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Introducing Principles of Land Surveying by Assigning a Practical Project

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***Abstract*—**A practical project is used in an engineering surveying course to expose sophomore and junior civil engineering students to several important issues related to the use of basic principles of land surveying. The project, which is the design of a two-lane rural highway to connect between two arbitrary points, requires students to draw the profile of the proposed highway along with the existing ground level. Areas of all cross-sections are then computed to enable quantity computations between them. Lastly, Mass-Haul Diagram is drawn with all important parts and features shown on it for clarity. At the beginning, students faced challenges getting started on the project. They had to spend time and effort thinking of the best way to proceed and how the work would flow. It was even more challenging when they had to visualize images of cut, fill and mixed cross sections in three dimensions before they can draw them to complete the necessary computations. These difficulties were then somewhat overcome with the help of the instructor and thorough discussions among team members and/or between different teams. The method of assessment used in this study was a well-prepared-end-of-semester questionnaire distributed to students after the completion of the project and the final exam. The survey contained a wide spectrum of questions from students' learning experience when this course development was implemented to students' satisfaction of the class instructions provided to them and the instructor's competency in presenting the material and helping with the project. It also covered the adequacy of the project to show a sample of a real-life civil engineering application and if there is any excitement added by implementing this idea. At the end of the questionnaire, students had the chance to provide their constructive comments and suggestions for future improvements of the land surveying course. Outcomes will be presented graphically and in a tabular format. Graphs provide visual explanation of the results and tables, on the other hand, summarize numerical values for each student along with some descriptive statistics, such as the mean, standard deviation, and coefficient of variation for each student and each question as well. In addition to gaining experience in teamwork, communications, and customer relations, students felt the benefit of assigning such a project. They noticed the beauty of the practical side of civil engineering work and how theories are utilized in real-life engineering applications. It was even recommended by students that such a project be exercised every time this course is offered so future students can have the same learning opportunity they had.

***Keywords*—**Land surveying, highway project, assessment, evaluation, descriptive statistic.

I. Introduction

JORDAN University of Science and Technology (JUST) is a government university located in Irbid, Jordan. JUST was established in 1986 as a national institute of higher education with the main objective of producing high-quality professionals in various specializations to help satisfy the local and regional labor market needs. Since its establishment, JUST has been at a leading position of higher learning in the Arab World as well as among the Middle Eastern universities due to its faculty and administrative staff, multi-disciplinary educational system and broad diversity of students. The number of students has increased considerably since the university's establishment. Today JUST has more than 20,000 undergraduate and 1800 graduate students compared to 2,300 students in the 1986/1987 academic year. Moreover, JUST comprises more than 5,000 international students of 60 nationalities [1].

Presently the university has twelve faculties, namely; Medicine, Engineering, Science & Arts, Pharmacy, Dentistry, Agriculture, Veterinary Medicine, Architecture, Information Technology, Applied Sciences, Nursing and Graduate Studies and 55 departments offering 42 undergraduate programs and 95 postgraduate programs. All departments, faculties and service units are working together as one body to ensure that the education we offer is of high-quality, supportive and rewarding [1]. Recently JUST has started to take into consideration improving its rank in the QS World University Rankings which placed JUST at 601+ according to the QS World University Ranking System. Nevertheless, JUST has been ranked 301 according to the following indicators: academic reputation, reviews by recruiters who hire JUST graduates, faculty student ratio, citations of published research. In addition, the university was ranked 71 in recruiting top quality international students [1].

Our vision at JUST is to become a world-class university distinguished in high quality teaching and research. The mission is to provide undergraduate and graduate students with broad, stimulating and rigorous education, professional skills, basic and applied research, and knowledge that meets the needs of the labor market and enable graduates to compete nationally, regionally and internationally. The university places a lot of focus on promoting and fostering a multicultural university community to attract more international students [1].

