

An Investigation into the Value and Benefits of the SOLIDWORKS Certification Program

Dr. Joseph Rudy Ottway, Murray State University

Dr. Rudy Ottway is an assistant professor in the Institute of Engineering at Murray State University in Murray, KY. He teaches SOLIDWORKS, AutoCAD, and engineering drawing in the Engineering Graphics and Design program. Prior to academia, he worked as a CAD Analyst with Science Applications International Corporation in Huntsville, AL. He completed a B.S. in Engineering Graphics and Design and a M.S. in Management of Technology from Murray State University, and a Ph.D. in Technology Management with a specialization in Manufacturing Systems from Indiana State University. His research interests include computer-aided design (CAD), computer-aided manufacturing (CAM), additive manufacturing, product design and development, and experiential learning.

Dr. Rustin Webster, Purdue University, New Albany

Dr. Rustin Webster is an assistant professor in the Purdue Polytechnic Institute at Purdue University and specializes in mechanical engineering and computer graphics technology. Dr. Webster's industry experience includes time as a contractor for the Department of Defense as an engineer, project manager, and researcher. He holds a B.S. in Engineering Graphics and Design and a M.S. in Management of Technology from Murray State University, and a Ph.D. in Interdisciplinary Engineering from the University of Alabama at Birmingham. Dr. Webster has received various professional certifications from the American Society of Mechanical Engineers, SOLIDWORKS, and the Project Management Institute. His research interests include ET outreach (e.g., recruitment and retention) and design education with focus areas in CAD, instructional techniques (e.g., project-based learning), and technology.

An Investigation into the Value and Benefits of the SOLIDWORKS Certification Program

Abstract

This descriptive research study explores the perceived value and benefits of the SOLIDWORKS certification program for students and working professionals. In the last decade, computer-aided design (CAD) certifications have grown in availability and popularity, and CAD software vendors and resellers have made bold claims concerning their value. However, minimal evidence-based research has been conducted to explore the actual value gained from obtaining such a certification. This study involved the use of an online survey given to a cross-sectional sample of certified SOLIDWORKS professionals located in the western region of the United States. Students, educators, and SOLIDWORKS employees and resellers were excluded in an attempt to reduce survey bias. LinkedIn® InMail™ messages containing the survey link were sent to 182 individuals, of which 36 (19.78%) responded. Results show respondents generally perceive SOLIDWORKS certifications as valuable and the benefits of obtaining a certification outweigh the cost. Students achieving a SOLIDWORKS certification may experience a competitive advantage over non-certified candidates when applying for a job. Earning a SOLIDWORKS certification demonstrates a benchmark skillset and indicates a candidate's level of interest in professional development. In general, this paper sheds light on an emerging academic and professional development trend and more specifically, calls for additional research studies investigating the impact of vendor-controlled certification programs.

Key words: Computer-Aided Design (CAD), Professional Certification, Industry Value, SOLIDWORKS, Professional Development

Introduction

Computer-aided design (CAD) software lies at the heart of the engineering design process. CAD software has myriad uses and spans a variety of industrial sectors. Since its inception CAD software has continuously evolved to meet the needs of its users and their applications. Patrick Hanratty, credited as the father of CAD and computer-aided manufacturing (CAM), developed Program for Numerical Tooling Operations (PRONTO) and automated drafting and machining (ADAM), two significant contributions to the idea and utilization of CAD [1]. PRONTO was developed in 1957 and is one of the first computer-numerical control (CNC) programs [1, 2]. Mr. Hanratty started Manufacturing and Consulting Services (MCS) in 1971 and created the drafting software ADAM [2, 3]. In 1964, Dr. Ivan Sutherland created one of the first CAD systems, Sketchpad, allowing a human-machine interaction to create graphics [4]. Since the creation of PRONTO, Sketchpad, and ADAM, many CAD software companies have come and gone, but Dassault Systèmes, Autodesk, PTC, and Siemens AG have emerged as industry leaders in the production of CAD software for mechanical design applications.

A group of engineers left Dassault Aviation to form the Dassault Systèmes company and developed CATIA CAD software in 1981 [5]. Dassault Systèmes acquired SolidWorks Corporation in 1997 [6]. SolidWorks Corporation was started by John Hirschtick in 1993 in Winchester, Massachusetts [7, 8]. The first version of SOLIDWORKS CAD software was

released in 1995. Dassault Systèmes [8] states there are “more than 3,246,750 product designers and engineers worldwide, representing 240,010 organizations” that use SOLIDWORKS CAD software.

Autodesk was formed in 1982 and AutoCAD CAD software was released in December of the same year [9, 10]. Autodesk also produces Inventor 3D CAD software and Fusion 360 for mechanical design applications. PTC traces its roots to 1985 and the formation of Pro/ENGINEER in 1988 [11]. Brunelli [11] states that PTC rebranded Pro/ENGINEER in 2010 with the name PTC CREO. Siemens AG began in 1847 but engaged in CAD software with acquisitions of Unigraphics (NX CAD software) and Solid Edge in 2007 [12-14].

CAD Certifications

An emerging trend in the CAD software industry are certifications. Certifications can be achieved by successfully passing an exam. Exams are typically generated from the CAD software company and can be taken online and/or through a certified testing center. Certification exams require requisite knowledge, application, and use of the particular CAD software for which the exam is being performed. Depending on the type of certification, the exam may test a user’s ability to model and modify 3D parts and assemblies, create and manipulate 2D drawings, and/or execute specific commands within the CAD software environment. Autodesk, Dassault Systèmes, PTC, and Siemens AG all offer certification exams.

