Entry-level engineers typically do not have all the skills needed to be effective immediately, and it costs extra money to train them, therefore, the positions for these inexperienced graduates have dwindled. The objective of this research is to discover what engineering software programs are most important in the civil engineering industry and if knowledge of these programs will benefit a graduating student. Once obtaining this knowledge, one can examine what types of programs could be taught, or at least introduced in academia. This serves two purposes. First, students will graduate with the new skill set of engineering software proficiency, and secondly, the employers can have the benefit of not having to invest so much time and money into training a new engineer on software that they would be required to know.

Examining the importance of software integration into academia was accomplished by using two different methods: a literature review and a survey. The data obtained was analyzed and presented in the following sections of this paper, along with recommendations on the subject matter. These suggestions are based upon this research, along with the personal experience of being a recent graduate of a civil engineering bachelor's degree program. In addition, the reader will find that from the constraints placed upon this research, the study was conducted to apply primarily to Mississippi State University's current situation. However, this study still contains insight that can be applied to any university curriculum.

CHAPTER II
LITERATURE REVIEW

The topic of integrating software instruction into the educational system is not new. The importance of computers and their potential impact on the civil engineering industry has been recognized for over three decades. The purpose of the 1979 ASCE Civil Engineering Educational Conference was to assess the condition of the educational system to identify any needed changes or problems. Recognizing the establishment of computers as calculation and design tools, curriculums must adapt to effectively instruct students how to use computers in their profession (Saul, 1983). Fast forward to the 21st century and not much has changed since then. As with any problem, various methods and opinions emerge as possible solutions, however, because every person feels that their solution is the superior one, progress has been slow. While engineers agree that computers are great tools, they argue that there are factors that simply do not allow for both a proper education and workplace preparation.

One issue, addressed by many in the literature (ASCE, 2007) (Chrisodoulou, 2004) (Fauerbach, 2010) (Jester, 2008), is the outdated university curriculum. In 2008, the American Society of Civil Engineers published a book that outlined tried to predict which skills a future engineer must be able to demonstrate in the more global economy (ASCE, 2008). One of the skills was “an ability to understand the techniques, skill, and modern engineering tools necessary for engineering practice” or in more simplistic terms “computer proficiency.” They also observed that students were currently not obtaining these skills. From the articles, there is a feeling that present classes teach students obsolete methods. However, there are others that urge that these methods are the basis of all engineering thought. One of the more complete discussions of this debate was given by Lawson (2002) in which he examined the history of the civil engineering field in order to know why the curriculum is the way it is. In his article, the time old argument between the instruction of theory versus practical knowledge in the classroom is explored. Engineering known today in academia is based upon engineering science of the mid 1800s, where the profession of civil engineering gained prestige and separation from that of a position such as mechanic. Their argument is that in order to be an engineer, one must be able to quantify and theorize phenomena in the world, and that these established rules govern. However, the flip side to that goes back to the first records of civil engineers who were just people with a strong sense of building knowledge and experience. These engineers based their work from previous designs and phenomena observed from other works, with no thought into the theory or rules of why these things happened. As long as the structure served its purpose, the journey to that solution was not important. He likened this “practical engineer” to the modern computer savvy 21st century engineer. Their thought of putting all the parameters in the computer to tell them the right answers with no need for books or thought is perfectly acceptable. They don’t realize that these programs are all based upon some kind of theory that someone has developed. Thus, there lies the problem. Theorists often forget that their theories are based upon practical thought processes, and “practical” engineers must know theory in order to realize if their design is reasonable. This argument eventually leads up to another source of disagreement, time.

Since “time is of the essence”, many also disagree on the proper use of a student’s time getting an education. If the curriculum structure is not changed, how do you add something else to an already tight schedule? One idea, which is also the premise behind this paper, was to narrow down exactly what types of programs engineers in the field felt were important. By creating a concentrated list, when opportunities arise for adding software instruction to a class, the professor will know which program will benefit the most. In order to do this, several surveys have been conducted over the years. Abudayyeh, et al. (2004) analyzed and compared these surveys to find any significance trends. Specific brands of programs were not considered only their general functions, such as: spreadsheet, word processor, etc... Using a rating scale from 1, least important, to 5, most important, the following table shows the results of these surveys. Note, however, that some of the types of software were not rated in older surveys. They observe that the four top skills remain relatively unchanged; indicating that these are likely a staple of the civil engineering profession. These can be compared to this paper’s research to see if the trend continues.

Table 2.1:
Comparison of Importance of Skills with 1995

	2002 Survey		1995 Survey		1989 Survey	
Skill	Rank	Rating	Rank	Rating	Rank	Rating
Spreadsheet	1	4.5	1	4.29	2	-
Word processor	2	4.13	2	4.13	6	-
Computer-aided design	3	4.03	3	3.76	1	-
Electronic communications	4	3.79	4	3.2	-	-
Presentation packages	5	3.47	7	2.66	7	-
Structural Software	6	3.34	-	-	-	-
Database	7	3.29	5	3.07	3	-
Environmental/water resources	8	3.08	-	-	-	-
GIS Software	9	3.02	-	-	-	-

Simply knowing which programs are used is not enough. For that reason, various articles have been published which describe specific methods of actually integrating software into the curriculum. One option is to add small doses of software in to multiple classes (Papadopoulos, Papadopoulos, & Prantil, 2011). Others have tried to add a lot of software instruction into a few classes. Faculty members of the United State Military Academy, Caldwell, Hanus, and Chalmers (2009), recorded some of the techniques they used to teach the site design software, Bentley PowerCivil, in a junior and senior level class. The two biggest issues encountered were the instructor not being as knowledgeable in the software as need, and spending too much time figuring out the program. Once again, lack of time plays a role in both issues faced by the academy.

Some engineering professionals have argued that the period of developing a civil engineer should be extended. Even though engineers are regarded as professionals, they are required to have far less education than that of other professionals, such as doctors and lawyers. This notion has caught on quite well. Extending the engineering curriculum to five years has been tried by some colleges, such as Colorado State University as described by Grigg, et al. (2004). In a more broad sense, the ASCE has proposed a few policies, such as ASCE Policy Statement 165, which requires thirty hours in addition to a bachelor's degree to qualify for a professional license (ASCE, 2008).

The current situation at Mississippi State University is essentially the same as the majority of universities around the country. With the time crunch of a regular undergrad curriculum, there are few classes that students actually get exposed to engineering software. The freshman level graphics communications class introduces students to the basic functions of Autodesk AutoCAD and isometric drawings. AutoCAD is not used again until the senior capstone design class which is not taken until the semester before graduation. Other programs used in more advanced classes include: Bentley Microstation for a class in geometric design of highways, Bentley WaterCAD for the second water resource engineering class, and Risa 2D for a structural analysis class. The extent of the program use varies from class to class, depending on which professor is teaching. Granted, not a large amount of time is spent on some of these programs, but students do typically get exposed to their main uses and benefits.

Integrating software is clearly a topic of concern and it has been for years. From the literature reviewed on this topic, it can be decided that the civil engineering industry and the universities are not quite sure how to approach this ordeal. The rest of this paper builds upon some of the ideas already established in the literature, and provides new insight into this subject matter.

CHAPTER III

ASSESSMENT METHODS

As stated earlier in the introduction, this research paper was accomplished by several means. The most important method of data collection was by way of a survey. Because the objective of the research paper is to discover what engineering software programs are most important in the civil engineering industry, the best way to do that is to literally "just ask". A survey provides direct feedback from the practicing engineers and produces unbiased, untainted results to analyze. A copy of the survey can be found in Appendix A of this report

3.1 ASKING THE RIGHT PEOPLE

Often the process of developing a survey is underestimated. It is not accomplished by merely throwing some questions on a piece of paper and picking someone off the street. In order to receive the intended feedback, one must first find a population of people to be represented. A typical population cannot be completely represented; even the United State Census does not ask every individual person in the country, therefore a sample, or a portion of a population, is surveyed. The results of proper sampling, can accurately generalize the state of the whole population without the expense of a larger survey.

