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Lessons Learned From Moving a Civil Engineering Fundamentals Course From Second-Year to the First Year

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Introduction

In 2005, the National Academy of Science recommended implementing first-year engineering courses to "introduce the 'essence' of engineering" early in the curriculum[1]. As a result, engineering colleges have developed various first-year engineering programming from a common first-year experience with multi-disciplinary projects, to a common first-year experience that spans multiple engineering disciplines with smaller projects, or to more discipline specific courses for students with direct matriculation into a specific major. These courses aim to provide an early introduction to the engineering discipline[3] thus positively impacting a student's engineering identity[5], which has been shown to increase student persistence within the engineering field[1].

Applicants to Villanova University's College of Engineering are directly matriculated into their selected engineering discipline (civil engineering, mechanical engineering, chemical engineering, or electrical engineering) but were previously provided with a common first year engineering experience that included two Engineering Interdisciplinary Project courses, one each in their fall and spring terms. While they were directly enrolled in their selected discipline, they were permitted to freely transfer to a different engineering discipline once admitted. This process caused imbalance in upper-level courses as students moved between the disciplines favoring one or two of the four disciplines each year. In addition, admittance criteria differed for various disciplines, and at times, students who transferred to a new discipline were less qualified than other applicants that were not admitted. To maintain a consistent student-to-faculty ratio and a fair admittance policy, Villanova University continues direct matriculation to a specific engineering discipline but now requires students to apply for a transfer between engineering disciplines, and the transfer is not guaranteed but rather based on their credentials and availability in that discipline. Because students cannot transfer as freely, the College of Engineering reduced the Engineering Interdisciplinary Projects course from two required courses to one taken fall of the first year. This allows students to gain exposure to various disciplines with a single Interdisciplinary Projects course, while also creating an opportunity for a discipline specific course in the first-year, which is an advantage of direct matriculation[4]. Students who take a discipline specific first-year engineering course with activities relevant to the identified major may develop stronger beliefs regarding their career choice and expectancy-related beliefs, improving engineering identity[5]. For this reason, the Civil and Environmental Engineering Department elected to move a previously offered second-year course titled Civil Engineering Fundamentals to the second semester of the first-year. This paper presents a before and after comparison of faculty-assessed student proficiency, as well as students' self-assessed proficiency, in select civil engineering technologies taught in the course to better understand how the transition from second-to-first year affected both learning of and comfort with these technologies.

Course Description

The Civil Engineering Fundamentals (Fundamentals) course was developed in response to an informal faculty survey to identify curriculum weaknesses, and it is intended to provide a strong foundation in the civil engineering discipline[6]. It introduces students to tools and techniques, such as surveying, understanding maps and plan sets, field sampling, and data analysis, as required for their civil engineering curriculum as well as throughout their professional career. By incorporating software and surveying skills, the course also provides resume enhancement for first-year students seeking summer internships, which can further enhance their engineering identity[7, 8].

The objectives of the course are as follows:

1. Define the profession of Civil Engineering,
2. Develop fundamental proficiency in mapping using ArcGIS,
3. Develop fundamental proficiency in graphical communication with AutoCAD,
4. Define common surveying terminology and develop basic surveying skills for land planning,
5. Develop and apply probability and statistics for solving civil engineering problems,
6. Develop basic analysis and programming skills in Microsoft Excel,
7. Compile a formal written project report with professionally presented figures, maps, and drawings.

This course was originally offered in the fall of the second-year, meeting twice weekly for a total of four hours per week. One weekly class meeting was 75 minutes and the second was 165 minutes (2 hr 45 min). When the course transitioned to spring of the first-year, the objectives remained the same. However, because the second-year students had previous introduction to topics including AutoCAD, Excel, and ArcGIS in their first year, there was a concern that the first-year students would not be able to grasp the course content as easily as the second-year students. To compensate for this, the Fundamentals course was expanded from 3-credits to 4-credits with an additional 75 minutes (1 hr 15 min) per week of in-class time for a total of 315 minutes (5 hr 15 min). When offered in the first-year, three weekly class meetings were 50 minutes each and offered on a Monday, Wednesday, Friday schedule with the remaining 165 minutes (2 hr 45 min) reserved for a weekly laboratory session.