SOLIDWORKS Certification Program

The purpose of this paper is to investigate the perceived value and benefits of the SOLIDWORKS certification program. The SOLIDWORKS certification catalog currently offers 17 unique certifications (see Figure 1). Users wishing to start their SOLIDWORKS certification journey may begin with the SOLIDWORKS Certified Associate (CSWA) level certification as it is the beginner or entry-level certification. Within the CSWA category, users can become certified in additive manufacturing, electrical, sustainability, and simulation. SOLIDWORKS also offers an academic version of the CSWA targeted specifically at students. The intermediate or mid-level certification is the SOLIDWORKS Certified Professional (CSWP). Within the CSWP category users can become certified in model-based definition, simulation, sheet metal, weldments, surfacing, mold making, and drawing tools. SOLIDWORKS also offers an academic version of the CSWP targeted specifically at students. For users seeking a certification in product data management (PDM), SOLIDWORKS offers the Certified PDM Professional Administrator exam. The advanced or top-level certification is the Certified SOLIDWORKS Expert (CSWE). For a user to attempt the CSWE they must have 1) successfully passed the CSWP and 2) successfully passed at least four of the CSWP advanced topic exams. Users can gain access to an exam voucher by 1) purchasing it online, 2) having it supplied by a certified testing center, 3) retrieving it through the SOLIDWORKS Customer Portal, 4) attending SOLIDWORKS World, or 5) being given one from a SOLIDWORKS employee or another representative of SOLIDWORKS. [REDACTED] [15] provide an overview of SOLIDWORKS certification pricing and further details. According to the SOLIDWORKS Certification Center there are, at the time of this writing, 232,168 CSWA, 100,997 CSWP, and 3,693 CSWE users world-wide.

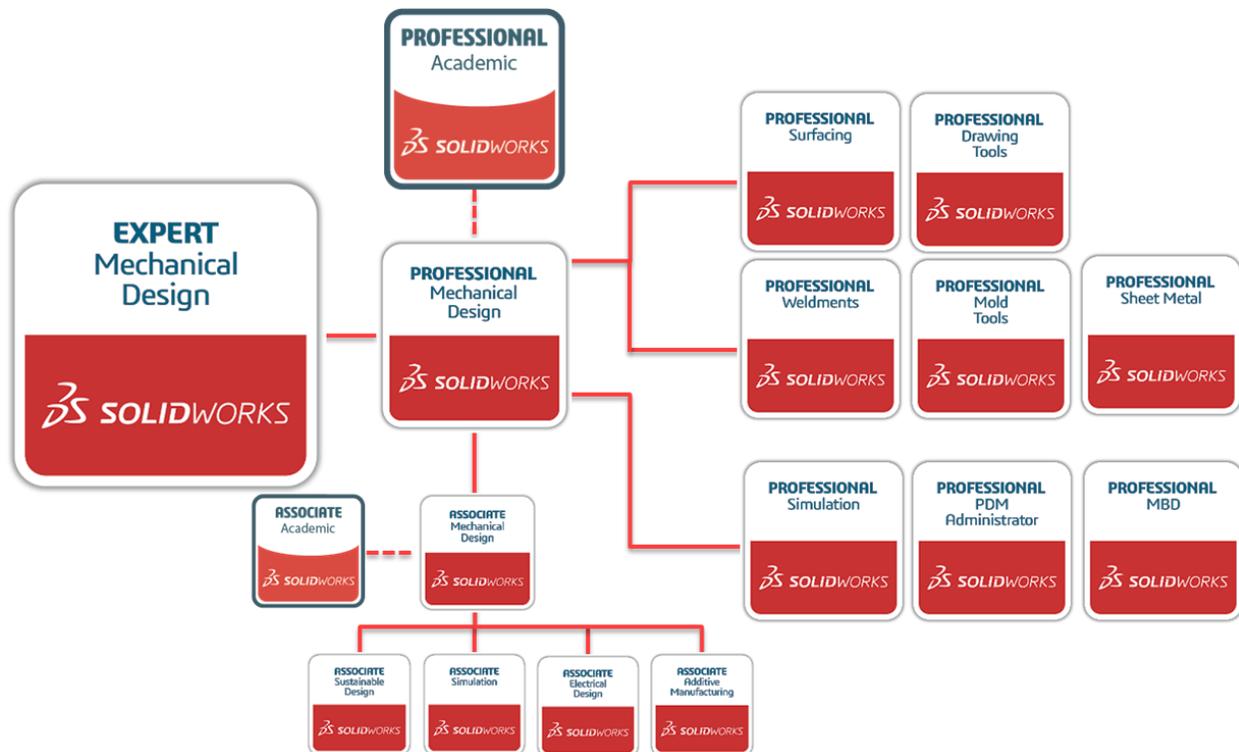


Figure 1. SOLIDWORKS Certification Catalog

Review of Literature for CAD Certification

To promote exams, CAD software companies have marketed perceived benefits of achieving a certification in their respective CAD software. Obviously, CAD software companies feel that there is value in becoming certified and claim that it provides users with an advantage. Autodesk offers certifications in AutoCAD, AutoCAD Civil 3D, Inventor, Fusion 360, Revit, Maya, and 3ds MAX [16]. Autodesk [17] suggests that a certification helps “prove your skill level and can get you hired” or “accelerate your professional development and help enhance your credibility and career success.” Siemens [18] asserts, “Solid Edge certification enhances the competitive edge and reputation of both users and organizations, and provides an industry recognized credential that both professionals and students can use to enhance their careers.” Dassault Systèmes [19] claims, “earning a SOLIDWORKS Certification can help you get a job, keep a job, or possibly move up in your current job” and achieving a certification validates competency and knowledge of the software. One might think that only CAD software companies are encouraging users to become certified to increase revenue or capture new customers, but working professionals also express their opinion on the positive benefits of achieving certifications. Archer [20] implies that a SOLIDWORKS certification adds value to a resume, instills confidence on the job, and establishes a universally recognized skillset. While not specifically discussing CAD certifications, Ricci [21] believes, “that engineering certifications are a way for professionals to distinguish themselves and to validate their experience, skill, and knowledge in a specific field.” Ricci [21] references Qualified Engineer, Prometric, and HR.com, each highlighting the benefits of achieving a certification.