For this paper, the distribution of the survey was limited to only civil engineering firms operating in the state of Mississippi. The geographic limitation is based upon the location of employment for students graduating from Mississippi State University. Historically, the majority of Mississippi State civil engineering students have pursued employment within their state after graduation. This notion allows the distribution limitation of the survey to be acceptable, since the respondents have a high chance of being the students' future employers.

Since Canon 2 of the ASCE Code of Ethics (2012) states that, "Engineers shall perform services only in areas of their competence", it goes without question that this should be a stipulation for being able to respond to the survey. Consequently, the sample population was limited to only currently practicing, licensed civil engineers. This restriction was clearly defined in the information on the cover page of the survey, which can be found with the rest of the survey in Appendix A.

For the selection of engineering firms to contact, the membership directory of the American Council of Engineering Companies (ACEC) was referenced (ACEC, 2011). By filtering out the companies not located in Mississippi, or in the field of civil engineering, a list of roughly ninety companies was generated. After sifting through the list further, some companies were found to be listed incorrectly and government agencies such as the Mississippi Department of Transportation and the Army Corps of Engineers were added. The final list contained a total of eighty private firms and government agencies.

3.2 ASKING THE RIGHT QUESTIONS

Not only does the right population have to be selected but a survey must also ask the right questions. The federal guidelines for statistical surveys give several general rules for generating surveys. All information about the use and objective of the survey must be clearly defined. Also, questions must not be biased, or imply certain answers over others (The United States Government, 2006). Bad questions can greatly skew results and broaches into the realm of unethical behavior. Nevertheless, all guidelines were followed in order to ensure legitimate outcomes and conclusions.

The survey consisted of three sections, the first section inquired about the company demographics. A company's size, location, and areas of expertise can greatly affect the way it functions, which in turn affects the computer software they use. For instance, Mississippi does not contain many high rise structures; therefore, the number of firms specializing in this discipline will likely be less than those in a big city, such as New York. Asking about their demographics adds an extra variable which can further enhance analysis capabilities. The second section contains an arrangement of multiple choice, short answer, and fill-in-the blank type questions to inquire about the respondent's software usage. This section was the main concern of analysis because it asked about which software the firm uses, and if they are planning to expand computer usage and other various questions asking about new hires' computer ability. The third section was merely an optional comments section. This allowed the respondents to express any thoughts that they felt were not covered by the rest of the survey with 43% of respondents using this section.

3.3 DISTRIBUTING THE SURVEY

Once the survey audience and questions had been picked, the final step was to decide how to distribute the surveys. The preferred method of distribution was one that was easiest, least expensive, but also returned good response rates. According to the University of Texas at Austin, the response rates for various survey delivery mediums are as follows (University of Texas at Austin, 2011):

Table 3.1:

Response rates for different survey media

Survey Medium	Average Rate	Good Rate	Very Good Rate
Mail	50%	60%	70%
Phone		80%	
Email	40%	50%	60%
Online	30%		
Classroom Paper		50%	
Face to Face		80% - 85%	

After taking these typical response rates into consideration, it was decided that the best form of distribution for this project would be through email. Messages are free to send and the majority of the firms had an email address for which they could be sent. In order to ensure that the respondents had to use little effort and time in filling out the survey, an electronic "Portable Document Form" or PDF was created that allowed for direct input on the computer. The respondent need only click on the spaces provided and type in their answers. About sixty firms and engineers were sent a survey directly through email. After about two weeks of waiting for surveys to arrive, a follow up reminder email was sent to those firms who had not replied back. For the larger global firms, it was often found that they had no direct email contact information for their firms located in Mississippi, only general inquiry forms on their website. A message was sent asking for an email address of an engineer that was willing to participate in the survey. The feedback received from these forms was very low, only about 1 of 10. This left around ten firms with only mailing addresses as contact information; therefore, a paper form of the survey was mailed to them. The other nine firms that did not respond to the website inquiry form were also mailed a paper survey in order to ensure that all firms had an opportunity to participate in this research. All surveys were accompanied by return information including an email address, postal address, and a fax number to allow for the respondents to choose their preferred method of delivery. A majority of the responses were received back via email, with about 5 returning via postal service. Overall, 35 of the 80 surveys were received back, making the response rate 42.75%. When compared to Table 3.1 shown previously, this rate can be considered average, since both email and postal mail were used.

CHAPTER IV

ANALYSIS OF SURVEYS

After about six weeks of waiting, the surveys stopped coming in. By making the survey a PDF form, the returned surveys could be directly imported and compiled into a spreadsheet document. Those that were received by mail were manually entered into the spreadsheet which allowed for all the data to be in one place and analyzed. As noted in the previous section, the survey was subdivided into three sections: demographics, software use, and optional comments. The same format will be the case for the presentation and analysis of results. Keeping the groups of questions separate allows for better analysis. The results are presented below.

4.1 DEMOGRAPHICS OF THE SAMPLE POPULATION

The purpose of the demographics section was to merely find out what type of engineering firm was responding to the questionnaire. It is common knowledge that civil engineering firms in different locations, or of different size, can have vastly diverse purposes and functions, even if they both are in the same industry. A total of four questions were asked to determine demographics. The following characteristics of the respondents were obtained in this section: staff size, firm classification, type of work, and areas of expertise.

For the size of the firm, it was necessary only to consider the number of professional engineers on staff. The other employees are important but the engineers really dictate how much of a workload the firm can handle. The survey participants were given four ranges to choose from to represent what could be considered a small, medium, medium-large, or large firm. It must be noted that these are different size ranges, smaller ranges, than specified in the ACEC directory. Reasonable analysis would not have been possible with their sizes because of the population surveyed. Mississippi is a rural state with a population of less than three million people. The state does not have the infrastructure to support very large firms, and as can be seen in Table 4.1 below, sixty percent of the firms surveyed are really small firms of less than ten engineers. It must be noted that the large firms also have offices outside of Mississippi. In distributing the survey, it was requested that an engineer working in a Mississippi office answer the survey, however there is no way of confirming their adherence to that request. This could skew some of the responses but with the small percentage of large firms that responded, this presence they have in other states will likely not matter.

Table 4.1:

Firm Size

Number of PE	Count	Percentage
1-10	21	60.00%
11-25	5	14.29%
25-50	3	8.57%
50+	6	17.14%

The software that a company uses is strictly motivated by the type of work performed. The next few questions evaluated the function and areas of expertise of the respondents. About 82% of the firms that returned surveys were private companies, 14% were classified as state government agencies, and 1 respondent was part of the federal government. Using multiple select type questions, firms were able to select the types of work they performed and their areas of expertise. These types of questions allow for the simplicity of multiple choice questions, but any combination of answers can be selected. The remaining demographic information of the firms is presented in the two tables below.

Table 4.2:

Firm Function

Firm Function	Count	Percentage
Design	33	97.06%
Project Management	27	79.41%
Assessments	24	70.59%
Planning	23	67.65%
Quality Assurance	16	47.06%
Construction	12	35.29%
Research	5	14.71%

Table 4.3:
Sub-disciplines

Sub-disciplines	Count	Percentage
Hydraulics	25	73.53%
Erosion	24	70.59%
Roadways	23	67.65%
Bridges	23	67.65%
Surveying	23	67.65%
Hydrology	20	58.82%
Environmental	19	55.88%
Structures	18	52.94%
Traffic	18	52.94%
Foundations	16	47.06%
Wastewater	14	41.18%
Airfields	11	32.35%
Materials	11	32.35%
Marine	7	20.59%
Architecture	5	14.71%

According to the tables, almost all the firms are tasked with the art of designing, where as few do some kind of research. It is not surprising that the majority of the firms focus on water resources and roads because they are located in Mississippi. From these statistics, it can be hypothesized that the software programs used by the surveyed firms will most likely be design software able to model entities such as roadways and watersheds. More analysis is provided in the discussion section later on in the paper.