Additional content that exposes students to the five different subdisciplines of civil engineering (structural, transportation, geotechnical, water resources, and environmental engineering) and the interrelationship of these disciplines was also incorporated in the first-year class. This allows students to develop domain identification – the extent to which students define themselves through a role or performance in activities related to the domain, such as engineering[9]. Domain identification has been linked to positive outcomes in classroom participation[10], higher achievement in grades and academic honors[11], and intention to pursue a career in engineering[12]. Table 1 shows a breakdown of the total course time allocated between topics.

The cohesion of the subdisciplines and importance of the learned technologies including surveying, ArcGIS, AutoCAD, and Excel are demonstrated in a semester long design project. Project-based learning is a type of inquiry-based learning that involves a major assignment in which students, often in teams, take part in the design and/or creation process[13]. Research indicates that project-based learning can result in gains in student achievement, problem solving capabilities and understanding of subject matter[14]. In addition, it can enable students to have a better understanding of the application of their knowledge in practice and the complexities of other issues involved in professional practice[15]. Further, first-year design projects that incorporate a hands-on component serve to increase student motivation and interest and improve students' engineering skills[16]. Thus, the design project is a key element of the course that was kept intact as the course shifted from second-year to first-year.

It is important to note that Fundamentals was designed by the faculty to be an in-person course and it was taught as such for the second-year iteration. However, the first-year iteration was taught during the Spring 2020 semester and was transitioned to an online course for the last seven weeks of the fifteen-week semester due to the Covid-19 pandemic. Possible implications of this transition on the results of this study will be discussed. In addition, future research will be conducted when the course transitions back to full in-person learning to determine the impacts of the virtual learning environment on the course transition.

Table 1. Course time allocated to various learning objectives.

Topic	Course Time Allocated (hours)		Learning Objective
	First-Year (4 credits)	Second-Year (3 credits)	
Maps and Plans	12.6	13.1	Reading and interpreting maps and engineering plans; Understanding, calculating, and applying scale; Creating and interpreting elevation, plan, profile, and cross-section views.
ArcGIS	6.1	5.3	Understanding GIS workspace and coordinate systems; Viewing, creating, and analyzing spatial data; Creating map layouts and establishing scale.
Surveying	8.0	6.8	Understanding survey terminology; Using total stations to collect traverse and profile data; Calculating elevation and coordinates based on raw survey data.
AutoCAD	11.2	9.5	Understanding CAD workspace, drawing set-up and structure; Using basic drawing and modifying commands; Setting up drawing layouts and establishing scale.
Probability and Statistics	10.8	8.0	Understanding common statistical analyses and terminology; Using t-tests, standard normal curves, box and whisker plots and exceedance probability curves to interpret real-world data.
Semester Project	7.5	8.0	Visiting project site to assess existing conditions and design constraints; Working on tasks related to semester-long design project; Understanding and preparing technical reports.
Introduction to Civil Engineering Disciplines	6.1	0.0	Investigating real-world local, national, and global engineering projects; Understanding work performed by structural, water resource, environmental, and transportation engineers.

Rational for assessment of student work

This paper presents the results of multiple assessments implemented to gage the success of transitioning the traditionally taught second-year Fundamentals course to the first-year. A significant part of the analysis was assessments related to civil engineering tools taught in the course, including surveying, ArcGIS, AutoCAD, and Excel. Included in this paper is i) a summary of survey data regarding students' self-identified proficiency in the different technologies both before they were introduced/reinforced and at the completion of the course, ii) a summary of survey data regarding students' perception of the importance of these technologies to complete a semester long project, iii) faculty assessment of students' proficiencies in the different technologies introduced/reinforced in the course, and iv) an evaluation of students' time worked outside of the class.