There are very few empirical studies that exist to provide evidence of either 1) supporting the positive benefits of a CAD certification or 2) establishing that a certification does not provide value to the holder. Trent [22] investigated “the perceived effect of industry recognized Computer Aided Drafting (CAD) certifications among community college drafting instructors and employers Trent [22]” and concluded that there is “no significant benefit to attaining such certification [22].” Trent [22] included only 14 community college drafting instructors and 12 drafting employers; a relatively small sample size that compares the perceptions of the value of drafting certifications of the community college drafting instructors to employers. Interestingly, Trent [22] suggests that drafting instructors neither agreed nor disagreed that a drafting certification was an asset. “Employers, however, somewhat agreed that certification was of value when hiring drafters [22].”

Dassault Systèmes and the Global Learning and Academic Organization conducted a survey in 2014 to investigate the impact of certification on people’s career [23]. The survey was sent to over 7,000 certified professionals worldwide and the respondents were grouped into two categories which include 1) employed people and 2) individuals [23]. Dassault Systèmes [23] concludes that, “certification resulted in significant opportunities for certified people.” Specifically, the survey states the “benefits were 1) increased employability and better job opportunities, 2) salary increase and better paid jobs, and 3) recognition within the company and among peers [23].”

[REDACTED] [15] conducted a survey of certified SOLIDWORKS users in the midwest region of the United States to investigate the value to undergraduate engineering students when obtaining a SOLIDWORKS certification. Results from this study include:

- 91.38% (53 of 58) of the respondents indicate that a SOLIDWORKS certification is valuable.
- 94.45% (52 of 55) of the respondents feel that the SOLIDWORKS certification program offers a benefit to students; 65.45% (36 of 55) indicate moderate to extreme benefit.
- 98.11% (52 of 53) of the respondents indicate that a SOLIDWORKS certification is valuable during the hiring process.

Of the respondents indicating that a SOLIDWORKS certification is valuable, the following items, listed in order of importance, were beneficial during the hiring process [15]:

1. Demonstrates benchmark skills
2. Reduces internal training and/or mentoring time
3. Provides a competitive advantage and places the candidate ahead of the competition
4. Serves as an eye catcher on a resume
5. Indicates interest in personal professional development

Interestingly, only 8.62% (5 of 58) of respondents indicated that there was no value in a SOLIDWORKS certification and only 1.89% (1 of 53) indicated that a SOLIDWORKS certification was not valuable during the hiring process [15].

Definitions

- Computer-Aided Design (CAD) (*v or n*) *computer-aided drafting, computer-aided design, or computer-aided design/drafting*. The usage depends on the context in the design process and on whether the acronym refers to the physical computer system or the activity of using such a system to support technical and engineering graphics [24]
- CAD Software (*n*) *CAD program*. Software that replaces manual drafting with a digital process using computer technology, such as SOLIDWORKS, Inventor, Fusion 360, Solid Edge, Creo, or Onshape [25]
- CAD Certification (*n*) *CAD certificate*. Industry recognized credentials obtained by passing interactive online or in-person exams that test an individuals' competency in the use of a specific version of CAD software [26]
- User (*n*). An individual who currently has or has had experience with CAD, CAD software, and/or CAD certifications
- Value (*n*). Relative worth, utility, or importance [27]
- Benefit (*n*). Something that produces good or helpful results or effects [27]

Methodology

[REDACTED] [15] should be referenced for complete study design, respondent selection, and data instrument details as this paper provides only a synopsis. This descriptive research study involved an online, cross-sectional study of SOLIDWORKS users located in the SOLIDWORKS Certification Center and from the western region of the United States. States included are Alaska, California, Colorado, Hawaii, Idaho, Montana, Nevada, Oregon, Utah, Washington, and Wyoming. The authors selected these users because 1) they are working professionals employed in an engineering-related field, 2) they earned, at minimum, a CSWP certification, and 3) they currently have or have had experience with SOLIDWORKS. Students, educators, and SOLIDWORKS employees and resellers were excluded in an attempt to reduce survey bias.

The target sample for this study consisted of 296 CSWPs and 54 CSWEs. The survey was sent by InMail, a messaging service for connected LinkedIn users, to 182 users. Thirty-six (19.78%) provided feedback, at some level (i.e., answering all questions was not mandatory), for the survey and met all inclusion criteria (see Table 1). See Figure 2 for the range of SOLIDWORKS certifications held by the respondents. The survey given in [REDACTED] [15] was slightly modified to include additional questions concerning the respondents' involvement in the hiring process (see Figure 3) and at which level of education the respondents had encountered a SOLIDWORKS certification exam(s) (see Figure 4).

Table 1. Respondent Demographics

Category	Count (%)	Category	Count (%)
Gender		Employment status	
Male	35 (97.22)	For-Profit Company	34 (94.44)
Female	1 (2.78)	Self-Employed	2 (5.56)
Ethnicity		Licensure status	
White	27 (75.00)	None	18 (50.00)
American Indian or Alaska Native	1 (2.78)	Engineer-in-training	15 (41.67)
Hispanic or Latino	5 (13.89)	Professional Engineer (PE)	2 (5.56)
Asian or Pacific Islander	3 (8.33)	Other	1 (2.78)
Age range (years)		Professional experience (years)	
18-25	4 (11.11)	Less than 1	0 (0.00)
26-34	17 (47.22)	1-3	4 (11.43)
35-54	12 (33.33)	3-4	1 (2.86)
55-64	3 (8.33)	4-8	12 (34.29)
Education level		8-10	3 (8.57)
No degree	3 (8.33)	10-15	7 (20.00)
Associates	5 (13.89)	15-20	3 (8.57)
Bachelors	19 (52.78)	20+	5 (14.29)
Masters	9 (25.00)	Career field	
Involved in the hiring process¹		Engineering	33 (94.29)
Yes	19 (52.78)	Utilities	1 (2.86)
No	17 (47.22)	Transportation or warehousing	1 (2.86)