As the practical surveying project had been implemented in the Land Surveying course, the classical topics mentioned later remained the same. The inclusion of this project into the syllabus was for many reasons: putting things together of what students had learned during the surveying course to strengthen the comprehension of the subject. Furthermore, knowledge of this kind comes in handy when students are working on their senior design projects in the transportation track besides getting some practical training before it is time to look for

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career positions [2]. Moreover, implementing this course improvement enabled the fulfillment of several ABET student outcomes such as "An understanding of how contemporary issues shape and are shaped by mathematics, science and engineering", "An ability to work effectively in teams" and "An ability to communicate". Student outcomes describe what students are expected to know and be able to do when they successfully complete a program (graduate). These benefits could not have been attained without implementing such a project as is discussed later based on the instructor's observations before implementing this course development. Fortunately, introducing students to such project is not time consuming and could be completed on their own time, in addition to extra help by the instructor as needed, without the need to remove any of the class content. The most recent student outcomes by ABET (a-k) are listed below [3]:

a. An ability to apply knowledge of mathematics, science and engineering
b. An ability to design and conduct experiments, as well as to analyze and interpret data
c. An ability to design a system, component, or process to meet desired needs within realistic constraints such as economic, environmental, social, political, ethical, health and safety, manufacturability, and sustainability
d. An ability to function on multidisciplinary teams
e. An ability to identify, formulate, and solve engineering problems
f. An understanding of professional and ethical responsibility
g. An ability to communicate effectively (3g1 orally, 3g2 written)
h. The broad education necessary to understand the impact of engineering solutions in a global, economic, environmental, and societal context
i. A recognition of the need for, and an ability to engage in life-long learning
j. A knowledge of contemporary issues
k. An ability to use the techniques, skills, and modern engineering tools necessary for engineering practice.

In general, students seemed to understand the scientific components of the Land Surveying course very well. However, when it comes to putting things together through using their knowledge developed during the semester they seem to have difficulty doing so. Additionally, it is always helpful to allow students the opportunity to work on a complete project from start to finish, which is one significant advantage of using and implementing a practical surveying project. These aspects were all addressed and investigated in detail in the course of this study.

Several studies were carried out to evaluate the benefit of implementing practical projects of design and analysis nature in undergraduate teaching in different majors. These studies were in general supportive of this course development. Steve Blank [4] studied an existing program which has incorporated undergraduate research projects into its curriculum. The goals of the program are to provide students with opportunities to apply their newly acquired skills to real problems and, in so doing, to gain specialized familiarity with a topic and/or occupation. The results of the program have been good, in general, despite some limitations. The conclusion reached is that the program offers many short and long run benefits to students in that it improves their performance both in the classroom and their career positions. Another study by Mick Healey and his coworkers [5] focused on final year projects concluded that both students and faculty should be given choices in the kind of project they undertake/supervise and in the nature of the outputs assessed. To them, this is the best way to meet the various needs of increased numbers of students in higher education and the pressure on staff resources to supervise them. This approach is likely to inspire a wider range of students, and hence increase the probability that more students will experience better learning. Hasok Chang [6] on the other hand studied the possibility of turning a class into a professional research community. He achieved only a part of a system of learning that enables students to function as a real and evolving community of researchers. Furthermore, there is evidence that participation and engagement in professional development activities are related to the quality of student learning [7], [8]. It is stated that "Provision of opportunities for professional learning and development, and obtaining relevant teaching qualifications, and establishing requirements that professional development and qualifications are undertaken are indicators of an institutional climate that recognizes the importance of the preparation of staff for future careers" [7], [8]. There is a need to conduct a parallel study to investigate the potential benefits of implementing this technique in a Land Surveying course at the undergraduate level.

II. Description of Land Surveying Project

Surveying class is developed to highlight the fundamental concepts of surveying, to familiarize students with theoretical backgrounds of optical instruments and to introduce mathematical concepts of surveying. The main components of surveying class are: principles of surveying; linear measurements, chain surveying, leveling and its application in contouring, profiles and cross-sections. Areas, volumes, and earthwork are also covered in a Land Surveying course at the undergraduate level at JUST. Measurement of angles; traverse surveys, tachometry and electronic distance measurements (EDM) are also discussed. Theory of errors and adjustments and principles of triangulation are all part of the course as well.