It was expected that the first-year students would not achieve the same level of proficiency in the course technologies as the second-year students because the second-year students had exposure to AutoCAD, ArcGIS, and Excel in the spring of their first-year and first-year students also may lack the maturity of second-year students. Therefore, two-sample, one-tailed, unequal variance t-tests were used throughout the assessments to determine statistical significance for both student and faculty assessed proficiency. Because this was the first semester long civil engineering project for the first- and second-year students, it was expected that they would have the same perception of the importance of the technologies to completing the project. Therefore, two-sample, two-tailed, unequal variance t-tests were used to determine statistical significance for student perception of the importance of technology to completing the semester project. One data set was considered less than or greater than another data set if the p-value was lower than 0.05.

Students' Self-Perceived Proficiency

An anonymous survey was administered at the start and end of the course to ascertain students' self-identified proficiency in the different technologies (Excel, AutoCAD, ArcGIS, and surveying) targeted throughout the course with a 1 (no proficiency) through 5 (very proficient) rating. The survey was voluntary, and students were not required to answer all questions. Therefore, the number of responses, n, for each course iteration varied from question to question. The survey questions were worded as follows:

- What is your current level of proficiency with Excel?
- What is your current level of proficiency with AutoCAD?
- What is your current level of proficiency with ArcGIS?
- What is your current level of proficiency with surveying?

At the start of the course, both the first-year and second-year students identified with having the highest proficiency in Excel and the lowest proficiency in surveying (Figure 1). While the self-assessed proficiency average scores in Excel and surveying for the first-year students (3.13 ± 0.90 ($n = 60$) and 1.54 ± 0.90 ($n = 59$), respectfully) were numerically lower than that of second-year students (3.37 ± 0.76 ($n = 58$) and 1.73 ± 0.93 ($n = 58$)) at the beginning of the course, the difference was not statistically significant (*p-value* > 0.055). The difference in self-assessed proficiency between first- and second-year students in AutoCAD and ArcGIS was more distinct with the average scores in AutoCAD and ArcGIS for first year students of 1.63 ± 0.90 ($n = 60$) and 1.13 ± 0.43 ($n = 60$) compared to 2.44 ± 0.92 ($n = 58$) and 2.10 ± 0.97 ($n = 58$) for second-year students. These results indicate that the students' self-assessed proficiency in AutoCAD and

ArcGIS at the beginning of the course for first-year students was less than for second-year students (*p-value* $< 2.5X10^{-6}$).

One first-year student reported having no proficiency in Excel; whereas, all of the second-year students had some proficiency. No proficiency in AutoCAD, ArcGIS, and Surveying was reported in 55%, 92%, and 67%, respectfully, of the first-year students, in comparison to 10%, 29%, and 53% of second-year students. It is not surprising that most of the second-year students identified as having at least some proficiency in Excel, AutoCAD, and ArcGIS because 56 of the 61 second-year students enrolled in the Fundamentals course had taken a three credit Introduction to Civil Engineering course in the spring of their first-year. This course included eight assignments that required use of Excel, a 2.5-hour introductory workshop in AutoCAD, and a 2.5-hour introductory workshop in ArcGIS. Civil Engineering Fundamentals is the first course in the curriculum where surveying is taught. Therefore, any exposure to surveying for either the first- or second-year students would have had to come through courses outside of the Civil and Environmental Engineering Department or from prior internship/research opportunities.

