Pedagogical Techniques Employed in an Engineering Drawing Course

Simon T Ghanat and Kweku Brown
The Citadel

Abstract

A variety of teaching and learning tools were employed to introduce the first year Civil Engineering majors at The Citadel to engineering drawing. These techniques engaged and motivated students to learn the fundamentals of engineering drawing. The effectiveness of various teaching and learning tools was assessed directly by measuring student learning through questions on the final exam and indirectly by examining student responses on a self-perception survey at the end of the course. More than 75% of students rated team project, class-wide tutoring, hands-on activities on Auto-CAD, employing models, and summarizing and correcting misconceptions very highly. The direct assessment of the learning objectives also showed statistically significant gains in learning engineering drawing concepts. The paper will discuss the teaching and learning tools employed, as well as the direct and indirect assessment of course learning objectives.

Keywords

Engineering Drawing, Pedagogical Techniques.

Introduction

The Engineering Drawing course at The Citadel is a two-credit-hour lab course that meets twice per week for two hours. This is a required class for all first year Civil Engineering Majors. The class time is divided between manual and CAD instruction. The sketching is employed to teach concepts and a limited number of tools are used when constructing manual drawings (e.g., triangles, scales, compasses, dividers, and mechanical pencils). Autodesk AutoCAD 2016 was used as the CAD software package. Topics covered in the course include lettering, sketching, orthographic drawings, isometric pictorials, dimensioning, auxiliary views, and section views. Previously, the course was instructed using traditional teaching methods (i.e., lectures with power point slides).

Overview of Effective Pedagogical Techniques

There has been extensive research on effective pedagogical techniques over the past few decades that are relevant to this study. Research shows that Class-wide Peer Tutoring, a widely-used instructional strategy from elementary education settings to college environments, has wide-ranging benefits. This approach assists at-risk students in acquiring literacy skill, retaining material and improving social interaction[1]. Also, class-wide tutoring increases overall productivity[2] and is beneficial to students with disabilities like attention deficit hyperactivity disorder (ADHD)[3]. Another well-practiced technique is project-based learning, which encourages students to play an active role in their learning by applying knowledge through discovery. This method has been found to produce more permanent knowledge acquisition by students[4]. Another effective teaching tool is the one-minute paper. This tool provides instructors with early feedback on student learning and student's perception of the effectiveness of teaching methods[5, 6]. Also, a study by Anderson and Burns reported that students made connections between key class concepts and knowledge being applied to other situations[7]. Similar to the one-minute paper, the Muddiest Point Paper[8] provides feedback to instructors on concepts that students might have a misconception or preconception that need to be retaught or reemphasized [8, 9]. A study by Adam, et al showed that students have a favorable view of the muddiest point assessment and that the reflections have a positive impact in their learning [10]. The methods, techniques and approaches mentioned in this review, as well as other techniques are employed in this study to assess their effectiveness in an engineering drawing course.

Pedagogical Techniques Used

To enhance Engineering Drawing course and improve the student learning environment, a wide variety of teaching techniques and activities were employed. These included incorporating learning objectives directly into the teaching of the course material, clickers, Muddiest Point paper, minute paper, peer instruction, class-wide tutoring, employing "real world" project, think-pair-share, individual and group exercises, and a number of other techniques.

Web-based pre-class reading responses[11] were used to motivate students to prepare for class regularly. Students were required to respond to one open-ended question on the course website prior to each lesson. Before each lesson, student responses were examined, and the in-class activities were tailored to meet their actual needs[11]. Physical models were used to demonstrate key engineering drawing concepts such as the orthographic, isometric, auxiliary and section views. Frequently, clickers were employed to assess the understanding of engineering drawing concepts, create an environment to engage students, and provide immediate feedback to both students and instructor[12]. At the end of each lesson, the One-Minute[13] or Muddiest point [9]paper was used to monitor student learning and address students' misconceptions. Students were typically asked to write a concise summary of the presented topic, or answer a big-picture question from the material that was presented in the current or previous lesson in 60 seconds.