One of the most important applications of surveying is to design and set out a highway. Therefore, to get students familiar with this concept, a highway design project was developed and distributed to students. A contour map for a given area (Fig. 1) was provided to students and the students were asked to deliver the following requirements:

1. Design a two lane rural highway to connect between two points A and B on the given contour map (Fig. 1).
2. Draw the profile for the proposed highway and show the ground level on the drawing (students should ensure that there are cut and fill sections in their proposed highway

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line.)

3. Draw a sketch for all cross sections. Draw, to scale, three of the cross section in details these sections should represent cut, fill and mixed sections. The distance between cross sections is 250 m (i.e. 1 cm on the map based on the map scale).
4. Calculate the area for all cross sections using any method you prefer, if you choose a method to calculate the area that needs drawing, then your drawing should be to scale.
5. Calculate the quantities of cut and fill between cross sections and show it in a table format.
6. Draw the Mass Haul Diagram and show all important parts and features on it.

Use the following assumptions: maximum slope of 7% (preferred); 12 ft lane width, 6 ft shoulders (see Fig. 2), in addition students can assume any values that are not given.

To deliver the items of the project mentioned above, students should use the knowledge they gained in the surveying class. Cross sectional areas and volume quantities methods are used. Excel Spreadsheets may be used to perform the calculations.