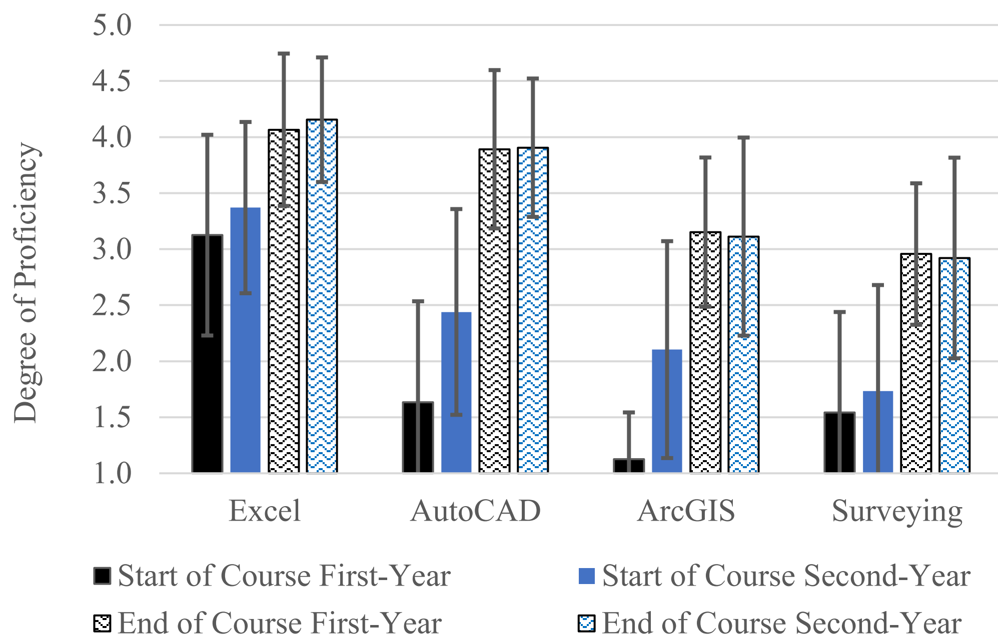

Figure 1. First-year students self-perceived proficiency (average ± standard deviation) in technologies at the start and end of the course.

The average self-reported proficiency scores at the end of the course for the first and second-year students, respectfully, were Excel: 4.07 ± 0.68 (n = 46) vs. 4.16 ± 0.56 (n = 61), AutoCAD: 3.89 ± 0.71 (n = 46) vs. 3.91 ± 0.62 (n = 61), ArcGIS: 3.15 ± 0.67 (n = 46) vs. 3.11 ± 0.88 (n = 61), and surveying: 2.96 ± 0.63 (n = 46) vs. 2.92 ± 0.90 (n = 60). The post-course assessment showed that the second-year students' self-assessed proficiencies were not higher than the first-year students in Excel (*p-value = 0.25*), AutoCAD (*p-value = 0.49*), ArcGIS (*p-value = 0.34*), and surveying (*p-value = 0.33*). Therefore, first-year students entered with the same self-assessed proficiency in Excel and surveying as second-year students and felt as confident using these technologies as their second-year counterparts at the conclusion of the course. In AutoCAD and ArcGIS, first-year students entered with less self-assessed proficiency in

AutoCAD and ArcGIS but were able to feel as confident using these technologies as their second-year counterparts at the conclusion of the course.

Students Perception of Importance of Technology

Another important goal of the course was incorporating the various technologies in a semester-long civil-engineering design project to demonstrate the importance of the technologies in the various civil engineering sub-disciplines. The semester project involved redesigning a walking path on campus to make it compliant with the Americans with Disabilities Act (ADA), while also reducing the risk of flooding from an adjacent constructed stormwater wetland during future storm events. Examples of how the different technologies were incorporated into the design project include using: i) Excel to quantify yearly variations in rainfall per storm event as well as quantify flow rate and pollutant reductions in the constructed stormwater wetland, ii) Surveying to obtain the existing elevations of the walking path, iii) AutoCAD to show the existing walking path profile along with the proposed redesign, and iv) ArcGIS to spatially locate the site and represent the survey data on an aerial imagery basemap.

Perceptions of the importance of the various technologies to complete this project were assessed through anonymous student surveys. The beginning-of-course survey was administered after the students were introduced to the semester long project but before they worked with technologies. The end-of-course survey was administered after the students handed in their final report for the project. The beginning-of-course questions are presented below (with the same questions used for the end-of-course questions except wording was changed to past tense).

- How essential do you think Excel will be for the completion of your design project?
- How essential do you think AutoCAD will be for the completion of your design project?
- How essential do you think ArcGIS will be for the completion of your design project?
- How essential do you think surveying will be for the completion of your design project?