Notes. N = 36, response rate = 19.78%, ¹ in current position/job

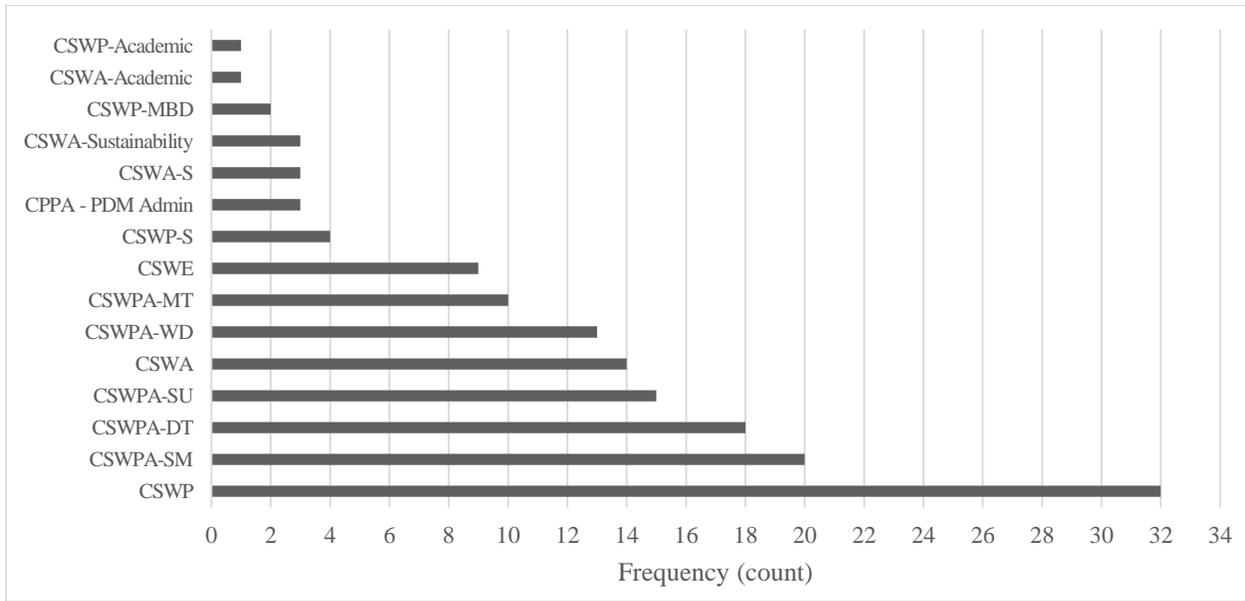


Figure 2. SOLIDWORKS Certifications Held by Respondents

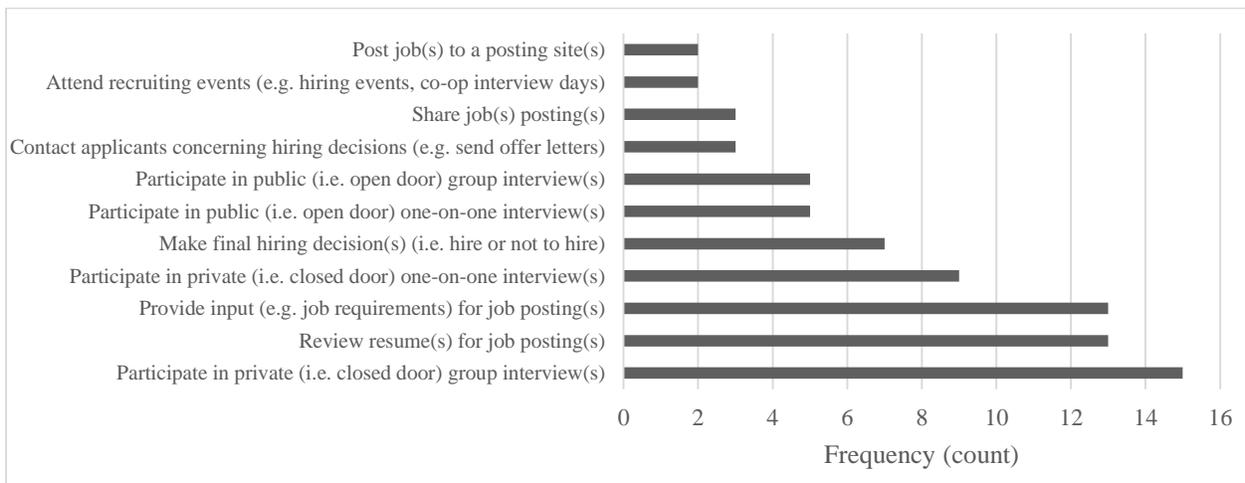


Figure 3. Hiring Process Involvement by Respondents in Their Current Position/Job

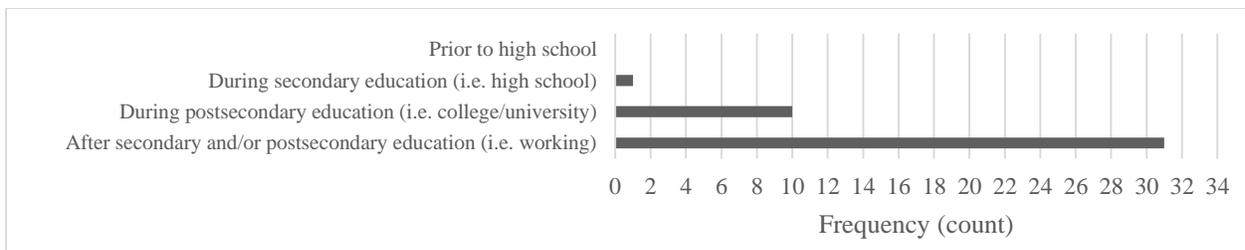


Figure 4. SOLIDWORKS Certification Exam Attempts by Respondents Over Time

Results

Results from the survey show that 28 of 34 (82.35%) respondents indicate that, in general, a SOLIDWORKS certification is valuable (i.e., has relative worth, utility, or importance) and 25 of 34 (73.53%) respondents indicate the benefit(s) of obtaining a SOLIDWORKS certification(s) outweighs the exam cost(s). Respondents also indicated that, in general, the SOLIDWORKS Certification Program benefits (i.e., produces good or helpful results or efforts) students more than Dassault Systèmes or industry (see Figure 5). A sample of comments from the 6 of 34 (17.65%) respondents indicating there is no value in a SOLIDWORKS certification are given below.

