

Industry Supplied CAD Curriculum: Case Study on Passing Certification Exams

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Abstract

Students who successfully pass professional certification exams while in school are often targeted first by industry for internships and entry level positions. Over the last decade, leading industry suppliers of computer-aided design (CAD) software have developed and launched certification exams for many of their product offerings. Some have also created educational curriculum and resources for educators, such as sample exams and training guides. This case study investigates students' passing rates of two SOLIDWORKS certification exams after utilizing free and openly available educator instructional material in the classroom. The engineering technology students were from Mechanical Engineering Technology and Electrical Engineering Technology degree programs. The Certified SOLIDWORKS Associate (CSWA) exam was administered at the end of a freshman level introduction to graphics course. The Certified SOLIDWORKS Professional Academic (CSWP-Academic) exam was administered at the end of a junior level advanced CAD course. This paper presents a brief description of the curriculum for both courses, including the instructional material and exams. Quantitative and observational outcomes from both courses will also be presented.

Introduction

Are professional certifications worth the time, effort, and cost for students, specifically in higher education? Yes, because certifications can help a student differentiate themselves from their peers, validate their experience and knowledge, increase their marketability, enhance their reputation, credibility, and confidence, prepare them for workplace demands and also help them earn respect (Dassault Systèmes, 2014, Ricci, 2012). They are often incorrectly associated and/or viewed in a similar manner to professional licensure, which is a mandatory credentialing process established by a state government board. Certifications are instead a voluntary credentialing process by a non-government, private professional association. The optimal scenario for many engineering disciplines, such as mechanical, electrical, or civil is that a student, and eventually an engineer, becomes professionally licensed (i.e. PE) and acquires a variety of certifications. In doing so, it displays an understanding of the importance to be a strategically well rounded engineer in the 21st century (Goldberg & Somerville, 2014). However, the reality is that the number of engineers seeking professional licensure is declining (Ricci, 2012).

When a student applies for an internship or their first engineering position, an industry-recognized certification listed on their resume can often be just enough to cause

hiring personnel to take a closer look. Just getting a foot in the door is sometimes the toughest hurdle for young engineers and a certification can serve as the basis for creating employment opportunities. This paper specifically focuses on those certification exams concerned with assessing computer-aided design (CAD) skills. While it is easy to justify the positive side of certifications, some will argue that certifications are just a means for companies and professional societies to gain additional revenue. No matter which side you are on, it is hard to ignore the dramatic increase in certification offerings, especially in the medical, information technology (IT), and engineering fields. Over the last decade many of the leading global companies who offer software solutions for CAD, computer-aided engineering (CAE), computer-aided manufacturing (CAM), and product data management (PDM) have all created certification programs. Table 1 lists the revenue position rankings of several Global 100 Software Leaders that develop CAD, CAE, CAM, and PDM software.

Table 1
Revenue Position Rankings by Year

Company	2014	2011	2010
Dassault Systèmes	15	19	22
Autodesk	18	22	19
Siemens	16	48	N/A
Mentor Graphics	43	77	38
PTC	44	80	36
ANSYS	50	92	58

Notes. (PwC & International Data Corp., 2014, Suhr, 2011)

According to Ault and Fraser (2012), “engineering graphics curricula have changed dramatically in the past three decades” (p. 1). Possibly the most impactful and largest change occurred with the advent of CAD software which could be run on desktop computers. This introduced a widespread introduction of solid modeling software into schools (Chester, 2007). With declining hardware costs and software vendors changing their pricing and marketing structures for educational institutions it has become very hard, if not impossible, to find an engineering-based department/degree that does not include CAD/CAE/CAM technologies in their curriculum. Many of the leading CAD software companies provide free educational use of their products in hope that students will become loyal to the brand and select commercial versions for primary use after graduation.

With increased utilization of CAD software in the industry and significant revenue growth for CAD software developers (see Table 1), one would believe that schools would increase the amount of CAD instruction available. However, “a majority of universities

often find it difficult to devote a significant amount of time to CAD instruction in the curriculum” (Ault & Fraser, 2012, p. 1). It is common for students to only be exposed to CAD software during a freshman introductory graphics/design-based course and a senior capstone course. There are many arguments for and against this case, but are all outside the context of this paper. However, if one believes that it is important and/or valuable for students to pass professional certification exams before graduating, then the most effective and efficient methods of CAD instruction needs to be researched. Results of this case study can be used to aid in the implementation of CAD instruction and to assist faculty in preparing students for certification exams.