A score of 1 indicated "not essential" and a score of 5 indicated "very essential." The average beginning-of-course scores for the first- and second-year students (Figure 2), respectfully, were Excel: 3.62 ± 0.80 (n = 60) vs. 4.26 ± 0.69 (n = 58), AutoCAD: 4.20 ± 0.80 (n = 60) vs. 4.50 ± 0.60 (n = 58), ArcGIS: 4.35 ± 0.71 (n = 60) vs. 4.47 ± 0.71 (n = 58), and Surveying 4.57 ± 0.67 (n = 60) vs. 4.28 ± 0.77 (n = 58). The first- and second-year students showed no difference in their perception of the essentialness of ArcGIS (*p-value = 0.38*) to complete the project when asked at the beginning of the course. However, there was a difference in first- students' perceived importance of Excel ($p\text{-}value=8.7\ x10^{-6}$), AutoCAD (*p-value = 0.023), and* surveying (*p-value = 0.031*) to completing the project as their second-year counterparts. Average values show that the first-year students perceived Excel and AutoCAD as less important, whereas surveying was perceived to be more important to completing the semester project.

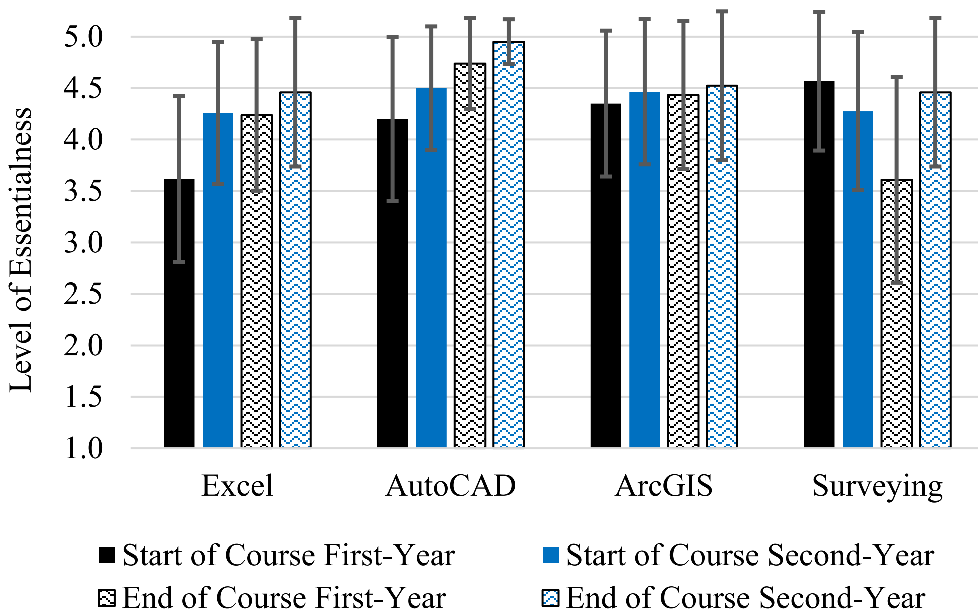

Figure 2. Students' perception (average ± standard deviation) of the essentialness of Excel, AutoCAD, ArcGIS and Surveying to complete the semester long-project.

The average end-of-course scores for the first- and second-year students, respectfully were Excel: 4.24 ± 0.74 (n = 46) vs. 4.46 ± 0.72 (n = 61), AutoCAD: 4.74 ± 0.44 (n = 46) vs. 4.95 ± 0.22 (n = 61), ArcGIS: 4.43 ± 0.72 (n = 46) vs. 4.52 ± 0.72 (n = 61), and surveying 3.61 ± 1.00 (n = 46) vs. 4.46 ± 0.72 (n = 61). There was no statistical difference between the first and second-year students' post-course perception of the level of essentialness of Excel (*p-value = 0.13*) and ArcGIS (*p-value = 0.53*) to complete the semester long civil engineering design project. There was a difference in perception of the importance of surveying ($p\text{-value} = 5.3 \times 10^{-6}$) and AutoCAD (*p-value = 0.0042*) between the first- and second-year students, with average values showing the first-year students viewed these technologies as less essential to complete the semester project compared to the second-year students' perception. The first-year student perception of the importance of Surveying to complete the project dropped significantly from the beginning-of-course to the end-of-course, which is discussed later.