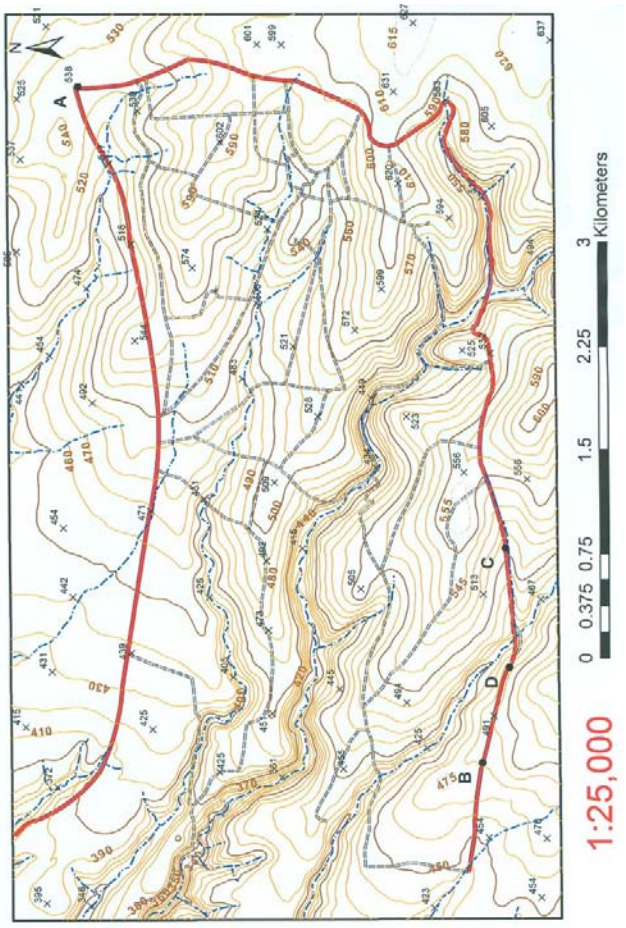


Fig. 1 Contour map



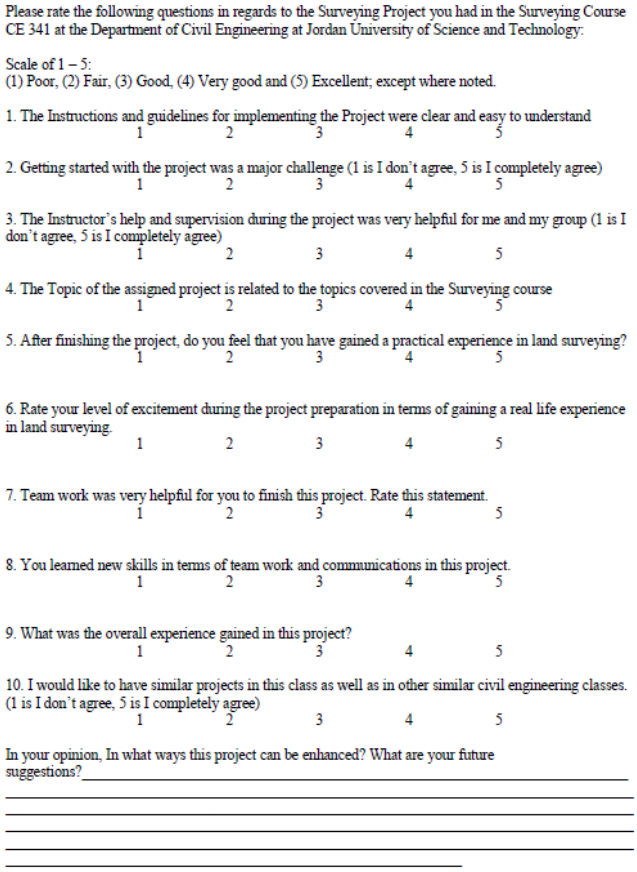
Fig. 2 Typical primary highway section

III. Survey Structure

In order to assess the usefulness of assigning a practical project in the Land Surveying course, a survey was designed carefully to cover important aspects of such course improvement. This survey was completed by students toward the end of the semester. The purpose of this survey was to provide numerical values indicative of the rate of success attained from this course addition. Ten questions were used in the survey. Question 1 measures the adequacy of instructions and guidance given to students as it shows if changes and modifications are needed in the future when this project is implemented again. Instructors noticed that students faced some challenges on how to get started; question number 2 was selected to quantify this hypothesis. In question 3 students voted on how valuable the help provided by the instructor was. Any course modification technique should be related to the topics covered in that course; question 4 measured this proposition. Attainment of practical experience and exposure to real life applications in land surveying was one main objective from the project in this study as indicated by questions 5 and 6, respectively. Question 7 and question 8 assessed the benefit of assigning the project in groups of two students each in terms of gaining team work skills and communication skills. Question 9 was a summarizing question to the overall experience gained in this project and question 10 inquired about whether students recommend this course project, or similar ones, in this class and other civil engineering classes.

Each question was rated on a 5-point scale; 1 denotes “poor”, 2 denotes “fair”, 3 denotes “good”, 4 denotes “very good” and 5 denotes “excellent”. Alternatively, in some questions 1 was used to indicate "I don't agree" and 5 "I completely agree" with 2, 3 and 4 used in an ascending order of agreement with the stated question. A copy of this survey similar to those completed by students is shown in Fig. 3.

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Please rate the following questions in regards to the Surveying Project you had in the Surveying Course CE 341 at the Department of Civil Engineering at Jordan University of Science and Technology:

Scale of 1 – 5:
(1) Poor, (2) Fair, (3) Good, (4) Very good and (5) Excellent; except where noted.

1. The Instructions and guidelines for implementing the Project were clear and easy to understand
1 2 3 4 5

2. Getting started with the project was a major challenge (1 is I don't agree, 5 is I completely agree)
1 2 3 4 5

3. The Instructor's help and supervision during the project was very helpful for me and my group (1 is I don't agree, 5 is I completely agree)
1 2 3 4 5

4. The Topic of the assigned project is related to the topics covered in the Surveying course
1 2 3 4 5

5. After finishing the project, do you feel that you have gained a practical experience in land surveying?
1 2 3 4 5

6. Rate your level of excitement during the project preparation in terms of gaining a real life experience in land surveying.
1 2 3 4 5

7. Team work was very helpful for you to finish this project. Rate this statement.
1 2 3 4 5

8. You learned new skills in terms of team work and communications in this project.
1 2 3 4 5

9. What was the overall experience gained in this project?
1 2 3 4 5

10. I would like to have similar projects in this class as well as in other similar civil engineering classes. (1 is I don't agree, 5 is I completely agree)
1 2 3 4 5

In your opinion, In what ways this project can be enhanced? What are your future suggestions?_____

Fig. 3 Survey Structure

IV. Results and Discussion

Total number of sophomores and juniors that participated in this study was 30. All answers were summarized in Table I. Average values as well as standard deviation, maximum and minimum were all presented. A detailed discussion of the results is also offered. A rating of 3 or greater out of 5 is considered to be within the agree range.