- “While it is somewhat beneficial while interviewing, once the job is attained the certificate means nothing to the company.”
- “In my experience, simply possessing a certification does not give me indication of their knowledge or skill.”
- “Certification is easy and not a good test of knowledge of software”

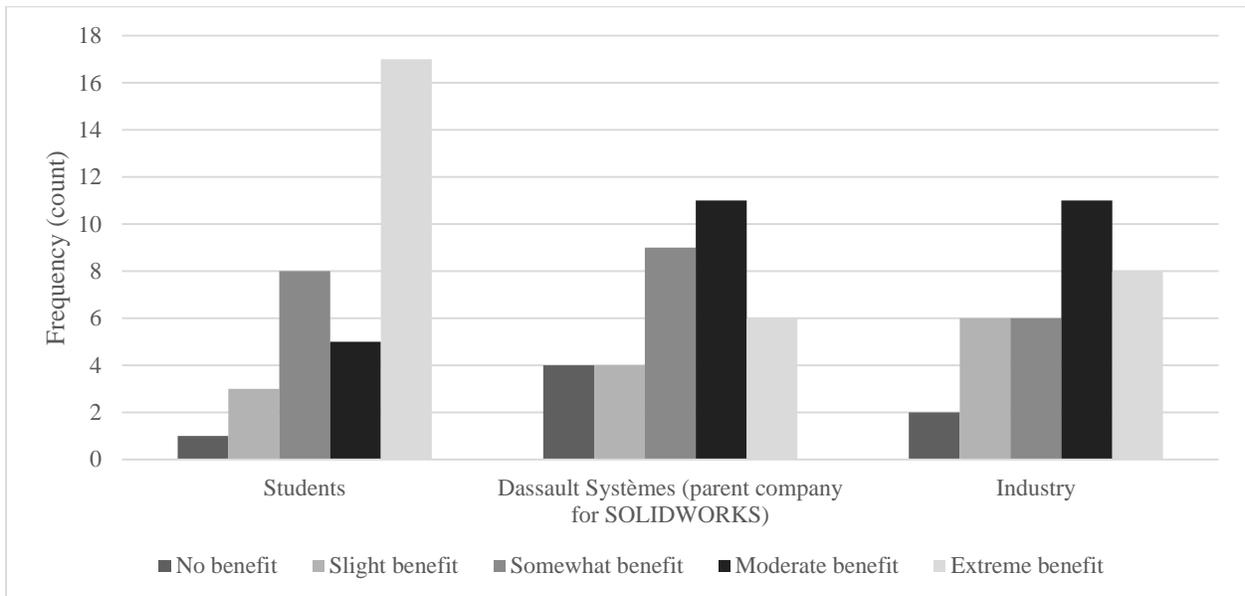


Figure 5. SOLIDWORKS Certification Program’s Benefit Levels

27 of 27 (100.00%) respondents indicating that, in general, a SOLIDWORKS certification is valuable, also added that a SOLIDWORKS certification is valuable for engineering students. Specifically, 23 of 27 (85.19%) of those respondents indicate moderate to extreme benefit for engineering students and only 3 of 26 (11.54%) for a working professional working in years 20 or more of their career (see Figure 6). Survey results also show that 25 of 28 (89.29%) respondents indicate that a SOLIDWORKS certification(s) is valuable during the hiring process. From a supplied list of nine options the respondents then identified their top three items of importance during the hiring process (see Figure 7). Respondents were also asked about the

frequency of receiving common work-related rewards or merits after passing a SOLIDWORKS certification exam (see Figure 8).