4.2 PREVIOUS KNOWLEDGE NEEDED?

There were essentially two different intentions of the software use section of the survey. In order to actually claim that the rest of the questions are important, it must first be proven that knowledge of engineering software actually benefits a new engineer vying for a job. Once prior software knowledge is deemed useful, further inquiry as to which software should be learned can be justified. Therefore, respondents were asked if previous software knowledge was expected in new hires, and also if the knowledge gave an advantage over other candidates. All of the respondents confirmed that prior knowledge gave prospective employees an edge over the competition, where as only 91% expected prior knowledge of software. These statistics overwhelmingly defend the purpose of this survey and research.

4.3 MOST COMMON SOFTWARE

The second main objective of the survey was to determine which programs were used most frequently. This is the basis for examination of integrating software into the curriculum because it shows which program would be most beneficial to spend time learning. The respondents were given free range to answer this question, because it was merely writing the name of a program and ranking it from 1 to 10 based on relative importance. The open ended format was believed to be best because of the vast number of software choices; a multiple choice question would hinder and possibly skew the true results.

In order to calculate which software program is used the most; a system of scoring had to be established. Even though there were spaces for ten different software programs to be recorded, most wrote down only about five different program names. Furthermore, the programs ranked six to ten were often used for very specific purposes and were rarely named more than once. So in order to simplify the results, only the top five programs listed on the survey were used in the analysis. This deviation from the original data does not, however, affect the final results.

Once the data field was narrowed, a set amount of points was given for each ranking. The points system essentially inversed the ranking, for example, a number one ranking would yield five points. These points linearly decreased as rank decreased, down to where a ranking of five would yield one point. These points were averaged together in order to determine which program was considered most important to the respondents. The raw score data can be found in Appendix A, if further inquiry is needed. Table 4.4 on the next page shows which programs ranked the highest.

Table 4.4:
Weighted Scores

Program	Average	Weight	Total
Microsoft Excel	3.56	27	**96**
Autodesk AutoCAD	4.05	20	**81**
Bentley Microstation	3.95	20	**79**
Microsoft Word	3.45	22	**76**
Microsoft PowerPoint	3.90	10	**39**
Autodesk Civil 3D	4.22	9	**38**
Bentley Geopak	3.33	6	**20**
Autodesk Revit	3.33	3	**10**
Risa 3D	3.00	3	**9**
Bentley STAAD.Pro	4.00	2	**8**
Bentley WaterCAD	1.67	3	**5**
Autodesk Map 3D	2.50	2	**5**
PTC MathCAD	2.00	1	**2**

There are a few key bits of information needed in order to completely read this table correctly. Notice that average scores are not in a numerical order; when the averages were calculated for each program; some of the less popular programs were ranking above some of the others. In order to have a true measure of significance and popularity, a weighting system was implemented. The weights were based upon how many times a program was recorded on the surveys. This number was then multiplied by the program's average score to achieve a final score. The weights are shown in the second column of Table 4.4 and their final weighted scores are in the third column. Microsoft Excel, Autodesk AutoCAD, Bentley Microstation, and Microsoft Word claimed the top four spots by a significant margin. The reason for the gap is not that they averaged a significantly high ranking, but their points were magnified greatly due to being listed at least twice as many times as the other programs.

Besides adding the weighting system to condition the raw data, another slight manipulation of data took place. On nine of the surveys, the respondents listed the whole Microsoft Office suite as a program. Because the suite offers many vastly different programs, it was felt that these answers could not adequately fulfill the intended purpose of the question. To include these answers into the survey and keep their relevancy, the average score of Microsoft suite, rounded down to a 4 from a 4.22, was applied to all the programs contained in it; such as Word, PowerPoint, and Excel. Simply said, each of these three programs received an extra nine scores of 4 points totaling 36 points. Two lists, given on the next page, were made to show the differences before and after modification. The one on the left has Microsoft Office suite included, and the one on the right has the distributed scores. The Microsoft programs were definitely benefitted by the modification but the results more likely follow the true intent of the respondents. Further specification in the question could have alleviated the need for the modification.

Table 4.5:

Pre- and Post-Microsoft Office Modification Rankings

Rank	Original Program List	Modified Program List
1	Autodesk AutoCAD	Microsoft Excel
2	Bentley Microstation	Autodesk AutoCAD
3	Microsoft Excel	Bentley Microstation
4	Microsoft Word	Microsoft Word
5	Microsoft Office Suite	Microsoft PowerPoint
6	AutoCAD Civil 3D	AutoCAD Civil 3D
7	Bentley Geopak	Bentley Geopak
8	Autodesk Revit	Autodesk Revit
9	Risa 3D	Risa 3D
10	Bentley STAAD.Pro	Bentley STAAD.Pro
11	Bentley WaterCAD	Bentley WaterCAD
12	Autodesk Map 3D	Autodesk Map 3D
13	Microsoft PowerPoint	PTC MathCAD
14	PTC MathCAD	

Whether the original or modified list of programs is used, there are still some discrepancies between the presented results and the results that were expected when considering the demographics of the respondents. Notice that water resources and hydraulics were some of the main concentrations of the firms surveyed, but barely showed up on the list of top programs. The reason for these differences is due to the nature of the question being asked. By allowing total freedom in the program listing question, the respondents named several brands of hydrological programs. Without brand reoccurrences in the results, the programs were deemed too specific or unpopular by the weighing scale. To ensure that there is some sort of trend with the demographics, the engineering programs were sorted into their concentrations and functions. Some programs are listed in multiple category types due to their versatility. The program type list can be found on the next page. This distribution of program types follows very closely to what would be expected when considering the respondent demographics. However, the purpose of this paper was to determine which program is the most widely used, therefore, this breakdown of the results is a confirmation of question validity, but of little use to this specific research topic.

Table 4.6:

Program Types

Program Type	No. of Programs
Traffic and Roadway Design	12
Water Resources / Hydraulics	10
CAD 2D/3D	8
Structural Analysis	7
Building Information Modeling (BIM)	7
Office Suite	6
Geographic Information Systems (GIS)	6
Geotechnical Analysis	3
Project Management/Scheduling	2
Computational	1

4.4 COMPUTER SKILLS

Having already established that prior software knowledge is advantageous and which programs are most widely used, it must be determined if the civil engineering industry feels that new engineering graduates are adequately equipped with the skills to run the computer programs needed on the job. Therefore, a question was included on the survey that asked the respondents to rate the software efficiency of new graduates joining their place of business on a scale from one to five. A rating of one represented only a basic knowledge level, where as a five meant the new hire navigated software with proficiency. The scores, shown in Table 4.6, averaged out to be a 2.6; meaning that the graduates are familiar with some of the programs, but far from being proficient at them.

Table 4.7:

Software Skill Level

Score	Count
1	6
2	10
3	9
4	4
5	3
N/A	3
Average	**2.625**

4.5 TECHNOLOGY IN THE FUTURE

Technology is still growing at a rapid pace, new software is being developed and the existing software is evolving to meet new needs. If the software used in the industry changes too quickly, there would be no feasible way for academia to teach engineering software, because graduates' knowledge would be outdated by the time of entering the workforce. Therefore, respondents were asked if their firm or agency had plans to expand their use of engineering software. If they answered "Yes", a follow up question was given inquiring if they were expanding the use of their current software or moving to a new software. Of the 80% answering "Yes", 82% of those respondents were merely using more of the same software. Some of the new software going to be used included Bentley SewerCAD, Ansys, and Bentley Microstation, along with a few programs developed internally. Since no respondents were planning on making radical changes to the software portfolio, the results of the survey will stay true for the near future.