A real world open-ended design project directly linked to the course learning objectives was employed to scaffold student understanding of the key engineering drawing concepts. The project not only stimulated creativity and deep thinking about the material, but also required them to use their engineering judgment. Students were asked to design a rectory structure for a neighborhood church. Each team was required to design a floor plan for the upstairs and downstairs, (including the placement of the stairs) of the rectory living space, where two priests occupy the living space. Teams were also asked to completely remodel the space. The following had to be included in the design: a bedroom and a sitting room for each priest; conversion of the tower room to a useable space; and providing space for a washer and dryer. The floor plan needed to include rooms and closets (with labels); doors, windows, basic plumbing fixtures, kitchen appliances (range and microwave). Dimensions and a title block with essential information needed to be shown on their drawing.

The first day of semester, the class was surveyed to see which students had the most prior experience with AutoCAD. From there, groups of four students were formed and the experienced students were placed as team leaders in each group. The team leader's role was to assist and critique fellow team mates with the course material and report the progress at the end of each class. The instructor then addressed any misconceptions at the beginning of the next class.

Student mastery of the course learning objectives was measured directly through the use of final exam questions. At the end of the course, students were also administered a self-perception survey of the course learning objectives. This indirect instrument was used to gauge student perception (on a five-point scale) anonymously in the areas of the five-course learning objectives (Table 1).

Student Perceived Survey on Course Learning Objectives

Students were asked to self-assess their ability in the areas of the five learning objectives and results are shown in Table 1 and Figure 1. The student self-assessment of course learning goals responses were converted to a percentage scale in the standard way, with a score of 5 being considered equivalent to 100. In this way, an equivalent mean percentage was obtained for the course learning goals 1 through 5. Mean percentage scores for questions 1-5 are 96, 88, 86, 90, and 82, respectively (Table 1).

Direct Assessment of Learning Objectives Scores

Direct assessment of the learning objectives was accomplished through the use of final exam questions and the results are shown in Table 1. Ratings of 82 percent or higher resulted from the direct assessment of the five-course objectives. Mean and standard deviation score for the five learning objectives range from 82 % to 96% and 8% to 15%, respectively. A comparison of the results for the direct and indirect assessment of the five learning objectives is shown in Figure 1. Average scores for the indirect assessments of learning objectives 2 and 3 are slightly lower than those of the direct assessments. It appears that students were modest about their own capabilities with regard to learning objectives 2 and 3. However, the average scores for the indirect assessments of learning objectives 1, 4, and 5 are slightly higher than those of direct assessment.

Table 1. Comparison of Direct and Indirect Assessment of Course Learning Objectives

Course Objectives	Student Self- Assessment of Course objectives	Direct Assessment of Course Objectives
1) How well are you able to develop orthographic drawings?	4.8/5 = 96%	87.6%
2) How well are you able to develop isometric pictorials?	4.4/5 = 88%	90.5%
3) How well are you able to develop auxiliary and section views?	4.3/5= 86%	93.3%
4) How well are you able to dimension basic objects?	4.5/5 = 90%	85.4%
5) How well are you able to solve a well-defined fundamental civil engineering problem?	4.1/5 = 82%	87.3%