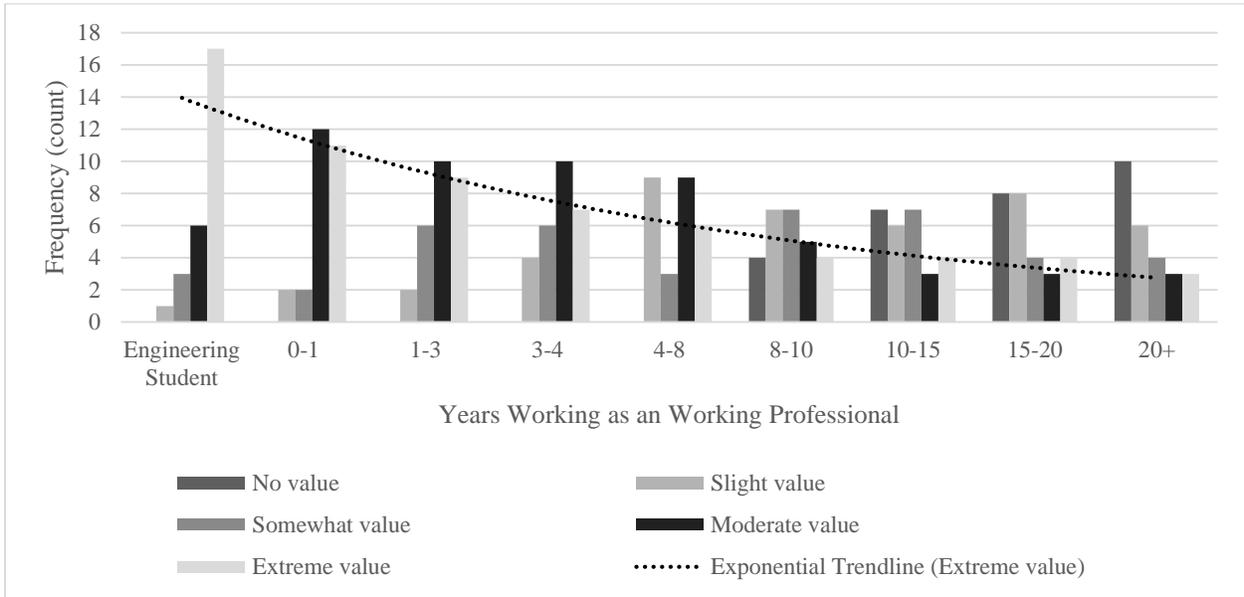


Figure 6. SOLIDWORKS Certification Value Over Years

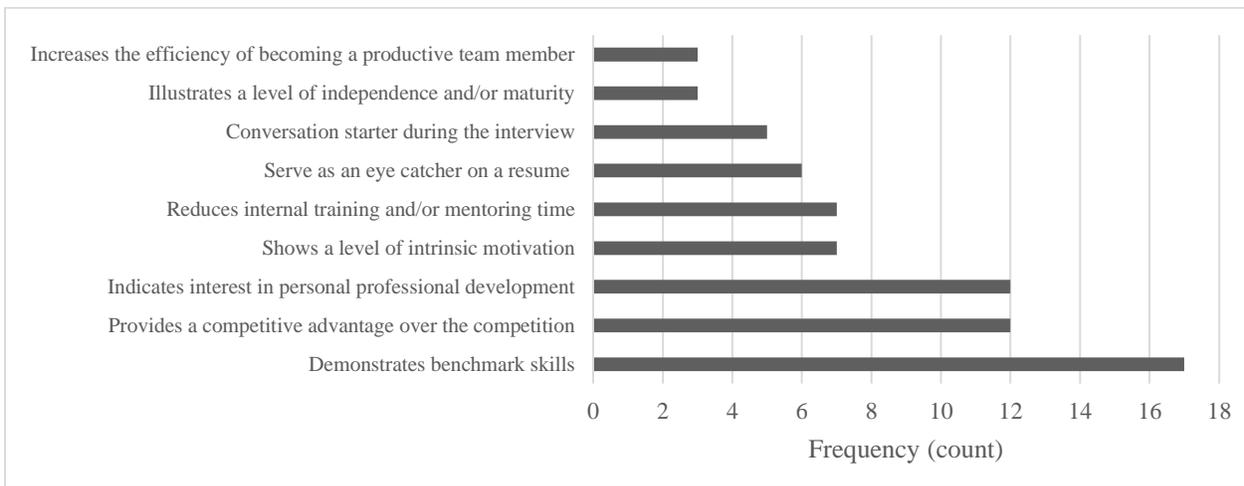


Figure 7. SOLIDWORKS Certification Value During the Hiring Process

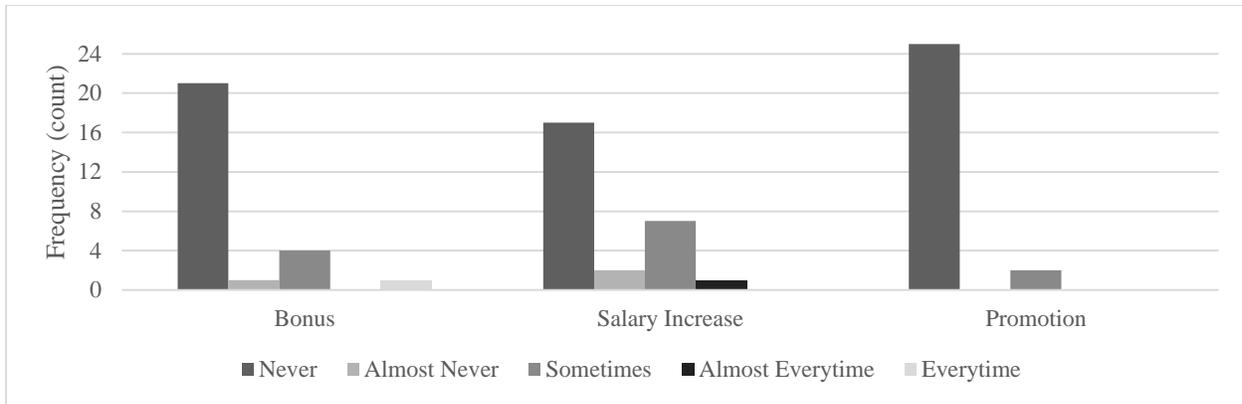


Figure 8. Work-Related Rewards or Merits Received After Passing a SOLIDWORKS Certification Exam

To further investigate the value for students that hold a SOLIDWORKS certification(s), the survey asked respondents to indicate the frequency to which students would get a phone interview, would get a site interview, would gain competitive advantage over other candidates, or would be offered an internship/co-op without being interviewed (see Table 2).

Table 2. Hiring Trends for Students Holding a SOLIDWORKS Certification(s)

Category	Frequency (%)						Count <i>n</i> ¹
	Never	Almost Never	Sometimes	Almost Every time	Every time	Unsure	
<i>Will get a phone interview:</i>							
CSWA	3 (12.00)	3 (12.00)	7 (28.00)	6 (24.00)	1 (4.00)	5 (20.00)	25
CSWP	2 (8.00)	3 (12.50)	5 (20.00)	7 (28.00)	4 (16.00)	4 (16.00)	25
CSWE	4 (16.00)	0 (0.00)	5 (20.00)	0 (0.00)	12 (48.00)	4 (16.00)	25
<i>Will get a site interview:</i>							
CSWA	3 (12.50)	3 (12.50)	10 (41.67)	3 (12.50)	0 (0.00)	5 (20.83)	24
CSWP	2 (8.33)	3 (12.50)	7 (29.17)	5 (20.83)	2 (8.33)	5 (20.83)	24
CSWE	4 (16.00)	0 (0.00)	5 (20.00)	1 (4.00)	11 (44.00)	4 (16.00)	25
<i>Will gain an advantage over non-certified applicants of similar skills/experience:</i>							
CSWA	5 (20.83)	3 (12.50)	10 (41.67)	2 (8.33)	3 (12.50)	1 (4.17)	24
CSWP	2 (8.70)	1 (4.35)	6 (26.09)	5 (21.74)	7 (30.43)	2 (8.70)	23
CSWE	4 (16.00)	0 (0.00)	4 (16.00)	2 (8.00)	15 (56.00)	1 (4.00)	25
<i>Will be offered an internship/co-op without being interviewed:</i>							
CSWA	12 (50.00)	7 (29.17)	2 (8.33)	1 (4.17)	0 (0.00)	2 (8.33)	24
CSWP	10 (41.67)	6 (25.00)	3 (12.50)	1 (4.17)	0 (0.00)	4 (16.67)	24
CSWE	11 (44.00)	3 (12.00)	4 (16.00)	0 (0.00)	4 (16.00)	3 (12.00)	25

Notes. Respondents who indicated value for engineering students who hold a SOLIDWORKS certification (see Figure 6)

Discussion

[REDACTED] [15] was the starting point in a series of studies which provide evidence-based research on the value gained from obtaining a SOLIDWORKS certification(s). This paper continues the research focused on undergraduate engineering students and includes working professionals. This study adds depth by asking respondents to indicate their involvement in the hiring process and when they were tested for a certification. Both types of questions assist in providing deeper insight into the value of the SOLIDWORKS certification program.