4.6 PROGRAM PROBLEMS

An area of interest, that is not necessarily essential to the objective of this research but is important to the engineering software topic, is discovering the flaws in current software. The last question of the software use section provided space to write any thoughts down on the greatest deficiencies, issues, or problems they encounter on a daily basis. Most of the responses often included key words such as: "Compatibility", "Steep Learning Curves", and "Updates". The general consensus of most of the respondents was that with new updates and versions of software each year, proper training is very difficult to maintain. Also, there are large differences between brands of software. If two different entities are collaborating with different software, translation between the software is often non-existent or very difficult. Integrating software training into college curriculum cannot solve these problems, but as far as steep learning curves and software being difficult to use; extra instruction in a classroom format may ease this training burden.

4.7 OPTIONAL COMMENTS

To conclude the survey, several blank lines were provided in order to allow for the respondents to express any other thoughts on the subject matter that were not addressed in the other questions. After reading the responses that were given, it almost seems as the survey could have just contained this question because of the large amount of insight these comments provided. Some comments backed the hypothesis of this paper by expressing that integrating software into the curriculum is needed, where as others felt differently on the topic.

The following few comments are in favor of integrating software into the civil engineering curriculum. Each comment has a slightly different reason for instruction such as one respondent stated,

> "I have thought for some time that engineering software should be included in a Civil Engineering curriculum. Hand calculations and the ability to draw by hand are very important and should not be overlooked. However, in business, efficiency and presentation mean so much. Engineering software helps increase the speed of production and greatly improves the "look"."

The statement above looks at it from a business prospective of cost reduction and presentation. If adequate job performance requires software proficiency, it must be learned one way or the other. The following respondent used personal experience about having to spend extra time above and beyond work, in order to do the job. In their words:

> "I believe that it is a priority to include AutoCAD civil software training in the curriculum. I graduated from MSU 20 years ago. I had to learn CADD on the job in order to do my job. I had to enroll in a night class at junior college to learn AutoCAD basics. CADD is not just drafting, it is the only way to efficiently design many civil systems in today's world."

Being in different concentrations of the civil engineering field often requires specific skill sets, but as one respondent states, being well rounded is also beneficial.

> "It would be very beneficial for an undergraduate curriculum to include these software programs, especially for a student interested in design. Even for students primarily interested in field work and construction management, a basic knowledge of these programs proves beneficial for a variety of applications."

Not all the respondents felt the same way. None of the comments really opposed teaching software during an engineer's education, but some felt that there are more important topics to spend time on. One respondent stated that, "Good communication is much more important than software abilities for a new engineering hire or any employee." Also some firms and agencies prefer to train their employees certain ways.

> "We would rather the new hires have the maximum amount of specific work related classes and/or work experience rather than software experience. We would rather train the new hire on the software, ex. Microstation, in certain departments. We do not evaluate new hires on prior knowledge of software, but if they do it is an added bonus."

All these comments provided the perfect insight into how practitioners around the state feel about integrating software instruction into education. Though just as the literature review showed, there are varying ideas on this topic which tend to occasionally conflict with each other.

CHAPTER V

DISCUSSION OF RESULTS

Before any trends and conclusions can be obtained from the results presented above, a key factor of the study was the location of focus. The state of Mississippi can be far different than other areas in the nation; therefore some of the tendencies the results depict can be skewed by these cultural and economic differences. To say that this research could be extrapolated to represent the civil engineering industry as a whole would be unwise. However, the focus of this study was engineering in Mississippi; hence the data collected can be considered an accurate representation of the state.

After examining all the results, there are some outcomes that were expected and a few new insights not expected. As stated previously, the demographics had a large influence on the results. According to the National Oceanic and Atmospheric Administration (NOAA), Mississippi has the second highest average annual precipitation of the 48 contiguous states surpassed only by its neighbor Louisiana, so having hydraulics and erosion top the list of respondents' sub-disciplines comes as no surprise (Nation Oceanic and Atmospheric Administration, 2012).

It is generally thought that small engineering firms tend to have fewer resources at their disposal than that of a large firm. So often times the more complex and expensive software is not used or not needed by the smaller firms. From the survey data however, there was no obvious correlation between firm size and the brands of programs used. The large firms and the small firms in the study typically kept to using the same couple of basic programs, thus debunking the train of thought.

By performing more advanced statistical analysis, Pearson product-moment correlation coefficients were tabulated comparing trends between each sub-discipline. Table 5.1 below shows the top six values. These correlations can provide helpful insight to students desiring to concentrate in a certain area, such as structures; will also have to be somewhat knowledgeable in another area like foundation design. This relationship is expected because structures sit upon foundations, therefore are largely inseparable entities. Students can then take advantage of these relationships during their education to be as prepared as possible, whether it be in theory or software skills, in each sub-discipline. Demographic trends other than the few already presented can be found, however they are intertwined within the result analysis of the software section of the survey.

Table 5.1
Correlation Coefficients of Sub-disciplines

Sub-disciplines	Correlation
Roadways-Surveying	0.75
Structures-Foundations	0.73
Roadways-Hydrology	0.71
Roadways-Environment	0.67
Roadways-Bridges	0.62
Roadways-Traffic	0.62

For the software inquiry section the most insightful question was finding out which software programs were used the most by firms. Often times, software companies claim to be the "most trusted name in engineering" or something of that nature which possibly could be true but some bias has probably been added for public relations. The most important facet of this research is that an independent third party went directly to the software users to find the most important and most common software used in the civil engineering industry. Though not groundbreaking in the findings, in order for a true integration of technology into the engineering curriculum to be most useful, universities' decisions on program instruction must not be clouded by brand loyalties or preferences. Understandably, fiscal factors can and more than likely will be the biggest deciding factor. However, these pros and cons must be weighed carefully in order to best provide for the student's needs.

Topping out the list of programs by a sizable margin was Microsoft Excel. Not considered engineering software in some ways, the capabilities of spreadsheet software allow engineers to make repetitive calculations easily. The majority of students typically get exposed to this software, and all the other Microsoft Office programs, through the course of their regular curriculum, so there is really no need to require extra instruction.

Autodesk AutoCAD has been one of the industry leading design programs for almost the length of its existence. A survey of the national engineering curriculum showed that a good proportion of the undergraduate students are exposed to a computer aided design (CAD) program of some kind. Thirty-seven percent of schools have a course focusing on just CAD, while others integrate their CAD instruction into another class, such as graphics communications and senior capstone design (Russell & Stouffer, 2005). Mississippi State University does the latter of the two. Therefore, it can be concluded that students have a very high chance of being exposed to CAD, however the extent of this exposure and instruction becomes the issue. This paper cannot venture into that realm due to lack of research, it can only speak of the author's experience, which will be expressed in the recommendations section.

Two programs with a high average ranking and fair amount of survey appearances were Bentley Microstation and Autodesk Civil 3D. Bentley Geopak can also be thrown into the same category since it basically is an add-on to Microstation which increases the functionality. If Geopak was mentioned, it was typically listed alongside Microstation. All three have the same purpose known as building information modeling (BIM). The reason for the strong showing of Microstation is likely due to the fact that 67% of the respondents work on roadways. The Mississippi Department of Transportation (MDOT) uses Microstation as their primary design tool and requires private firms to use the program on their projects. Some respondents said they prefer Civil 3D and that for private industry jobs, they choose not to use Microstation. As a side note, one of the major deficiencies of current software as stated in the surveys, was that needing to have knowledge of both was cumbersome, but seamless integration between the two programs does not exist at the time. One respondent's best advice, for students, was to decide on which sector they would likely be working in and accordingly choose Microstation or Civil 3D to learn.

One result that seemed curious was the lack of project management software, or software used for scheduling and cost analysis. With almost 80% of respondents specializing in project management and 35% in construction, one would assume that some sort of project management software would appear more frequently. However, it showed up only three times with low rankings; not even important enough to be mentioned. The respondents must rely on the construction contractor to fully handle that aspect of the job.