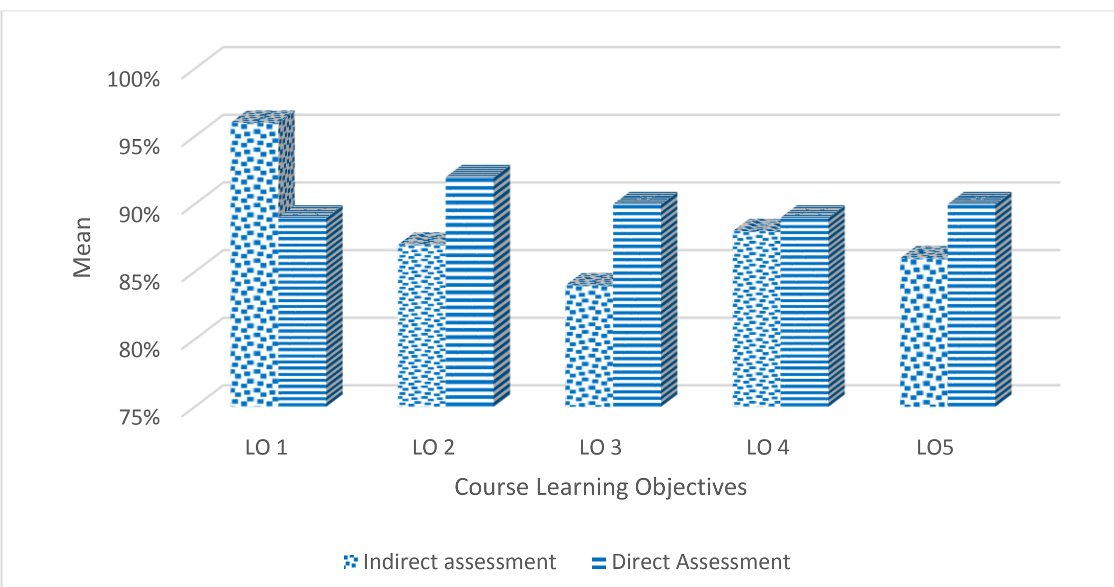

Figure 1. Comparison of direct and indirect assessments

At the end of the course, student's perceptions of various learning tools were also assessed anonymously by examining their responses on a survey. They were asked how effective the various teaching and learning tools were in helping them to learn the course materials. They were also asked to rate each teaching and learning technique as very ineffective, not effective, somewhat effective, effective, or very effective. Overall, student's responses reflected a positive perception of the learning tools. Students rated team project, class-wide tutoring, hands-on activities on Auto-CAD, employing models, and summarizing and correcting misconceptions very highly, with more than 75% rating them as effective or very effective as shown in Figure 2. Only 48% of students rated the web-based pre-class reading responses as very effective or effective.

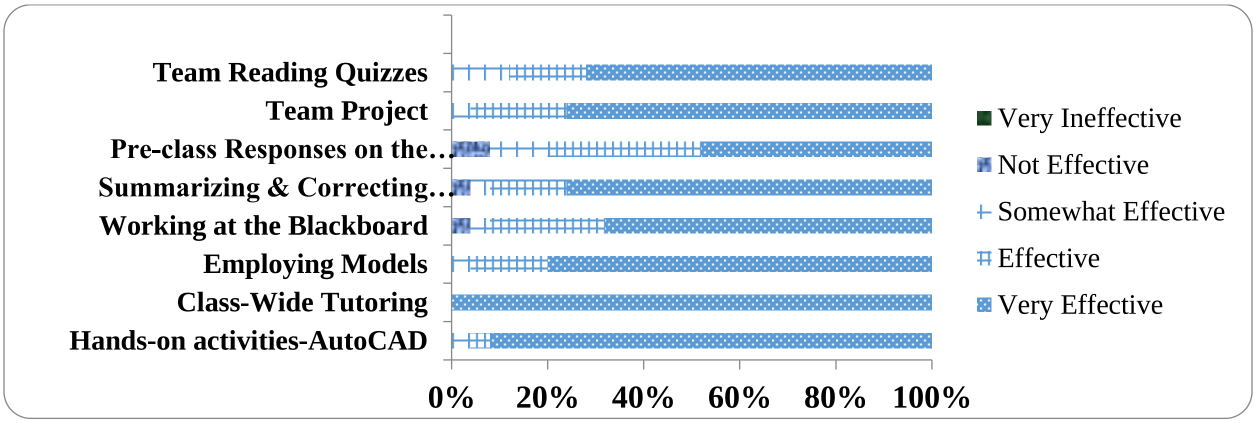

Figure 2. Student rating of various teaching and learning techniques used

Conclusions

A variety of teaching and learning tools were employed in Engineering Drawing course at The Citadel. These techniques engaged and motivated students to learn the fundamentals of engineering drawing. The effectiveness of these techniques was assessed indirectly by examining student responses on a self-perception survey and directly by measuring student learning through the use of questions on the final exam. More than 75% of students rated the team project, class-wide tutoring, hands-on activities on Auto-CAD, employing models, and summarizing and correcting misconceptions as effective or very effective.

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Simon T. Ghanat is an Assistant Professor of Civil and Environmental Engineering at The Citadel in Charleston, South Carolina. He received his Ph.D. in Civil Engineering from Arizona State University (ASU). Dr. Ghanat's research interests are in Engineering Education and Geotechnical Earthquake Engineering. He previously taught at Bucknell University and ASU.

Kweku Brown is an Assistant Professor of Civil and Environmental Engineering at The Citadel. He received his Civil Engineering Master's Degree from the University of Connecticut and his Doctoral Degree at Clemson University. He is an active part of the transportation engineering communities represented by the South Carolina Department of Transportation, the Institute of Transportation Engineers, and the Transportation Research Board. His research focuses on transportation safety utilizing geographic and spatial analysis methods.