In general, students benefit the most from becoming SOLIDWORKS certified as is evident by the trends shown in Figure 6 (e.g. extreme value trend line). When searching for employment, additional value is given to students who hold multiple certifications as is evident in Table 2 (i.e. every time frequency increases between certification levels for each category). It would be unreasonable to expect a student to attempt all possible certifications. However, caution is needed as the certification exams are subject to change based on criteria set by the SOLIDWORKS certification program. Certifications may also be added or removed to reflect current trends and applications of CAD software.

In general, the value for working professionals who are, or should become, SOLIDWORKS certified is minimal and steadily declines with years of employment. Figure 2 could be used to identify perceived importance for working professionals. Figure 4 clearly shows that 31 of 42 (73.81%) attempted their first SOLIDWORKS certification exam after graduating from either high school or college (i.e. became a working professional). The authors believe there should be stronger encouragement for high school and post-secondary students to seek professional CAD certification(s). Webster, et al. [28] can be used as a resource on certification implementation strategies for introductory and advanced engineering graphics and CAD courses.

Maxey [29] states “though I've outlined the value that SOLIDWORKS certification, or for that matter, any CAD certification provides, there will still be cynical engineers out there arguing that certification programs amount to nothing more than a revenue stream that provides little to the end user.” The empirical data presented in this paper will hopefully show the *cynical engineers* that CAD certifications provide value for students and industry, as much or more than the companies who create, control, and sell the certifications (see Figure 5). When surveyed to what extent they agree or disagree with the opinion that *CAD certification programs amount to nothing more than a revenue stream*, 25 of 37 (67.57%) disagreed.

This study shows that 94.29% (n = 33) of the surveyed respondents were employed in the engineering field; however, only 5.56% (n = 2) are professionally licensed engineers. When surveyed to what extent they agree or disagree with the opinion that *CAD certification programs are not meant to replace professional licensure, but the reality is that many engineers don't seek professional licensure*, only 1 of 36 respondent disagreed. Future studies should explore the impact certification programs are having on engineering professional license.

While this work focuses solely on the value of the SOLIDWORKS certification program, similar research is needed on other vendor-controlled CAD certifications. Another area to investigate could include how industry values an applicant who holds a specific CAD certification(s) from a specific vendor (e.g., SOLIDWORKS) but is applying for a position that uses a different CAD system (e.g., CREO).

Limitations

The definitions for value and benefit are generally easy to comprehend (see Definitions Section); however, when explored in the context of this study, incorrect assumptions can easily be made. For example, assuming *all* CAD certifications are beneficial or valuable for students and working professionals would be incorrect. Additionally, it would be incorrect to assume that *one* supplier of CAD certifications is more valuable than another (i.e., SOLIDWORKS is more valuable than Autodesk).

The study sample was limited to individuals from the western region of the United States, who at a minimum have passed the CSWP exam, and have connected via LinkedIn to the authors in order to receive the survey. The recruitment process began in January 2018 by generating a target sample list using the SOLIDWORKS Certification Center; however, the number of potential certified SOLIDWORKS users whom met the study inclusion criteria has grown significantly since the surveys were distributed. Thus, with the rapid growth of certified users, the data may not be generalizable for an extended period of time.

The sample is also limited by the exclusion of SOLIDWORKS certified users who do not work in an engineering-related field. Eliminating what the authors perceived as non-technical personnel (i.e. not tech-savvy) and/or those outside the expertise of a SOLIDWORKS certification, such as HR or other hiring personnel, the data represents individuals who may naturally perceive the value of certifications to be higher.

Data comparisons against [REDACTED] [15] should be done with caution as additional questions were added to the survey for this study. Survey reliability and validity testing is also needed.

Conclusion

The purpose of this paper was to investigate the value and benefits of the SOLIDWORKS certification program. Results indicate that a SOLIDWORKS certification is valuable; especially for undergraduate engineering students. Engineering educators teaching SOLIDWORKS CAD software should seek certifications as a professional development activity and encourage students to acquire certifications. While achieving a certification does not guarantee SOLIDWORKS proficiency it does provide validation of benchmark skills, provides a competitive advantage when applying for a job, and demonstrates interest in personal development.

CAD certification has grown in popularity over the last decade and seems to be a mainstay of the CAD industry. Many of the key CAD software companies, including SOLIDWORKS, Autodesk, and Siemens, offer free versions of CAD software for students and educators. This allows students 24/7 access to the latest software and learning resources which can be used in preparation for successfully completing a variety of certification exams. Experience with applications and use of CAD software, paired with an industry-recognized certification(s), helps create a marketable student with skills for solving problems in a challenging and technical world.