Faculty Assessment of Student Work

Three assessments of student work were used to quantify students' proficiency in surveying, AutoCAD, and ArcGIS[6]. Surveying was assessed for each individual student using a quiz problem (n = 59 first-year students, n = 61 second-year students). The students were provided with raw survey data and were required to process the data and draw a plan view and elevation view of the total station and surveyed point. Proficiency required that the drawings be properly hand-sketched and dimensioned and that the numerical values of point elevation, horizontal distance, vertical distance, and survey point coordinates were accurately calculated.

AutoCAD and ArcGIS were assessed for each semester-long project team using drawing and map components of their final report (n = 11 for ArcGIS first-year and second-year student groups, n = 12 for AutoCAD first- and second-year student groups). In both course offerings, ArcGIS results from one project group were not included in the assessment because they did not submit the required ArcGIS map in their final report. Proficiency in ArcGIS required that the students import, accurately locate, and label spatial data on a properly scaled basemap showing current site conditions and that they include an appropriate title block. Proficiency in AutoCAD required the creation of three orthographic views of a concrete outlet structure located at the project site. Proficiency further required that the views be placed in standard orthographic view positions on the drawing sheet, that the drawings be complete with all visible and hidden lines, properly dimensioned, and drawn to scale, and that they included an appropriate title block. Assessment criteria is outlined in Table 2.

Table 2. Designation of assessment criteria.

Category	Corresponding Grade
Complete mastery of concepts	A (90-100)
Mastery of concepts with minor errors	B (80-89)
Satisfactory attainment of concepts	C (70-79)
Limited attainment of concepts	D (60-69)
Unsatisfactory attainment of concepts	F (below 60)

For the second-year students, all three assessments had comparable average assessment scores (Figure 3): surveying 83.6% ± 15.8%, ArcGIS 86.4% ± 10.7%, AutoCAD 83.1% ± 8.9%. However, the average assessment scores for the first-year students varied: surveying 77.0% ± 22.2%, ArcGIS 90.9% ± 10.4%, and AutoCAD 68.1% ± 14.9%. This assessment of student work indicates that the second-year students did not have greater proficiency than the first-year students in ArcGIS (*p-value = 0.16*). However, attainment of surveying and AutoCAD proficiency was less for first-year students compared to second-year students (*p-value < 0.035*).

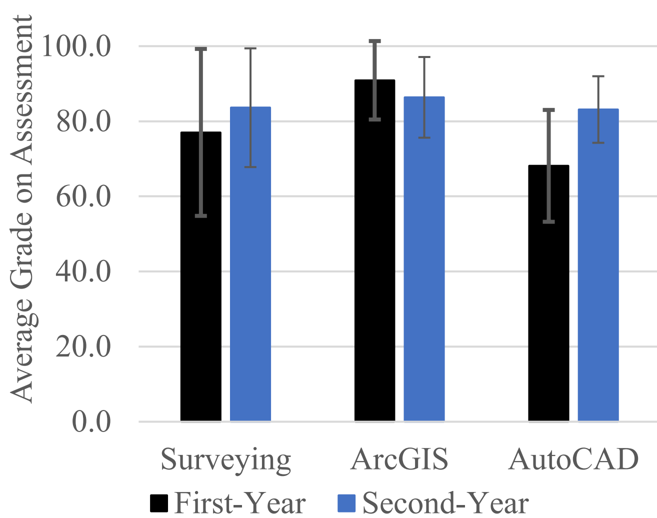

Figure 3 – Average (± standard deviation) grade for three faculty assessments of student work.