Question 1 "The Instructions and guidelines for implementing the Project were clear and easy to understand". 100% of students rated this question above 3 (60% satisfaction); with 20% of participated students saying 3 (good), 17% saying 4 (very good) and 63% saying 5 (excellent). This indicates that there is a significant consensus among students about the clarity of provided instructions and guidelines for implementing the project. Questions 2 " Getting started with the project was a major challenge (1 is I don't agree, 5 is I completely agree)", only 13% of students seemed not to agree with this statement versus 87% partially to highly agreed with the fact that knowing how and where to start was a major challenge. This could be due to the new nature of such a project for students in the sophomore or junior level. Students highly thought that instructor's help was adequate to get them through as can be seen from the high numerical values of question 3 " The Instructor's help and supervision during the project was very helpful for me and my group (1 is I don't agree, 5 is I completely agree)".

Question 4 is "The Topic of the assigned project is related to the topics covered in the Surveying course". As expected, students highly agreed (97%) that the assigned project is related to the topics covered during the Land Surveying course. This result is in line with the objective of this study that is to measure students' comprehension of the material covered and their ability to use that knowledge in real life problems.

For question 5 "After finishing the project, do you feel that you have gained a practical experience in land surveying?" 97% of students were satisfied about the knowledge gained and how it affected their practical experience concerning land surveying. 20% were moderately satisfied, 44% were satisfied and the remaining 33% were highly satisfied. Questions 6 "Rate your level of excitement during the project preparation in terms of gaining a real life experience in land surveying"; this aspect was, according to students, 87% fulfilled. Results of questions 5 and 6 are indicative of the fact that students learning experience was enhanced through the implementation of this project related to major land surveying concepts.

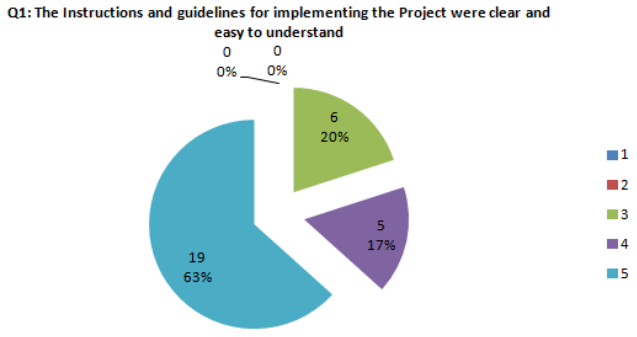
Question 7 is "Team work was very helpful for you to finish this project. Rate this statement." and question 8 is "You learned new skills in terms of team work and communications in this project". Results of these two questions proved the validity of assigning group activities in civil engineering courses to allow students to work in groups in order to improve their team work and communication skills. 87% and 100% results were obtained for questions 7 and 8, respectively.

Question 9 " What was the overall experience gained in this project?" indicated that 93% of students were moderately (13%), satisfied (50%) and highly (30%) satisfied about their overall experience gained from this mini project. Finally, question 10 "I would like to have similar projects in this class as well as in other similar civil engineering classes. (1 is I don't agree, 5 is I completely agree)" showed a 100% consensus among students about the validity of incorporating such a project in the Land Surveying course and other courses in the civil engineering curriculum.