CAD Instruction Techniques

There are many different techniques to teach CAD. A common way is by textbook, where students sequentially work through the chapters. The majority of authors will structure the textbooks in a fashion that begins with the basics, such as user interface, part and assembly modeling, and drawing creation (Reyes, 2015). Other texts may be structured to combine the fundamentals of engineering graphics and dimensioning practices in a project-based approach (Planchard, 2015). Some instructors may prefer a *Simon Says* type of instruction. This is where the instructor will execute a command at an instructors’ station while students observe, followed by the students replicating the same action at their stations. This approach is often used to teach command knowledge, which is “referred to as knowledge of the commands (algorithms or tools) and the procedures to use those tools within CAD software” (Chester, 2007, p. 1). “Strategic knowledge is concerned with knowledge of the alternative methods by which a specific task may be achieved and the process by which a choice may be made” (Chester, 2007, p. 1). Both types of knowledge are needed in the development of CAD expertise. Additionally, an instructor may choose to create his or her own classroom material or utilize online resources. As internet access became more available and the World Wide Web grew, publishers have also moved further away from printed textbooks and now offer more e-books. Free online streaming video providers (i.e. YouTube, Dailymotion, Vimeo, etc.) and online learning and teaching marketplaces (i.e. Udemy, Lynda, SolidProfessor, etc.) can also be valuable resources. These services can include free or for purchase instructional material, tutorials, and training for students and educators

Finally, many of the software providers themselves have created free and for purchase educational resources, such as guided tutorials, educational projects, and training guides, to accompany their products (Dassault Systèmes, 2014). The help documents alone, which are often accessible online, are extensive and often contain beginner tutorials (Dassault Systèmes, n.d.-i). Some have even created online portals where a user can create a profile and connect with others, discover new things, share content, or complete self-paced training all in one place (Dassault Systèmes, 2016).

Research Question

The authors are concerned with finding the most effective way to teach CAD to undergraduate engineering technology students. The effectiveness of the instructional techniques is measured by the passing rate of professional certification exams. For this case study, the following was the driving research question:

- Can engineering technology programs produce a higher passing rate than the national average for the Certified SOLIDWORKS Associate (CSWA) and Certified SOLIDWORKS Professional Academic (CSWP-Academic) exams by using free SOLIDWORKS supplied instructional material?

Methodology

Certified SOLIDWORKS Associate (CSWA)

The CSWA is the starting point in the lineup of available certification exams based on the three-dimensional (3D) CAD design software SOLIDWORKS, which is published by Dassault Systèmes. The CSWA, like all other exams, is a practical test that features hands-on challenges in the following areas (Dassault Systèmes, n.d.-a, n.d.-f):

- Drafting competencies
- Basic part creation and modification
- Intermediate part creation and modification
- Advanced part creation and modification
- Assembly creation

Dassault Systèmes also offers an academic version of the CSWA, which is intended for a student with a minimum of six to nine months of SOLIDWORKS experience and basic knowledge of engineering fundamentals and practices (Dassault Systèmes, n.d.-b). The CSWA-Academic is divided into five major categories (Dassault Systèmes, n.d.-a):

- Basic theory and drawing theory
- Part modeling
- Assembly modeling
- Advanced part modeling
- Advanced part analysis

Both versions of the CSWA require a minimal passing grade of 70 percent and are three hours in length. As of July 2016, the national average passing rate, including both CSWA and CSWA-Academic, is 67 percent (personal communication, July 29, 2016).

Procedure and setting.

Two courses were co-located, took place in the Fall 2015 academic semester, and had the same syllabus (i.e. course objectives, grading scheme, etc.). CGT16300 is a three credit course while CGT11000 is a two credit course. The reason for different course labels and credit hours is due to the differences in plans of study between the mechanical engineering technology (MET) and the electrical engineering technology (EET) degrees.

The class took place in a typical CAD classroom/lab, containing desktop workstations (single monitors), white boards, projectors, and printers. The primary author was the only professor of record and prepared for and conducted the course. The class met twice a week for 15 weeks and once in week 16 to take the certification exam. During week 16 there were three different testing sessions offered so that students could have dual monitors during the exam. The 15 weeks were subdivided in the following categories:

- Weeks 1-4: Design Process, Technical Graphics Communications, Sketching, Lettering, and Visualization
- Weeks 5-6: AutoCAD Introduction
- Weeks 7-10: SOLIDWORKS Introduction
- Weeks 11-12: Design Challenge
- Weeks 13-15: CSWA Preparation

Participants.