Hours Worked Outside of Class

The students' hours spent working on course material outside of class per week were compared for the respective first- and second-year courses. Surveys indicated that the average hours per week that first and second-year students worked outside of the classroom throughout the respective courses was comparable with 3.3 hours per week for the first-year students vs. 3.2 hours per week for the second-year students. This demonstrates that first-year students achieved larger growth in self-assessed proficiency in ArcGIS and AutoCAD (Figure 1) with a similar amount of time spent working outside of class. However, working a comparable amount of time outside of class, in addition to spending more time in class (Table 1), did not result in the first-year students achieving the same level of measured proficiency in AutoCAD and surveying (Figure 3). The average amount of hours worked per week outside of class were greater than the Civil Engineering Department average values of 2.60 (fall 2019) and 2.70 (spring 2020) when the Fundamentals course was respectively delivered to the second-year and first-year students, indicating that this course is more demanding than average departmental courses.

The fact that first-year students achieved larger growth in self-assessed proficiency in ArcGIS and AutoCAD with a similar amount of time spent working outside of class may be a result of the extended in-class course time allocated to these technologies: 15% increase in ArcGIS and 18% increase in AutoCAD and surveying. However, this self-proficiency was not validated with the faculty assessment for AutoCAD.

Discussion

The first- and second-year students had similar pre-course and post-course self-assessed proficiencies in Excel. While the first-year students perceived Excel as less important to completing the semester long project at the start of the course, there was no difference between the first- and second-year student's perception of the importance of Excel to complete the project at the end of the course. Faculty assessment of Excel proficiency was not performed. Based on student assessment only, the first-year students were as successful as the second-year students in achieving Excel proficiency and understanding its importance to the semester project.

Faculty assessment of surveying indicates that first-year students did not achieve the same proficiency as the second-year students. However, the reason for this difference is not immediately evident. Neither set of students had surveying as part of their prior curriculum. The second-year students' pre-course self-assessed proficiency in surveying was not higher than that for the first-year students ($p\text{-}value > 0.055$) suggesting that both first- and second-year students had comparable prior surveying experience. Another possible explanation for the lower faculty-assessed surveying proficiency of first-year students could have been related to the second surveying lab being virtual as opposed to in-person for the first-year students due to the COVID-19 pandemic. The pandemic resulted in 42% of the first-year Fundamentals course being taught virtually, including 45% of the surveying content.

The first-year students perceived surveying as being significantly less important to completion of the semester design project than their second-year counterparts (Figure 2). This may also be related to the first-year students transition to online learning. The second surveying lab, which included collecting surveying data that was essential for their semester long project, was delivered in an online class setting where the survey data was simulated. Because the students were provided with the surveying data in a virtual format as opposed to collecting the data themselves in the field, there could have been a disconnect with the physical meaning of the data. This would result in the students' inability to understand just how integral field surveying is to completion of the semester-long project. Although the surveying exam problem that was assessed did not directly relate to the second survey lab, the first-year students' performance on the assignment may have been negatively affected by not having as much experiential surveying experience as the second-year students. Surveying is not a subject conducive to online instruction but rather better delivered in a hands-on environment.

Faculty assessment of AutoCAD indicates that first-year students did not achieve the same proficiency as the second-year students (Figure 3) despite faculty allocating more class time to the technology. The AutoCAD results are not surprising because most of the second-year students received a 150-minute introduction to AutoCAD their previous semester, which is more than the additional 75 minutes of AutoCAD instruction time incorporated in the Fundamentals course for the first-year students. In addition, some second-year students may have had internships involving AutoCAD during the summer in between their first and second years. Second-year students having more experience in AutoCAD than first-year students was also evident by second-year students assessing themselves as having greater proficiency in AutoCAD than their first-year counterparts at the start of the course (Figure 1).

The AutoCAD portion of the faculty assessment was related to drawing orthographic views of an outlet structure. When the second-year students completed this project assignment, they spent additional time at the site while surveying and had access to the site to verify the construction details and obtain additional dimensions that they may have missed during the original site visit, although data is not available to know how many students took advantage of this opportunity. While first-year students did have physical access to the site to obtain initial measurements, they did not have access to the outlet structure toward the end of the semester because they were in an online format. Faculty did provide access to photographs of the outlet structure with tape measures applied to the various surfaces for the students to interpret. However, this is not equivalent to the students observing and measuring the structure on their own. Virtual instruction in AutoCAD (53% virtual) may have contributed to the lower faculty assessment in this technology as well, although this finding is not consistent for ArcGIS.