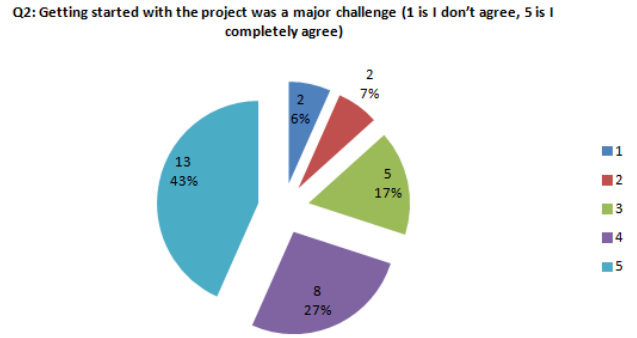
As shown above, it is proven that this work is good in the sense that it shows the importance of working in a professional project in the development of a student toward their careers. These results are graphically shown with great details in Fig. 4. A pie chart showing number of students for each answer (1, 2, 3, 4 and 5) and the corresponding percent to the total number of participating students is prepared for each question.

TABLE I
SURVEY DATA (SAMPLE)

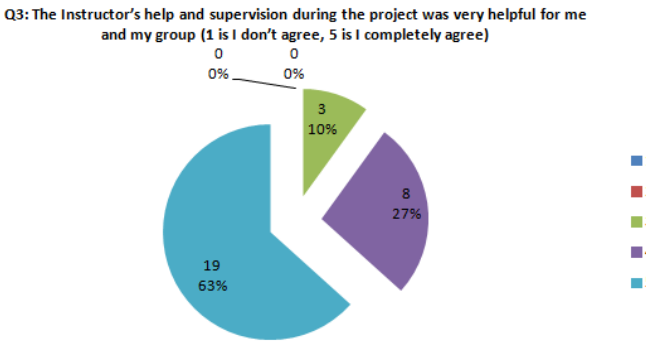
Question #	S1	S2	S3	S4	S5	S6	S7	S8	S9	S10	…	Average	Standard Deviation	Maximum	Minimum
1	3	3	5	5	5	3	4	5	4	5	…	**4.4**	**0.8**	**5.0**	**3.0**
2	4	5	4	5	5	5	1	5	5	3	…	**3.9**	**1.2**	**5.0**	**1.0**
3	3	5	5	4	5	5	4	5	5	5	…	**4.5**	**0.7**	**5.0**	**3.0**
4	2	5	4	5	5	5	5	4	5	5	…	**4.5**	**0.7**	**5.0**	**2.0**
5	4	5	5	4	3	4	3	4	5	4	…	**4.1**	**0.8**	**5.0**	**2.0**
6	3	4	3	1	1	3	5	4	5	4	…	**3.8**	**1.3**	**5.0**	**1.0**
7	5	5	5	1	1	4	1	5	5	2	…	**4.1**	**1.3**	**5.0**	**1.0**
8	3	5	5	3	3	3	3	5	5	3	…	**3.9**	**0.8**	**5.0**	**3.0**
9	4	4	4	4	2	3	2	4	5	4	…	**4.0**	**0.9**	**5.0**	**2.0**
10	5	5	5	5	3	5	4	5	5	5	…	**4.7**	**0.6**	**5.0**	**3.0**
Average	**3.6**	**4.6**	**4.5**	**3.7**	**3.3**	**4.0**	**3.2**	**4.6**	**4.9**	**4.0**	**…**				
Standard Deviation	**1.0**	**0.7**	**0.7**	**1.6**	**1.6**	**0.9**	**1.5**	**0.5**	**0.3**	**1.1**	**…**		**Sample Size = 30**		
Maximum	**5.0**	**5.0**	**5.0**	**5.0**	**5.0**	**5.0**	**5.0**	**5.0**	**5.0**	**5.0**	**…**				
Minimum	**2.0**	**3.0**	**3.0**	**1.0**	**1.0**	**3.0**	**1.0**	**4.0**	**4.0**	**2.0**	**…**				