With respondents not really emphasizing on structures and architecture, it was hypothesized that these types of programs were not highly used. Risa 3D, STAAD.Pro, and Autodesk Revit each appeared about three times in the survey responses but doesn't seem prevalent enough to warrant using valuable educational instruction time on these programs. However, keep in mind that the surveyed group represents a largely rural state with a relatively small population. These scores could change dramatically if it were moved to a more populated, more developed location.

Knowing which software to use is not the end of the problem. While it is a part of the solution, some of the other survey results are troubling such as the software skill level of a typical entry level engineer. The skill ratings were fairly spread out, even though a rating of two or three was most common, these results can be skewed because it is an opinion question. Depending on the technological level of the firm or agency, prior knowledge can sometimes be sufficient to do all the required tasks. A few surveys were also returned with "N/A" selected. These respondents may not have been in the position to adequately answer the question, which is more beneficial that they did not try answering something they did not know. Nevertheless, with respondents grading their software skill levels less than average, it can be discouraging to a graduating student having worked hard for at least four years, just to be told that they don't really know enough to do their job well. Since the surveys showed there is an advantage, a university that could increase a student's software proficiency can acquire higher employment rates for its graduates. In this scenario, both parties win.

As far as the optional comments are concerned, there is really no quantitative manner in which to analyze the responses. As quoted in the previous chapter, the responses have a very wide range of views on software instruction. Interestingly enough it follows right along with the ideas expressed in the literature review. Ever since the dawn of computers, there has been the same argument that teaching software is more beneficial in a classroom setting or whether it should be learned on the job. This disagreement is one of the reasons why nothing in academia has really changed for decades as far as this topic is concerned.

CHAPTER VI

SOLUTION ALTERNATIVES

Even after all the data has been tabulated and the results analyzed, the ever present question is still unanswered. With the reduced number of credit hours, can software instruction even be fit in to the already tight schedule? The following paragraphs contain a few different solutions that attempt to answer this question. These recommendations are merely one person's point of view, but are enforced by the information obtained in this research. The three recommended approaches are as follows: add software use to multiple classes, modify existing graphics communications class, or wait for ASCE Policy Statement 465. These recommendations can be applied to any university curriculum, but most aspects of the recommendations are given specifically to apply to Mississippi State University's current civil engineering curriculum.

6.1 INTEGRATE ENGINEERING SOFTWARE

Given the current curriculum requirements, time restraints, and having read about other schools that have done this, the best method for allowing extra software instruction is to incorporate software use into the current classes. Some of the ways this can be done is outlined in an article by Papadopoulos, Papadopoulos, & Prantil (2011), which presents a few examples of how software can be used in a variety of engineering mechanics classes. By allowing students to utilize modeling and analysis software, the instructor can enforce the underlying principles and theories effectively. It has been shown to benefit the students by allowing for better visualization of the problem at hand (Sacks & Barak, 2010). Students can still be assigned homework to be done by hand, which requires the knowledge of theory, but request it be done on a computer program and checking the results to what was done on paper.

To the ones still concerned about time issues, if the full integration takes place throughout the whole curriculum, no one teacher or class is burdened with the task of teaching new software skills. Just a small exposure of the software in each class, spending no more than a few lectures, still allows for teachers to teach what they want the students to learn. With this technologically savvy generation of students, the teacher may even find that their job becomes easier. Using applied methods of solving problems tend to hold a student's interest for longer periods of time. If extra instruction is needed, students can ask questions outside of class to the professor, or typically engineering classes have a graduate student helping with the class; just ask them to have the knowledge of the software. Realizing that some universities do not have as many resources as others, another idea would be to make instructional videos. These can be done beforehand by recording the computer screen while the professor solves the assigned problem. This should not add much of a burden to the professors because they would eventually have to solve the problems anyways; recording the screen while doing this requires little effort. Give the students a way to access these videos, if further instruction is needed.

Before performing this research, a point was brought up that given the current educational climate of intense research burdens, a professor's time can be better spent on research rather than learning a new software. This is a valid point, however, typically professors already use these software programs in their own research; therefore, only a small percentage of instructors should encounter this problem. Furthermore, once the initial learning curve of a new software is mastered, keeping up to date with the software is relatively easy, thus in the long term this problem becomes miniscule.

The key component for this recommendation to work correctly is that the whole curriculum must add small steps of software instruction, in order to not create a large burden. As with anything else in modern society, other extraneous factors of human nature will play a role in this integration. The largest problem that can be foreseen is the interdepartmental cooperation that will be needed, which sometimes is easier said than done.

6.2 MODIFY EXISTING GRAPHICS COMMUNICATIONS CLASS

Another plan of action could be to overhaul existing classes that are meant to teach the basics of CAD. Typically labeled "engineering design graphics" or "graphics communications", these classes often teach students how to visualize or create simple drawings pertaining to engineering through use of sketching or simple CAD software use. Historically, the graphics classes have focused more on the visualization through hand sketches, than from computer software. This method is considered by many to be outdated, because drafting by hand has become close to nonexistent. Some of the time spent on repetitive sketching exercises can be replaced by more advanced CAD drawing, or more useful skills. There are some cases in which these classes are taken a step further, surpassing two dimensional drafting techniques to expose the students to BIM and three dimensional modeling (Sacks & Barak, 2010). With the growing use of BIM in the CAE industry, those students wanting to go into this field can benefit greatly from this experience.

The main idea of this recommendation comes from experience as a student. The very limited instruction, limited implementation of CAD software, and lack of further instruction in any other classes, did not fully prepare most the students for higher level classes, specifically senior capstone design. It was expected of the students to create a full set of drawings with CAD software, however, the only students that were capable of completing this task had only learned this skill set outside of school at their cooperative education jobs. This same scenario could also follow a student into the workplace after graduation. The new graduate would likely be required to complete a simple task with some form of software, as was assigned in school, but have no knowledge of how to complete it. This scenario would probably be troubling for a student, as well the employer that hired him.

6.3 WAIT FOR ASCE POLICY STATEMENT 465

The waiting scenario is the least disruptive and most simplistic way to possibly increase the amount of engineering software exposure to students. As mentioned earlier in the literature review, ASCE is planning on implementing new requirements for professional engineering licensure. Deemed ASCE Policy Statement 465, the new requirements add thirty hours of class work after a typical bachelor's degree (ASCE, 2008). This is essentially means that a master's degree would be required to qualify for professional licensure. With the extra ten classes of instruction, a class teaching real world solutions with programs, such as Microstation, Risa 3D, or even some sort of geotechnical analysis software, could easily be fit into the students schedules. It would be best to offer different software programs each semester in order to allow all students the chance to become more knowledgeable in their field of interest. The downside of this scenario is complexity of its ratification and the opposition by some professional engineering groups. Currently, NCEES adapted the policy several years ago, but each state has to vote and agree on the change. Only one state has attempted to ratify this policy and it was voted down. Therefore, the time table in which this change will take place is unknown. Not knowing when exactly the change will happen, doesn't really allow for immediate remediation of the software integration addressed in this research.

CHAPTER VII

RECOMMENDATIONS FOR FUTURE WORK

Even after the completion of this research there are still many unanswered questions that need to be explored in order to come up with a good solution for integrating software into academia. One obvious shortfall in this research is the fact that some of the questions were too broad, especially the question that required listing the names of software used at the firms. It was brought to attention after the surveys had been returned, that a good portion of engineering firms have CAD technicians that do all the drafting work. If this is the case, then engineers never even use AutoCAD, therefore, the argument that engineers need more AutoCAD experience in school is no longer valid. If further research is done on the topic, it would be best to ask which programs the engineers use specifically. This method would likely yield more accurate results.

Other research regarding this same topic could focus on more of the cost-benefit analysis with respect to the civil engineering departments. Though this paper presents several scenarios in which departments could integrate software, the costs of each are not considered. By examining the costs associated with software licenses and training faculty on the software, one could easily find whether software integration is actually even feasible given realistic constraints such as money.