Fourteen undergraduate students (13 male) enrolled in CGT16300: Introduction to Graphics for Manufacturing, of which 64 percent (N = 9) were freshman (0-29 credit hours), 29 percent (N = 4) were sophomores (30-59 credit hours), 7 percent (N = 1) were juniors (60-89 credit hours), and 0 percent (N = 0) were seniors (90+ credit hours). Twelve were majoring in MET, a major in the School of Engineering Technology at Purdue University and two were undeclared. All participants were registered Purdue University students and took the course at the Purdue Polytechnic New Albany campus.

Five undergraduate students (5 male) enrolled in CGT11000: Technical Graphics Communications, of which 20 percent (N = 1) were freshman, 20 percent (N = 1) were sophomores, 20 percent (N = 1) were juniors, and 40 percent (N = 2) were seniors. All participants were majoring in EET, a major in the School of Engineering Technology at Purdue University. All participants were registered Purdue University students and took the course at the Purdue Polytechnic New Albany campus.

Materials.

Classroom computers had SOLIDWORKS 2014 Education Edition software installed, which included (Dassault Systèmes, n.d.-h):

- SOLIDWORKS Premium (3D CAD software)
- SOLIDWORKS Simulation Premium (FEA tools)
- SOLIDWORKS Flow Simulation (CFD tools)
- SOLIDWORKS Motion (kinematics analysis)
- SOLIDWORKS Plastics (part and mold filling analysis)
- SOLIDWORKS Sustainability (environmental impact tools)
- SOLIDWORKS Model Base Definition (define, organize, and publish 3D PMI)
- SOLIDWORKS Electrical (electrical systems design tools)
- Certified SOLIDWORKS Associate – Academic Certification
- Certified SOLIDWORKS Professional – Academic Certification

The CSWA (the non-academic version) was the administered exam. The instructor is a SOLIDWORKS academic certification provider and received free vouchers for the exam. Exam vouchers were distributed to the students by the instructor. The license subscription also enabled the instructor to offer students access to SOLIDWORKS software outside of the classroom by installing the software on one personal device (Dassault Systèmes, 2013e).

During weeks 7-12 (SOLIDWORKS introduction), the instructor utilized the CAD Student Guide (Dassault Systèmes, 2013b) and the detailed drawing exercises booklet (Dassault Systèmes, n.d.-e). Both are free and distributed online by Dassault Systèmes along with additional curriculum and lessons. The accompanying CAD Instructor Guide contained lesson plans, PowerPoint presentations, student goals, vocabulary worksheets, lesson quizzes, and answers sheets (Dassault Systèmes, 2013a). Only the lessons (i.e. 1-4 and 9-10) that were determined to cover material needed for the CSWA were assigned in class. Typically, each week (two class meetings) consisted of the following outline:

- Class 1:
 - a) Instructor presented the lesson(s) overview PowerPoint to the students.
 - b) Students were assigned to complete the lesson(s). The instructor emphasized following the guide with great detail and accuracy.
 - c) Instructor displayed and discussed modeling practices/procedures for any *widgets* that were assigned (see Day 2/c).
- Class 2:
 - a) Class reviewed the previous lesson(s).

- b) Instructor displayed and discussed modeling practices/procedures for the corresponding models provided in the lesson(s).
- c) Students were assigned *widgets* from the detailed drawings exercises booklet to 3D model.

During weeks 11-12 (Design Challenge), the instructor introduced an individual project-based assignment (see Figure 1). Students were tasked with identifying an opportunity for reverse engineering a mechanical device used in their daily lives. During the reverse engineering process, students had to add value to the original design. This could be accomplished in many ways, such as, integrating additional hardware or improving overall form, fit, and/or function. Students were required to use SOLIDWORKS to model the entire original design and all value-added modifications. It was required that they create both part and assembly files. Finally, the student had to use the rapid prototyping (3D printers and laser cutter/etches) and subtractive manufacturing equipment in the lab to produce a prototype of their value-added reverse engineered product and then present their work to the class.



Figure 1. Design challenge project sequence

During weeks 12-15 (CSWA Preparation), the instructor reviewed the CSWA competencies and administered three free CSWA practice exams. The first two were taken and converted to a Blackboard exam, while the third was taken in the Tangix VirtualTester (Tangix Design & Development, n.d.). The first practice exam was six questions and had a three hour limit (Dassault Systèmes, 2007). The second practice exam had seven questions and a three hour limit (Short & Pritchett, 2010). The third practice exam had eight questions and 90 minute limit (Dassault Systèmes, n.d.-f). A week-long Thanksgiving break was also included during this time frame.