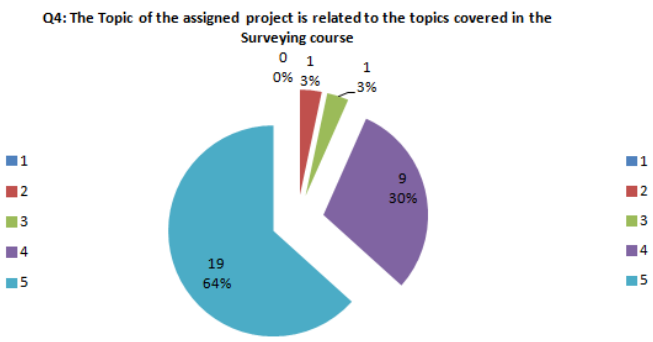
(a) Question 1 Results



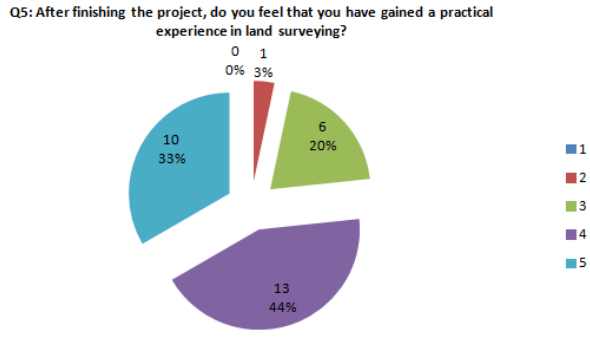
(b) Question 2 Results



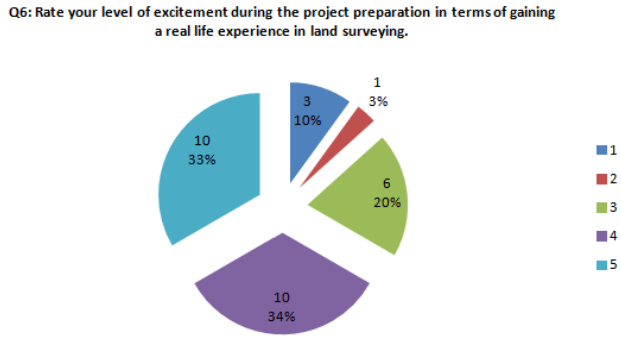
(c) Question 3 Results



(d) Question 4 Results

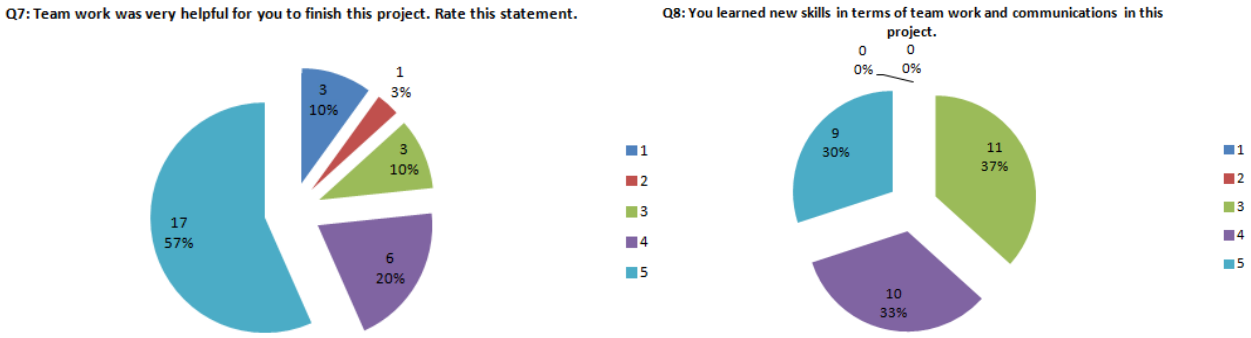


(e) Question 5 Results

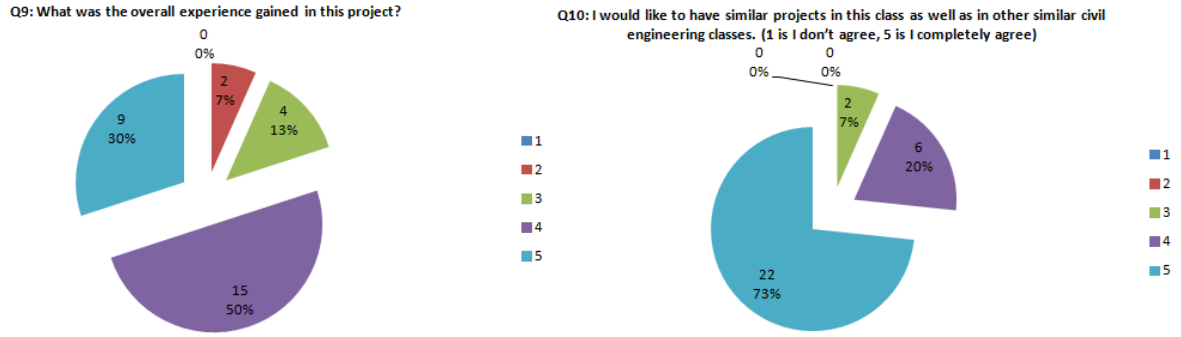


(f) Question 6 Results

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(g) Question 7 Results (h) Question 8 Results



(i) Question 9 Results (j) Question 10 Results

Fig. 4 Survey Results for Questions 1 through 10 (a)-(j)

Student outcomes by ABET that were used to argue the need for this project can be easily tied back to this study results as described herein. After a careful analysis of the results it can be reasonably said that most of ABET student outcomes a-k were clearly addressed through the survey as seen in Table II. It is also worthy to mention that students had the opportunity to use modern engineering tools necessary for engineering practice such as AutoCAD and AutoCAD Civil 3D that meets student outcome k.

TABLE II
ABET STUDENT OUTCOMES VS. STUDY RESULTS

Question No.	ABET Student Outcomes										
	a	b	c	d	e	f	g	h	i	j	k
1	√		√		√						
2			√		√						
3											
4	√										
5	√				√			√		√	
6								√		√	
7				√							
8				√			√				
9	√		√								√
10									√		

Students provided few comments and suggestions that are listed below:

1. In my opinion it was very nice project and I have learned a lot of things in the surveying class. Also, I want to say thanks for this opportunity.
2. Let's do projects more than homeworks.
3. I hope for more practical and research projects in addition to regular classes.
4. We should discuss our results as a team with instructor in front of class to be fully beneficial to us.
5. Use software programs to help get more accurate and fast results.
6. In my opinion the project doesn't need enhancement.
7. Make it even more challenging.

V. CONCLUSION

The specific remarks and statements from the study can be mentioned succinctly as:

1. Students showed high satisfaction about the instructions and supervision they received from their instructor.
2. As a supplementary tool following students' proficiency in the course material, the incorporation of a practical project was found to enhance students' learning experience, solidifies methods presented in class and better clarifies the details taught as well.