CHAPTER VII

CONCLUSION

The purpose of this paper was relatively straight forward. The objective of this research was to examine the topic of integrating software program instruction in to the civil engineering curriculum. This was accomplished in three stages: a literature review, a survey, and a paper explaining what was ascertained. First, by reviewing current literature of the topic, a broad range of ideas and solutions about integrating software into the civil engineering curriculum were uncovered. It was established that the internal conflict between ideas, for or against this topic, has greatly hindered the adaptation and evolution progress of the national university curriculum. Solutions already being implemented at some universities tried to appease both sides of the isle, but these instances are still meager in the retrospect of things. Secondly, in order to explore what options would be best for Mississippi State University; a survey was created and distributed to almost all the civil engineering firms in the state. This survey inquired about the aspects of each of the firms such as: what kind of work they did, what software programs they used, and asked for their thoughts on the importance of integrating software into academia. From these surveys it was found that the majority of firms in Mississippi are small firms of less than ten engineers that focus mostly on watersheds, hydraulics, and roadways. The programs that are most widely used include

Bentley Microstation, Autodesk AutoCAD, and most of the programs in the Microsoft Office collection. The majority of respondents agreed that software proficiency was beneficial for entering the workforce out of college, but some preferred to train employees on the software themselves. While some participants stated that they would like to see more software being taught in academia; others claimed that learning good communication and social skills is of greater use.

The hypothesis of this paper was that was that by integrating software into the civil engineering curriculum, graduates emerge with more skill sets, which benefit them when searching for full time employment. From the results, it can be concluded that the hypothesis is indeed confirmed, at least for the constraints given to this research. Whether a person is for or against the study given above, the topic of computer software instruction is just the tip of the iceberg. The ultimate goal of this research, and the most important issue that needs to be addressed, is the examination of the national civil engineering curriculum. Has the curriculum adapted to the changes in society, and does it still prepare civil engineering students for life after the classroom? Only time and further research can answer these questions.

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APPENDIX A

THE SURVEY

Survey of Engineering Software Use for Thesis Research

Dear Participant,

My name is Andrew Torries and I am a graduate student at Mississippi State University. For my thesis, I am examining the use of computer software in the Civil Engineering field, and specifically, how academic curriculum can adapt to the growing use of this software. Because your firm is part of the Civil Engineering community, you are invited to participate in this research study by completing the survey attached to this letter.

The following questionnaire will take less than five minutes to complete. There is no risk involved, nor is there any compensation for completing this survey; it is merely for educational purposes. If there is a concern or you have reservations about any of the questions, feel free to skip questions as necessary. All data will remain confidential, and business names will never be included in the paper or statistical analysis. If you choose to complete the questionnaire, please answer questions accurately and if possible return it within a week of receiving it. To return the survey, it can be attached to an email and sent to **amt191@msstate.edu,** or mailed to:

Attn: Andrew Torries
Department of Civil and Environmental Engineering
Mississippi State University
501 Hardy Road, 235 Walker Engineering Bldg
Box 9546
Mississippi State, Mississippi 39762-9546

Thank you for taking time out of your day to support my research. The data collected will be very helpful in gaining knowledge of the types of software used in the civil Engineering industry and will possibly enable colleges to better prepare their graduates for future employment. If you would like a copy of the research findings, please provide your name and address along with the questionnaire submission.

Any further inquiries can be sent to Dr. Seamus Freyne in the MSU CEE Department via email, **freyne@cee.msstate.edu**, or by phone, **(662) 325-0515.**

Sincerely,

Andrew Torries
(601) 528-2368
amt191@msstate.edu

MISSISSIPPI STATE UNIVERSITY

Survey of Engineering Software Use for Thesis Research

This survey is intended to evaluate which types of computer software are currently used in existing Civil Engineering firms and agencies. The questionnaire contains multiple choice, and open ended questions. The boxes can be clicked to check the appropriate answer, and words can be typed directly under the open ended questions.

Demographics of Firm/Agency:

This section will be used to categorize firms into respective sizes and areas of concentration in order to find trends in software used.

Number of licensed professional engineers on staff:

❍ 1-10 ❍ 11-25 ❍ 26 - 50 ❍ 50 +

Classification of your firm or agency:

❍ Private ❍ State Gov. ❍ Federal Gov.

Type of work done: (Select all that Apply)

☐ Design ☐ Construction ☐ Planning ☐ Research

☐ Quality Assurance ☐ Assessments / Inspection ☐ Project Management

Areas of civil engineering your firm works in: (Select all that Apply)

☐ Structures ☐ Architecture ☐ Foundations ☐ Airfields

☐ Marine / Waterways ☐ Roadways ☐ Traffic ☐ Bridges

☐ Materials Testing ☐ Environmental ☐ Wastewater Treatment ☐ Hydrology

Software:

This section will be used to determine software use at your firm or agency.

Is having prior knowledge of computer software a trait that is expected in new hires?

❍ Yes ❍ No

Is having prior computer software knowledge considered an advantage over other prospective employees?

❍ Yes ❍ No

If applicable, how would you rate the engineering software skills of new college graduates that have been hired at your firm or agency within the past few years?

1 (Basic)	**2**	**3** (Moderate)	**4**	**5** (Proficient)	**N/A**
❍	❍	❍	❍	❍	❍

Please use the lines below to list software an engineer would use at your firm or agency and rank the software, with most widely used being a rank of one:

Rank (1,2,..)	**Software Name** (i.e. AutoCAD, Microstation, Risa 3D, Microsoft Excel, etc…..)
_____	____
_____	____
_____	____
_____	____
_____	____
_____	____
_____	____
_____	____
_____	____
_____	____

What is the greatest problem/issue/deficiency with the software you currently use?

____

____

____

____

____

Does your firm or agency have future plans (within the next few years) of expanding the use of engineering software?

❍ Yes ❍ No

If your firm does plan on expanding software use, will it be using more of the current software or new software?

❍ Current Software ❍ New Software Name(s): ______________________________
____

Optional Comments:

Any additional comments or suggestions about software use can be added below:

____
____
____
____
____

APPENDIX B

SURVEY RAW DATA

Survey	Number of PE	Classification of your firm or agency	Design	Construction	Planning	Research	Quality	Assessments	Project
1	1-10	Private	On	Off	On	On	Off	On	On
2	1-10	Private	On	On	On	Off	On	On	On
3	1-10	Private	On	On	On	Off	On	On	On
4	1-10	Private	On	Off	On	Off	Off	On	On
5	1-10	Private	On	Off	On	Off	On	Off	On
6	1-10	Private	On	Off	Off	Off	On	On	On
7	50 +	Federal Gov	Off	Off	Off	On	On	On	On
8	1-10	Private	On	On	Off	On	Off	On	On
9	1-10	Private	On	On	On	Off	On	On	On
10	50 +	Private	On	Off	Off	Off	On	On	On
11	1-10	Private	On	Off	Off	Off	Off	Off	Off
12	1-10	Off	On	Off	On	Off	On	On	On
13	11-25	State Gov	On	On	On	On	On	On	On
14	1-10	State Gov	Off	On	Off	Off	On	On	On
15	11-25	State Gov	On	Off	On	Off	Off	Off	Off
16	50 +	State Gov	On	On	On	Off	On	On	On
17	11-25	State Gov	On	Off	On	Off	Off	Off	Off
18	1-10	Private	On	Off	On	Off	Off	Off	On
19	1-10	Private	On	On	On	Off	Off	On	On
20	1-10	Private	On	Off	Off	Off	Off	On	On
21	50 +	Private	On	Off	On	Off	On	On	On
22	26-50	Private	On	On	On	Off	On	On	On
23	11-25	Private	On	On	On	Off	On	On	On
24	50 +	Private	On	Off	On	Off	On	On	On
25	1-10	Private	On	Off	On	On	Off	Off	Off
26	1-10	Private	On	Off	Off	Off	Off	Off	On
27	26-50	Private	On	Off	On	Off	Off	On	On
28	1-10	Private	On	Off	Off	Off	Off	Off	On
29	50 +	Private	On	On	On	Off	Off	On	On
30	1-10	Private	On	Off	On	Off	Off	On	Off
31	1-10	Private	On	Off	Off	Off	Off	Off	Off
32	1-10	Private	On	Off	Off	Off	Off	On	Off
33	11-25	Private	On	On	On	Off	Off	On	On
34	1-10	Private	On	Off	Off	Off	Off	Off	Off
35	26-50	Private	On	Off	On	Off	On	Off	On