Certified SOLIDWORKS Professional (CSWP)

The CSWP is the next level of available SOLIDWORKS certifications. The CSWP is taken in three individual segments and features hands-on challenges in the following areas (Dassault Systèmes, n.d.-c, n.d.-g):

- Segment 1
 - o Creating a part from a drawing
 - o Using linked dimensions and equations to aid in modeling
 - o Using equations to relate dimensions

- o Updating parameters and dimension sizes
- o Mass property analysis
- o Modifying geometry on initial part to create a more complex part
- o Modifying parameters on the part at different stages while maintaining all other dimensions and design intent
- Segment 2
 - o Creating configurations from other configurations
 - o Changing configurations
 - o Creation of configurations using a Design Table
 - o Mass properties
 - o Changing and/or rearranging features of an existing SOLIDWORKS part
- Segment 3
 - o Creating an assembly
 - o Adding parts to an assembly
 - o Doing collision detection when moving a part in an assembly
 - o Interference detection
 - o Basic and advanced mates
 - o Rigid and Flexible subassemblies
 - o Replacing a part with another part in an assembly
 - o Creating a coordinate system
 - o Using a coordinate system to perform mass properties analysis

Dassault Systèmes also offers an academic version of the CSWP, which is intended for a student with a minimum of one to two years of SOLIDWORKS experience and advanced knowledge of engineering practices (Dassault Systèmes, n.d.-d). The CSWP-Academic covers the same topics as the CSWP and can be taken as a three-hour exam or divided into three part segments.

Both versions require a minimal passing grade of 75 percent on each segment. As of July 2016, the national average passing rate, including both CSWP and CSWP-Academic, is 64 percent (personal communication, July 29, 2016).

Procedure and setting.

MET30200, a three credit hour course took place in the Spring 2016 academic semester. The class took place in a typical CAD classroom/lab, containing desktop workstations (single monitors), white boards, projectors, and printers. The primary author was

the only professor of record and prepared for and conducted the course. The class met twice a week for the first six weeks and as needed for the following 10 weeks. During week 16 all students took the CSWP together. The 16 weeks were subdivided in the following categories:

- Weeks 1-6: SOLIDWORKS Mountainboard Project
- Weeks 7-16: Design Challenge

Participants.

Eleven undergraduate students (10 male) enrolled in MET30200: CAD in the Enterprise, of which all were seniors (90+ credit hours) and majored in MET. All participants were registered Purdue University students and took the course at the Purdue Polytechnic New Albany campus.

Materials.

Classroom computers had SOLIDWORKS 2014 Education Edition software installed. The CSWP-Academic was the administered exam, and the instructor received free vouchers for the exam.

During weeks 1-6 (SOLIDWORKS Mountainboard Project), the instructor utilized the Mountainboard Student Guide (Dassault Systèmes, 2013d). The guide is free and distributed online by Dassault Systèmes along with the accompanying Mountainboard Instructor Guide (Dassault Systèmes, 2013c). All the lessons (i.e. 1-9) were assigned. After completing the guide, each student should have the skills needed to create 3D solid models and assemblies, fully define 2D dimensional drawings from 3D geometry, conduct simple static simulations, analyze motion, and clearly communicate their design intent with powerful visuals, such as animations and photorealistic renderings. Typically, each week (two class meetings) consisted of the following outline:

- Class 1:
 - a) Instructor presented the lesson(s) overview PowerPoint to the students.
 - b) Students were assigned to complete the lesson(s). The instructor emphasized following the guide with great detail and accuracy.
- Class 2:
 - a) Class reviewed the previous lesson(s).
 - b) Instructor displayed and discussed modeling practices/procedures for the corresponding models provided in the lesson(s).
 - c) Instructor administered an online quiz in regard to that weeks' lesson(s)

- d) Students were assigned to complete the lesson(s). The instructor emphasized following the guide with great detail and accuracy.