3. Starting the project was the major challenge students faced. Specifically, it was somewhat difficult for them to visualize the route they are designing along with cut and fill volumes in three dimensions.
4. The practical experience gained and the level of exposure to real life land surveying problems were both rated high by participating students. This was one of the main objectives from implementing course development that

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touched upon critical concepts of geomatics.

5. Students also gained team work and communication skills they would otherwise lack.
6. A project of more challenging cases covering different scenarios was recommended. It was also recommended to implement the highway design project for years to come.
7. Students preferred presenting their effort in front of class in a professional setting.
8. ABET student outcomes were generally addressed in the survey implemented in this study.

The practical training undergraduate students get from such course development may be extremely beneficial to the industry as well as civil and construction engineering programs worldwide. Larger sample sizes in the future are needed or, at least, additional statistics, such as margin of error. Also, several semester data set with a control group who does not use the project is suggested for comparison purposes.

It is recommended that the long-term benefits of this implementation be measured. This could be done by changing the sample selected to make it cover students who have just finished their senior design capstones and engineers and/or surveyors after few years of college graduation. This might help further understand the benefits of assigning such a project, or any other similar projects in civil engineering courses at the undergraduate level.

It will be a great future idea to enhance the survey tool to draw out information about whether the objectives of such projects were satisfied, what concepts the students used from the course materials, what student outcomes were achieved, etc. that would better describe how the project enhanced learning. It is also valid to tailor the survey instrument to reflect ABET student outcomes in a more direct way.

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