Survey	Structures	Architecture	Foundations	Airfields	Marine	Roadways	Traffic	Bridges	Materials	Environmental	Wastewater	Hydrology	Hydraulics	Erosion	Surveying
1	On	Off	On	Off	Off	Off	Off	On	Off	Off	Off	Off	On	On	Off
2	Off	Off	Off	On	Off	Off	Off	Off	Off	Off	Off	Off	Off	Off	Off
3	On	Off	On	Off	Off	On	On	On	On	On	On	Off	On	On	On
4	Off	Off	Off	Off	On	On	On	On	Off	Off	On	Off	On	On	On
5	On	Off	On	On	Off	On	On	On	On	On	On	On	On	On	On
6	Off	Off	Off	Off	Off	On	On	On	On	On	Off	On	On	On	On
7	On	Off	On	On	On	On	Off	On	On	On	Off	On	On	On	On
8	Off	Off	Off	Off	Off	Off	Off	Off	Off	On	Off	Off	Off	On	Off
9	On	Off	On	On	Off	On	Off	On	On	On	On	On	On	On	On
10	Off	Off	Off	On	On	On	On	On	On	On	On	On	On	On	On
11	On	Off	On	Off	Off	Off	Off	Off	Off	Off	Off	Off	Off	Off	Off
12	On	On	Off	On	Off	On	Off	On	On	Off	On	On	On	On	On
13	On	Off	On	Off	Off	Off	Off	On	Off	Off	Off	Off	Off	On	Off
14	Off	Off	Off	Off	Off	Off	Off	Off	On	Off	Off	Off	Off	On	On
15	Off	Off	Off	Off	Off	On	On	On	Off	Off	Off	Off	On	On	Off
16	On	On	On	Off	On	On	On	On	On	On	Off	On	On	Off	On
17	Off	Off	Off	Off	Off	Off	On	Off	Off	Off	Off	Off	Off	Off	Off
18	Off	Off	Off	Off	Off	On	On	On	Off	Off	Off	On	On	On	On
19	Off	Off	Off	Off	Off	On	On	On	Off	On	On	On	On	On	On
20	Off	Off	Off	Off	Off	On	On	On	Off	On	Off	On	On	On	On
21	On	Off	On	On	On	On	On	On	On	On	Off	On	On	On	On
22	On	Off	On	On	On	On	On	On	On	On	On	On	On	On	On
23	Off	Off	Off	Off	Off	On	On	On	Off	On	On	Off	Off	Off	On
24	On	On	On	On	Off	On	On	On	Off	On	On	On	On	On	On
25	Off	Off	Off	Off	Off	On	Off	Off	Off	On	Off	On	Off	Off	Off
26	Off	Off	On	On	Off	On	On	On	Off	On	On	On	On	On	On
27	On	Off	Off	Off	Off	On	Off	Off	Off	On	On	On	On	On	On
28	Off	Off	Off	Off	Off	On	Off	Off	Off	Off	Off	On	On	On	On
29	On	On	On	Off	Off	On	On	On	Off	On	On	On	On	Off	On
30	Off	On	Off	Off	Off	Off	Off	Off	Off	Off	Off	Off	On	Off	Off
31	On	Off	On	Off	Off	Off	Off	Off	Off	Off	Off	Off	Off	Off	Off
32	On	Off	Off	Off	Off	Off	Off	Off	Off	Off	Off	Off	Off	Off	Off
33	On	Off	On	Off	Off	Off	Off	Off	Off	Off	Off	Off	On	Off	On
34	Off	Off	Off	Off	Off	Off	Off	On	Off	Off	Off	On	On	On	Off
35	On	Off	On	On	On	On	On	On	Off	On	On	On	On	On	On

Survey	Prior Knowledge Expected?	Prior knowledge Advantage	Skill Rating
1	No	Yes	2
2	Yes	Yes	1
3	Yes	Yes	2
4	Yes	Yes	3
5	Yes	Yes	3
6	Yes	Yes	1
7	Yes	Yes	3
8	Yes	Yes	5
9	Yes	Yes	2
10	Yes	Yes	3
11	Yes	Yes	1
12	Yes	Yes	3
13	No	Yes	3
14	Yes	Yes	2
15	Yes	Yes	2
16	Yes	Yes	2
17	Yes	Yes	Off
18	Yes	Yes	6
19	Yes	Yes	4
20	Yes	Yes	2
21	Yes	Yes	3
22	Yes	Yes	3
23	Yes	Yes	1
24	Yes	Yes	2
25	Yes	Yes	4
26	Yes	Yes	2
27	Yes	Yes	1
28	Yes	Yes	4
29	Yes	Yes	5
30	No	Yes	4
31	Yes	Yes	2
32	Yes	Yes	3
33	Yes	Yes	5
34	Yes	Yes	Off
35	Yes	Yes	1

Survey	Rank	Program Name	Rank	Program Name	Rank	Program Name	Rank	Program Name	Rank	Program Name
1	1	STAAD.Pro	2	AutoCAD	3	STAAD Foundation Advanced	4	Shoring Suite		
2	1	AutoCAD	2	MS Word	3	MS Excel				
3	1	AutoCAD Civil 3D	2	Microstation						
4	1	Excel	2	Word	3	AutoCAD Light / 3D Civil	4	WaterCAD / SewerCAD		
5	1	AutoCAD Civil 3D	2	Excel	3	Word	4	KY Pipe (hydraulics)	5	Microstation
6	1	AutoCAD Civil 3D	2	Microsoft Word	3	Microsoft Excel				
7	1	Microsoft Excel	2	Microsoft Word	3	Microsoft Power Point	4	ARC View	5	AutoCAD
8	1	Microsoft Office	2	AutoCAD						
9	1	Microsoft Word	2	Microsoft Excel	3	AutoCad	4	WaterCad	5	Hec-Ras
10	1	Microstation	2	Microsoft Excel	3	Geopak	4	Inroads	5	AutoCAD
11	3	RISA 3D	2	Microsoft Excel	6	ProgeSoft	5	GT-Strudl	1	Microsoft Word
12	1	Autodesk Civil 3D	2	Autodesk Map 3D	4	Autodesk Storm and Sanitary Analysis	5	Revit	6	Autodesk Infastructure Modeler
13	1	Microstation	2	Microsoft Office	3	CSI Bridge	4	Bentley Leap Bridge	5	Conspan
14	1	Microsoft Office	2	Miicrostation	3	Geopak				
15	1	Microstation	2	Geopak						
16	1	Microsoft Office	2	Microstation	3	Geopak	4	AutoTurn		
17	1	Microsoft Office Site	2	Microstation	3	Traffic Analysis Software	4	GeoMedia Professional		
18	1	AutoCAD - Civil 3D	2	Excel	3	Word				
19	1	AutoCAD	2	Microstation	3	Excel				
20	1	Microstation	2	AutoCad						
21	1	AutoCAD	2	Microstation	3	Bentley Geopak				
22	1	Microsoft Office	2	Microstation	3	AutoCAD	4	ASACE HEC-RAS	5	Trafficware Synchro
23	1	Autocad	2	Microstation	3	Microsoft Products	4	Google Earth		
24	1	AutoCAD	2	Microstation	3	Microsoft Word	4	Microsoft Excel	5	Adobe Acrobat
25	1	Microstation	2	Geopak	3	Microsoft Excel	4	Microsoft Outlook	5	AutoCad
26	1	AutoCAD	2	Microsoft Excel	3	Microsoft Word	4	Microstation	5	HEC-RAS
27	1	Civil 3D	2	Microstation/Inroads	3	Microsoft Office	4	Drainage softward	5	Water/sewer hydraulic software
28	1	AutoCAD	2	Eagle Point	3	AutoCAD Civil 3D	4	Excel	5	Word
29	1	Microstation	2	AutoCAD	3	Microsoft Suite	4	3D Software	5	GIS
30	1	AutoCAD	2	MicroStationv8i	3	Trane Trace	4	Excel	5	Word
31	1	TEKLA	2	AutoCAD	3	Risa3D	4	AutoSD	5	RAM
32	1	AutoCAD	2	Revit	3	Risa3D	4	Microsoft Excel	5	Microsoft Word
33	1	AutoCAD	2	CADWorx	3	Microsoft Excel	4	NavisWorks	5	Vision
34	1	HEC-RAS	2	HY-8	3	AutoCAD	4	Microsoft Excel		
35	1	AutoCAD Civil 3D	2	Excel	3	Microsoft Word	4	Microstation	5	ArcView

