Investigating Performance Assessment Practices in Post- Secondary Fundamental Technical Graphics Courses

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Abstract

Performance assessment is a common method of determining proficiency and what students can do with that knowledge. Students in engineering design graphics courses engage in performance tasks, such as creating technical sketches or solid computer models of parts, and instructors must determine how well students can execute tasks aligned with the course objectives. The extant literature contains documented changes in the objectives taught in the classes, skills required for industry, and methods of assessing students' proficiencies in the desired skills. This study examined the current performance assessment practices utilized in post-secondary introduction to engineering design graphics (EDG) courses.

A web-based survey was developed, distributed, and employed to investigate course performance objectives, the importance of performance assessment, type of work assessed, and performance practices in introductory EDG courses. Responses from current introductory EDG instructors provided insights into the current performance assessment methods in introductory EDG courses.

Introduction

Fundamental technical graphics (FTG) courses in post-secondary institutions in the United States have seen significant changes in the content and practice (Clark & Scales, 2006; Barr, 2012) due to the significant changes in technology and policy. The inclusion of constraint based computer aided design (CAD) into the curriculum means that, "Examining print-outs of solid models or drawings is no longer sufficient to determine the correctness of geometry," (Wiebe, Branoff, & Hartman, 2003, pp. 7). Large class sizes in these fundamental courses has led to a variety of approaches to assess student artifacts. These assessments were used to make judgements about student's proficiency that were a part of the student's grade as well as provide data utilized for instructional improvement. Significant portions of student's grades were determined by performance assessment and decisions were made with this data (Baldizan & McMullin, 2005; Elrod & Stewart, 2005).

Discussion of different assessment practices in the literature provide the advantages and disadvantages for each approach but do not explain the extent to which they are being used. The grassroots development of these assessment methods also limit the ability to determine the extent that these methods were utilized. This research helped clarify the type of student artifacts generated and assessment methods utilized in FTG courses.

Methodology

Trochim, Donnelly, and Arora (2015) suggest that surveys are a systematic way to gain information about people's opinions or behaviors through interviews or questionnaires. Performance assessment trends gathered from the EDGD literature were compiled into a questionnaire intended to answer the following research question: What is the status of performance assessment in FTG courses at postsecondary institutions?

The questions for the survey were developed based upon trends discussed in technical graphics performance assessment and rubric literature including Barr's (2012) list of learning objectives that most align with their course's learning objectives, types of student work assessed, assessment methods for this work rubric usage questions. Development of the questionnaire followed Diem's (2002) process for survey development along with Trochim et. Al's (2015) considerations for population, sampling, question, content, bias and administration issues.

Population

The researchers used the 2016 EDGD directory of active members to compile a list of 200 email addresses from which to solicit participants. Fifty members responded, providing a response rate of 25%. Of the 50 responses, 47 taught undergraduate technical graphics courses and 39 of those 47 were currently teaching one of these courses at their university. These 39 respondents met the selection criteria of being current instructors of a FTG course at a post-secondary institution.

Experience was reported as the number of years teaching introductory graphics. The mean experience for this study was 14.59 years (SD = 11.23) and ranged from 1 to 41 years of experience teaching technical graphics. These instructors currently taught between one and six courses per semester (M=1.81, SD=1.06). The academic rank of the participants ranged from graduate teaching assistants to full professor. Academic rank data were self-reported and ranged from lecturer to full professor as seen in *Table 1*.

Table 1. Academic rank of survey population.

Academic Rank	Percentage	Count
Instructor/Lecturer	23.08%	9
Teaching Assistant Professor	5.13%	2
Teaching Associate Professor	5.13%	2
Assistant Professor	12.82%	5
Associate Professor	20.51%	8
Professor	23.08%	9
Other	10.26%	4
Total		39

Results

FTG Course Enrollment. The survey asked the respondents about the number of sections and students per section. The number of sections varied by the university, ranging from 1 to 30 (M=7.76, SD=6.59, n=38), and the average number of students per section reported ranged from 15 to 380 (M=51.31, SD=61.2, n=39).

FTG Student Learning Objectives. Participants selected the objectives that most aligned with their FTG course from the performance objectives, as defined by Barr (2012). The objectives were placed in descending order by the percentage of participants that indicated that it aligned with their course. This ranking can be seen in *Table 2.*

Table 2. Course objectives covered in introductory engineering graphics courses.

Objectives	Percentage
Ability to create dimensions	94.87%
Ability to create section views	84.62%
Ability to sketch engineering objects in freehand mode	79.49%
Ability to visualize 3-D solid computer models	76.92%
Ability to create 2-D computer geometry	76.92%
Ability to create 3-D solid computer models	71.79%
Ability to generate engineering drawings from computer models	69.23%
Ability to perform design projects	56.41%
Ability to create presentation graphics	43.59%

Ability to analyze 3-D computer models	38.46%
Ability to solve traditional descriptive geometry problems	35.90%
Ability to create geometric construction with hand tools	25.64%
Knowledge of manufacturing and rapid prototyping methods	17.95%
Other	17.95%

The “other” category allowed participants to write in their own objectives and yielded responses including, field sketching, creating moving assemblies, teamwork, tolerancing, and the ability to read and understand engineering drawings. From the list of objectives, the first twelve use the term ability, which indicates that the students should be able to demonstrate some sort of performance to meet this objective.