References

- [1] D. Cohn. *Evolution of Computer-aided Design*. Accessed on: January 25, 2019. [Online]. Available: <https://www.digitalengineering247.com/article/evolution-of-computer-aided-design/>
- [2] A. Barnhorn and L. Caudill. *60 Years of CAD Infographic: The History of CAD Since 1957* Accessed on: January 25, 2019. [Online]. Available: https://partsolutions.com/wp-content/uploads/2017/09/The-history-of-CAD_CADENAS_R3.png
- [3] D. E. Editors. *Gentleman Genius: Patrick Hanratty*. Accessed on: January 25, 2019. [Online]. Available: <https://www.digitalengineering247.com/article/gentleman-genius-patrick-hanratty/>
- [4] I. E. Sutherland, "Sketch Pad A Man-Machine Graphical Communication System," in *Spring Joint Computer Conference*, Detroit, MI, 1964, pp. 329-346. Accessed on: June 27, 2018. [Online]. Available doi: 10.1145/800265.810742
- [5] Dassault Systèmes. *History: From Digital Mock-up to 3DEXPERIENCE*. Accessed on: January 25, 2019. [Online]. Available: <https://www.3ds.com/about-3ds/history/>
- [6] Dassault Systèmes. *Dassault Systemes Signs Definitive Agreement to Acquire SolidWorks*. Accessed on: January 25, 2019. [Online]. Available: <https://www.3ds.com/press-releases/single/dassault-systemes-signs-definitive-agreement-to-acquire-solidworks/>
- [7] Dassault Systèmes, SOLIDWORKS, and F. Hiss, "SolidWorks 1995 to 2012 - The Evolution of a 3D CAD System," ed, 2011.
- [8] Dassault Systèmes. *Company Information*. Accessed on: January 25, 2019. [Online]. Available: https://www.solidworks.com/sw/183_ENU_HTML.htm
- [9] S. Hurley. *AutoCAD 1.0 December 1982*. Accessed on: January 25, 2019. [Online]. Available: https://autodesk.blogs.com/between_the_lines/ACAD_R1.html
- [10] J. Walker. *The Autodesk File: Bits of History, Words of Experience*. Accessed on: January 25, 2019. [Online]. Available: <https://www.fourmilab.ch/autofile/e5/>
- [11] M. Brunelli. *A Quick History of PTC and PTC Creo*. Accessed on: January 25, 2019. [Online]. Available: <https://www.ptc.com/en/cad-software-blog/a-quick-history-of-ptc-and-ptc-creo>
- [12] Siemens. *1847–1865: Company Founding and Initial Expansion*. Accessed on: January 25, 2019. [Online]. Available: <https://new.siemens.com/global/en/company/about/history/company/1847-1865.html>

- [13] T. Suradkar. *Solid Edge - A Journey Through Time - V1 to V5*. Accessed on: January 25, 2019. [Online]. Available: <https://community.plm.automation.siemens.com/t5/Solid-Edge-Blog/Solid-Edge-A-Journey-Through-Time-V1-to-V5/ba-p/495560>
- [14] Siemens Product Lifecycle Management Software Inc. *Siemens Closes Acquisition of UGS; Introduces Business as UGS PLM Software*. Accessed on: January 25, 2019. [Online]. Available: <https://www.plm.automation.siemens.com/global/en/our-story/newsroom/siemens-press-release/43058>
- [15] [REDACTED], "[REDACTED]," *Journal of Engineering Technology*, vol. [REDACTED], no. [REDACTED], p. [REDACTED], 2018. Accessed on: June 27, 2018. [Online]. Available: <http://www.engtech.org/jet/>
- [16] Certiport Inc. *Autodesk Certifications*. Accessed on: January 25, 2019. [Online]. Available: <https://certiport.pearsonvue.com/Certifications/Autodesk/Certifications/Certify>
- [17] Autodesk. *Training and Certification*. Accessed on: January 25, 2019. [Online]. Available: <https://www.autodesk.com/training-and-certification/certification>
- [18] Siemens. *Solid Edge Certification*. Accessed on: January 25, 2019. [Online]. Available: <https://solidedge.siemens.com/en/resources/solid-edge-certification/>
- [19] Dassault Systèmes. *Certification*. Accessed on: January 25, 2019. [Online]. Available: <https://www.solidworks.com/sw/support/solidworks-certification.htm>
- [20] C. Archer. *Why SOLIDWORKS Certification for Students is Important*. Accessed on: May 25, 2017. [Online]. Available: <http://www.amtekcompany.com/why-solidworks-certification-for-students-is-important/>
- [21] T. Ricci. *Are Certifications Worth the Effort?* Accessed on: May 25, 2017. [Online]. Available: <https://www.asme.org/career-education/articles/certification/are-certifications-worth-the-effort>
- [22] D. L. Trent, "Efficacy of Computer Aided Drafting (CAD) Certifications," Ph.D dissertation, Occupational and Technical Studies, Old Dominion University, Norfolk, VA, 2011.
- [23] Dassault Systèmes. *Academia: Value of Certifications*. Accessed on: January 25, 2019. [Online]. Available: https://www.3ds.com/fileadmin/Training/PDF/3DS-2015-ACADEMIA_WHITEPAPER_VALUE_OF_CERTIFICATION.pdf
- [24] G. R. Bertoline, E. N. Wiebe, N. W. Hartman, and W. A. Ross, *Fundamentals of Graphics Communication*, 6th ed. New York, NY: McGraw-Hill, 2011.
- [25] Autodesk. *CAD Software*. Accessed on: May 26, 2017. [Online]. Available: <https://www.autodesk.com/solutions/cad-software>

- [26] T. Brown. *Measuring CAD Skills Gives Greater Efficiency*. Accessed on: May 25, 2017. [Online]. Available: <http://www.moldmakingtechnology.com/articles/measuring-cad-skills-gives-greater-efficiency>
- [27] Merriam-Webster Online. *Value*. Accessed on: May 26, 2017. [Online]. Available: <https://www.merriam-webster.com/dictionary/value>
- [28] R. Webster, J. Dues, and R. Ottway, "Industry Supplied CAD Curriculum: Case Study on Passing Certification Exams," *Engineering Design Graphics Journal*, vol. 81, no. 2, pp. 1-14, 2018. Accessed on: May 30, 2018. [Online]. Available: <http://www.edgj.org/index.php/EDGJ/issue/archive>
- [29] K. Maxey. *Getting Certified In SOLIDWORKS : What Good Is It? - Engineers Rule*. Accessed on: July 26, 2016. [Online]. Available: <http://www.engineersrule.com/getting-certified-in-solidworks-what-good-is-it/>