In ArcGIS, the students' self-perceived proficiency, faculty assessed proficiency, and importance of the technology to completing the semester-long project were all similar for both first- and second-year students, despite 41% of the instruction in ArcGIS being delivered virtually. It is possible that the students learned ArcGIS as effectively in the virtual classroom as they did in-person. Zoom technology with screen sharing, breakout rooms, remote access to students' computers to instruct and troubleshoot were implemented in the virtual classroom for both ArcGIS and AutoCAD. In addition, both faculty teaching the Fundamentals course when it moved to an online format had taught online classes previously and were comfortable with various modalities of online instruction. This study will be repeated with first-year students when in-person classes resume to determine if the online vs. in-person delivery affects the results.

Part of the curriculum change that resulted in making Fundamentals a first-year course also involved adding separate AutoCAD and ArcGIS courses to the curriculum for upper-class students. Fundamentals is a prerequisite for these two courses. Students will be required to take one of these software courses or an approved equivalency to satisfy a new CEE Software elective requirement added to the department curriculum. The authors feel that the addition of these upper-level courses to the curriculum more than compensates for any potential decrease in learning AutoCAD and ArcGIS caused by making Fundamentals a first-year course. Additionally, future iterations of this course will utilize ArcGIS Pro, the newest version of ArcGIS software, which has an interface similar to AutoCAD and Microsoft Office programs, so the authors anticipate that this more familiar interface may help improve GIS-based learning outcomes for first-year students.

Faculty assessment indicates that the first-year students also did not achieve the same mastery of the surveying concepts in comparison to their second-year counterparts. This may be related to a lack of maturity of the students or because of the online delivery of one of the surveying labs due to the COVID-19 pandemic, as this was the first exposure to surveying in the curriculum for the first- and second-year students. Fundamentals is the only course in the curriculum that includes surveying. Additional course time will be allocated in future offerings of Fundamentals to address this perceived lack of proficiency as well as the decrease in the perceived importance of this technology for the semester-long design project. The additional content may include a 50-minute class on leveling, a 165-minute laboratory class with the total stations and potentially data loggers, and an additional 50-minute class using surveying data from data loggers in association with AutoCAD.

Conclusions

This research indicates that a Civil Engineering Fundamentals course involving Excel, AutoCAD, ArcGIS, and surveying can be successfully transitioned from the second year to the first year, but it may be necessary to provide supplemental instruction time for some course content to achieve the same level of proficiency. During the first offering of the Fundamentals course to the first-year students, student self-assessment and perceived importance of Excel was similar for both the first- and second-year students, and the faculty assessment of student work indicates that first-year students did attain the same level of proficiency in ArcGIS as second-year students. However, first-year students did not attain the same level of faculty assessed proficiency in surveying and AutoCAD as their second-year counterparts. Additional in-class instruction in AutoCAD and surveying will be added to future course offerings to improve proficiency since student worktime outside of the class is already equivalent to that of the second-year Fundamentals students and greater than the departmental average.

While faculty assessed proficiency was lower for surveying and AutoCAD, first-year students reported feeling as confident with ArcGIS, AutoCAD, Excel and surveying as their second-year counterparts. In addition, upper-level courses in ArcGIS and AutoCAD are incorporated into the revised departmental curriculum, so less proficiency in the freshman year may be acceptable for these two technologies knowing that it will be enhanced with the future courses. It is interesting that the first-year students scored lower in faculty assessment in the same two topics that they perceived as being less essential to their semester project. Additional research is needed to determine if these trends are also observed in future offerings of the course. If students understand the importance of these technologies as they relate to the semester project, there may be more commitment to achieving proficiency.

This research provides reflection for department faculty who are developing upper-class software electives and gives them an understanding of the current level of proficiency of students entering these courses. The results of the assessments also provide guidance to implement changes in the

Fundamentals course as well as the Civil and Environmental Engineering curriculum with the goal of positively impacting student learning in fundamental civil engineering concepts and these associated technologies.

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