FTG Performance Assessment. Instructors indicated that a strong majority (94.87 percent, *n*=39) of courses require students to use an engineering graphics software as part of their course. When asked: “What percentage of the student's course grade is determined by assignments requiring students to demonstrate technical ability?” the instructors indicated that over half of the student’s course grade is determined by their ability to perform technical tasks (*M*=65.18, *SD*=22.12, *n*=39). The type of technical tasks that the students create in the class were reported in *Figure 1*.

Responses indicate that the majority of fundamental courses require students to turn in technical sketches (92.31%), computer generated assemblies (89.74%), computer generated engineering drawings (69.23%), and computer generated 3D models (69.23%). Far fewer courses require students to turn in physical models created by hand (5.13%) and digitally fabricated models (15.38%). Respondents who selected the other option (12.82%) were given an open-ended text box and their responses included: field sketches, open-ended design project deliverables, written reports, presentations, and working drawing packages.

A range of assessment methods discussed in the literature sparked interest in the way that each type of work is assessed. *Figure 1,* below, shows the responses and reveals performance assessment method trends. A majority of the performance assessment relies on the instructors and teaching assistants. Ault and Fraser (2013), Baxter and Guerci (2003), Goh, Shukri, and Manao (2013), Hekman and Gordon (2013), Kirstukas (2016), and Kwon and McMains (2015) provide multiple discussions about automated systems and their advantages. However, the survey results suggest that these automated grading systems are not yet widespread despite their stated advantages.

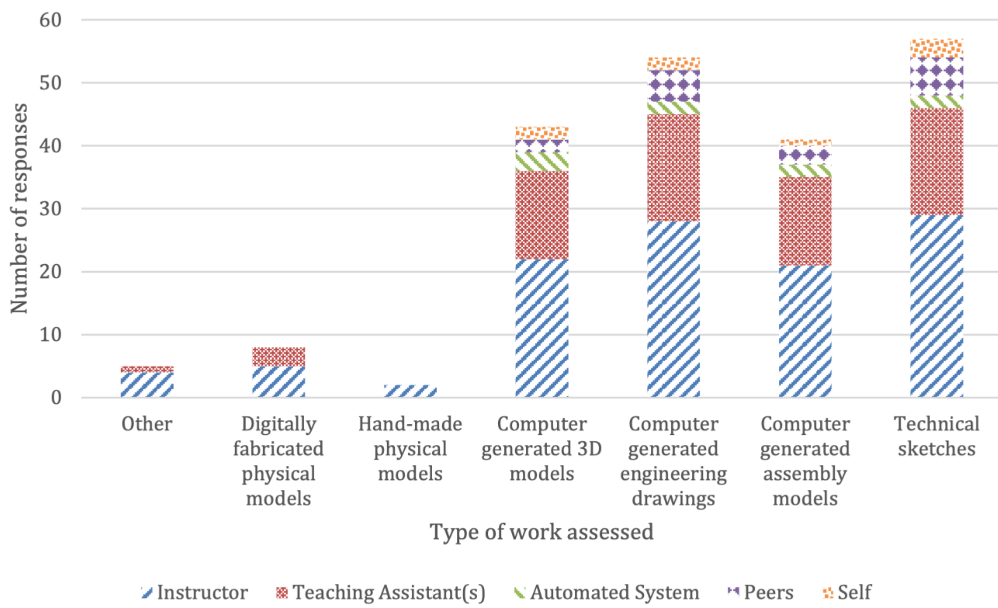

Figure 1. Grading method utilized for different types of work assessed in post-secondary technical graphics courses.

Manual grading methods commonly relied on rubrics in order to define criteria and specify performance that qualifies for each level or grade. A majority of the participants (*n*=39, 79.49%) indicated that they utilize rubrics for assessing student work in their course.

Conclusions

Across universities, the data suggests that these courses have common objectives. A majority of the participants suggest that their FTG course covers dimensioning, section views, 2-D computer geometry, and 3-D solid computer models, how to sketch engineering objects in freehand mode, visualize 3-D solid computer models, generate engineering drawings from computer models, and perform design projects. These results support that most FTG courses are still currently utilizing the top rated outcomes reported by Barr (2012). This study expanded upon Barr's (2012) work by also including types of work and methods employed in these courses to measure these learning outcomes. This study found that the types of work assessed in these courses also shared commonality. Digital and physical models were assessed at a few universities, but the four primary types of student work assessed in FTG courses are technical sketches, computer generated engineering drawings, 3D models, and assemblies. Similarities can be seen across course objectives and types of student work assessed in FTG courses.

Multiple approaches to performance assessment have emerged in technical graphics courses, including computer-automated methods, example Ault and Fraser (2013) and Baxter and Guerci (2003); manual grading with rubrics or checklists, example Barr et al, (2014); verbal protocol analysis, example Menary, Robinson, & Belfast (2011); peer; self; observation; and adaptive comparative judgement. Each of these approaches is thoroughly described in the literature with their advantages and limitations, but it is difficult to tell the extent of their usage. Even though there are many positives, including the speed and accuracy of automated computer grading, the data suggest that these are not widely utilized in FTG courses at this time. However, the survey results from this study support that the majority of the performance assessment is completed by instructors and teaching assistants, with peer assessment in a distant third place. A few universities utilize self- assessment and computer automated assessment systems, but a majority of the performance assessment workload falls to manual grading done by instructors and teaching assistants using rubrics. These results support the need for validated rubrics in fundamental EDG courses as they are the primary measure of student achievement.

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