During weeks 7-16 (Design Challenge), the instructor introduced a group project-based assignment (see Figure 2). The groups were presented with a fictional customer, who was a professional mountain boarder and sporting goods store owner. The customer asked each group to make the following changes (i.e. scope change) to the mountain-board:

- Increase product value (i.e. increase potential sales)
- Increase rider safety
- Increase rider stability (does not count towards increased safety)
- Increase manufacturability
- All drawings shall be IAW ASME Y14.100-2004 (no GD&T)
- Transition from purely mechanical to electromechanical (optional)



Figure 2. Design challenge project sequence

The objective of the project was to prepare students for industry-based design practices which generally occur prior to detailed prototyping and/or production manufacturing. Each team had to deliver a mind map, preliminary design review (PDR), and critical design review (CDR).

Results

Certified SOILDWORKS Associate

Eleven undergraduate students (10 male) completed CGT16300 (three freshman students withdrew) and took the CSWA at the end of the semester. Four undergraduate students (4 male) completed CGT11000 (one freshman student withdrew) and took the CSWA at the end of the semester. The class as a whole (N = 15), passed the CSWA on the first attempt with a passing rate of 60 percent (N = 9; CGT16300 = 6; CGT11000 = 3). Students who retook the exam (N = 4; CGT16300 = 3; CGT11000 = 1) passed at a rate of 100 percent. Two students did not attempt a retake. Including the retakes, the course had an 86.67 percent passing rate.

Certified SOLIDWORKS Professional

Ten undergraduate students (9 male) completed MET30200 (one student withdrew).

Table 2
Exam Results: First Attempt

Class # of test takers	Passed CSWA Count (Class Percent)	Passed CSWP-Academic Count (Class Percent)
CGT16300, N = 11	6 (54.54)	N/A
CGT11000 N = 4	3 (75.00)	N/A
MET30200 N = 8	N/A	5 (62.50)

Table 3
Exam Results: Second Attempt

Class # of test takers	Passed CSWA Count (Class Percent)	Passed CSWP-Academic Count (Class Percent)
CGT16300, N = 3	3 (100.00)	N/A
CGT11000 N = 1	1 (100.00)	N/A
MET30200 N = 0	N/A	N/A

Eight took the CSWP at the end of the semester (one took the CSWA and one had previously passed it). The class passed the CSWP on the first attempt at a rate of 62.5 percent (N = 5). No student attempted a retake.

Discussion

The authors are concerned with finding the most effective way to teach CAD to undergraduate engineering technology students. The effectiveness of the instructional techniques is measured by the passing rate of professional certification exams. In this case study, the methodology developed engineering technology students' SOLIDWORKS expertise to a level in which they will pass the CSWA and/or the CSWP-Academic exam on average with the national passing rate (first attempt).

There are many uncontrollable variables that may influence the results, such as students' prior CAD experience or the course instructor, who may be less or more qualified, motivated, and/or experienced. To ensure homogeneity between groups, prior CAD experience needs to be collected at the beginning of the course if group comparisons by year/semester are to be studied.

Positives of using the stated methodology include:

- The supplied guides and exams were free to the instructor and students.

- Students developed best modeling practices through the guides' step-by-step instructions.
- The design challenge offered an open-ended task where students could push their limits and also freely explore more advanced SOLIDWORKS features.
- The design challenge showed students, in a simple manner, how they might apply their education after graduation.

The following questions can be used as a guide for future research:

- Does additional published research on CAD instruction techniques and the passing rates of professional certifications by different software packages and student/instructor demographics exist?
 - a) Are CAD professional certifications too young that research is still taking place?
 - b) Is the impact and utilization of CAD in the classroom still evolving?
- Are professional certifications, specifically those concerned with CAD, valued by the industry?
 - a) How does the level of value change between interns, new hires, and entry/senior engineers and why?
 - b) How do they affect promotions and salaries? Why?
 - c) Do the findings change based on industry and/or geographical region (local, regional, national)? Why?
- Does the design project help or hurt the passing rates? Why?
 - a) Would replacing the design project with more defined (i.e. closed ended) assignments, such as more 3D *widget* modeling and assembly modeling help or hurt passing rates? Why?
- What are the passing rates of other engineering technology programs?
 - a) What are they doing differently

Conclusion

In conclusion, a case study was conducted on students' passing rates of two professional certification exams (CSWA and CSWP-Academic) when the instructor utilized free industry supplied CAD instructional material (i.e. guides and practice exams). Engineering technology students passed the CSWA at a rate slightly below (i.e. 60 percent) the national average (i.e. 67 percent) on first attempt and significantly above after one re-take (86.67 percent). Students passed the CSWP at a rate comparable (62.50 percent) to the national average (64 percent) on the first attempt. Results of the case study have

uncovered the need for additional research on the most effective and efficient methods of CAD instruction for post-secondary education.

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