Survey	Rank	Program Name	Rank	Program Name	Rank	Program Name	Rank	Program Name	Rank	Program Name
1										
2										
3										
4										
5										
6										
7	6	Primivera	7	Microsoft Project	8	Mathcad	9	Solid Works		
8										
9										
10	6	Caice								
11	4	Mathcad								
12	3	Microsoft Office								
13	6	RC Pier	7	PennDot Box Culvert	8	Risa 3D	9	MathCAD	10	L Pile
14										
15										
16										
17										
18										
19										
20										
21										
22	6	McTrans HCS 2010	7	CORSIM	8	Vissim	9	H20 Map	10	Pipe 2000
23										
24	6	WaterCAD	7	Microsoft PowerPoint	8	Hydraflow				
25										
26	6	Pipe2010								
27	6	Hydrogaphic surveying software	7	Primavera P6 scheduling software						
28										
29										
30	6	PowerPoint	7	Sketch Up	8	EQuest				
31	6	BRICSYS NV								
32										
33	6	Hypack	7	Kubit	8	Faro Scene	9	Microsoft Project	10	Microstation
34										
35										

Survey	What is the greatest problem/issue/deficiency with the software you currently use?
1	have not been able to find any software that is capable of checking the AREMA design code
2	For AutoCAD, many new graduates have a very limited knowledge of the full capabilities of the software. Most can draw lines, and that's about it. No real design capabilities. We also see a very limited knowledge of MS Office products, especially Excel.
3	Most training and experience of the new hires within the design areas of CAD and/or Microstation is limited. These software packages are doing so much more relative to the engineering design work we do; that early training is accentual to placement of new hires in the market place.
4	Technology is changing so fast that we cannot learn the latest version before the next version is released.
5	Software stability, ease of customization, and in-depth knowledge of the software capabilities
6	It is not easy to learn how to use it (Autocad C3D)
7	Due to increased IT security recently imposed, software must be on an approved list, and then loaded by an IT technician, not in your organization, and all functions may not operate as they were designed to do.
8	No problems
9	Too much variation between our versions/brands and those of other firms, especially state agencies. Exchanging data can oftentimes be difficult.
10	Compatibility
11	None
12	Lack of water distribution design in Autodesk Civil 3D.
16	Little changes in a project requires lots of work to correct in microstation
18	Software is not user-friendly
20	MicroStation primary use, when others use AutoCad, bringing in to MicroStation, translation problems in line styles, weight and sometimes location.
23	Having time to learn new versions.
24	Proper training
25	Cost
26	Steep learning curves.
27	Private practice for commercial and residential site development is done with Civil 3D, but Corps and Hwy Dept's in states used Microstation/Inroads.
28	Just changing from Eagle Point to Civil 3D. Eagle Point is no longer being updated and will only work with AutoCAD 2010 or earlier. Civil 3D is time consuming to get all of the settings set up properly and is a totally new system and has a long learning curve.
29	Time needed for proficiency and training
30	New graduates want to use their Mac and most widely used Engineering software currently is not compatible with Mac. Little or no training for HVAC specific software in mechanical engineering curriculum.
32	Poor to inadequate Documentation, Lack of Valid (Real World) Examples
33	Lack of training by employees
34	Some of the programs have been 'bought out' by CAD companies and are now only available in the CAD package. This is a problem.
35	Continuous Updates - Every Year

Survey	Plans of Expanding Software Use?	Expanding Current or New?	Specify new Software
1	No	Off	
2	Yes	Current	
3	Yes	Current	
4	Yes	Current	
5	Yes	New Software	Microstation
6	Yes	Current	
7	Yes	New Software	We develop our own. PCASE, PAVER, PenCurve, AT Planer
8	No	Off	
9	No	Off	
10	Yes	Current	
11	Yes	New Software	ANSYS
12	Yes	Current	
13	Yes	Current	
14	No	Current	
15	Yes	Current	
16	Yes	Current	
17	Yes	Current	
18	Yes	Current	
19	Yes	Current	
20	Yes	Current	
21	Yes	Current	
22	Yes	Current	
23	Yes	Current	
24	Yes	Current	
25	Yes	Current	
26	No	Current	
27	Yes	New Software	Constructability software that will interface with Primavera P6
28	Yes	Current	
29	Yes	Current	
30	Yes	Current	
31	Yes	Current	
32	No	Off	
33	Yes	Current	
34	No	Off	
35	Yes	New Software	SewerCAD

Survey	Optional Comments
2	I have thought for some time that engineering software should be included in a Civil Engineering curriculum. Hand calculations and the ability to draw by hand are very important and should not be overlooked. However, in business, efficiency and presentation mean so much. Engineering software helps increase the speed of production and greatly improves the "look."
4	Good communication is much more important than software abilities for a new engineering hire or any employee.
6	I believe that it is a priority to included Autocad civil software training in the curriculum. I graduated from MSU 20 years ago. I had to learn CADD on the job in order to do my job. I had to enroll in a night class at junior college to learn AutoCAD basics. CADD is not just drafting, it is the only way to efficiently design many civil systems in today's world.
7	In our work, knowledge of software and its use is critical to project completion.
10	We carry annual maintenance contracts on all of the software we use. The maintenance contracts include free version upgrades.
13	We would rather the new hires have the maximum amount of specific work related classes and/or work experience rather than software experience. We would rather train the new hire on the software, ex. Microstation, in certain departments. We do not evaluate new hires on prior knowledge of software, but if they do it is an added bonus.
14	We prefer candidates with knowledge of CADD and Spreadsheet software as it reduces the amount of training involved with new employees.
15	It would be very beneficial for an undergraduate curriculum to include these softwares, especially for a student interested in design. Even for students primarily interested in field work and construction management, a basic knowledge of these programs proves beneficial for a variety of applications.
18	I believe it would be helpful for students to learn the use of AutoCAD-Civil 3D and Microstation in school to better prepare them for the job market.
21	As a student of MSU CE I wish they would have taught more than drafting in CAD programs. I would love to have used microstation and Geopak in a roadway class.
22	It's expected that new employees have basic computer skills and knowledge of some software applications, it is also expected that additional software skills will need to be developed. The above listed software packages are some of the major ones we use, however there are many different types of specialty software programs that we use for specific functions.
23	As a student, the more you can learn about all software the easier to find a job.
28	If you are going into government work (i.e. MDOT, Corp of Engineers, FHWA) suggest Microstation experience. Private consulting work suggest AutoCAD.
32	Critical that engineers be able to properly visualize the problem and loading. Must be able to check both input and output simply. Too much reliance on software to solve problems. Must know limitation and work around of all software.
34	Besides having knowledge of standard CAD and engineering software, graduating engineers should have a basic knowledge of word processing, spreadsheet and database software.