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Survey of the Current Academic and Industrial Trends in Utilizing the CADD Technology

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Abstract

The era of information technology has influenced our personal lives, industries, and in a broader sense, our societies. Design and drafting technologies have been transformed over the years to increase the efficiency in the product and process development. Lean product development strategies have been a strong force in revolutionizing the computer-aided drafting and design (CADD) technologies.

Increased economic pressure on our industries has influenced the engineering design and drafting process. Multi-tasking and multiple responsibilities have been increasingly observed as part of job requirements. Taking a product from ideation to the development stage used to require only a few designers and many drafters; this might be the reverse nowadays. Model Based Enterprise (MBE) has revolutionized our design and drafting departments in industry and influences the job market for both engineering designers and drafters. To obtain a clear understanding of similar large transitions in the engineering design and drafting industry, a survey was developed and distributed to both academic and industrial professionals in related fields of study.

In this paper, we will present and discuss the results of a national survey on the topic of designing and drafting using CADD. The areas covered in this survey are: spatial thinking, 2D versus 3D CAD software, current trends in drafting versus designing careers, textbooks for CADD software, CADD taught during the college freshman year, the most effective ways of teaching/learning CADD, challenges in teaching CADD classes, challenges for CADD users in industry, and other similar topics. We would like to compare the responses from both academic and industrial professionals and discuss if there is any wide gap in the viewpoints from both parties on the topics related to the CADD technology.

1. Introduction

Recent economic turmoil has influenced the way engineering is being practiced; many firms require engineers to be multi-functional in their role. Using computers, the internet, and a vast variety of software in engineering design has further changed the roles of technologists, engineering practitioners, and engineers. In the realm of drafting and engineering graphics, drafting boards and instruments were replaced by computers which inherently changed the culture of design departments in industry. In addition, recent initiatives toward collaborative design through internet and freelancing have influenced the roles and security of drafting and design jobs that once were a full time job one wanted to retire from.

Early in the advent of computers in design departments, researchers studied the impact of computers on the job functions of drafters and designers[1]. Those early investigations showed that a number of drafters supported a single or a fewer number of designers in order to create detail and assembly (or working) drawings for a product, a process, or any other engineering system. Design engineer used to develop the idea and initial sketches required to solve a problem or to enhance the function of a product. Then, drafters would take the idea and develop the production drawings using ANSI, ASME, ISO, or any other drafting and engineering drawing standards. Drafting was done using paper and pencil which took tremendous amount of time to produce or modify any set of drawings. Yet, there were clear job distinctions between drafters and design engineers. At that time, the curricula for drafters and design engineers were best fit for their job functions.

CADD software has been continuously evolving; the engineering design process has become lean in the sense that many stages of the design and development can be accomplished with a single CADD software that can be set up on a single pc station. Figure 1, for example, demonstrates different capabilities exist in Creo Parametric software.

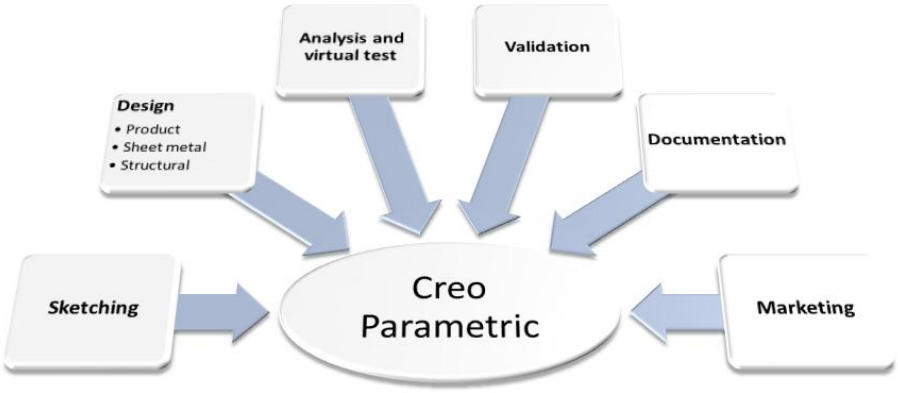

Figure 1 – Engineering design stages covered in Creo Parametric CAD software

As depicted in Figure 1, many stages of a typical design process can be accomplished in Creo Parametric. Other CADD software, especially the ones for product design and development (e.g. SolidWorks, Autodesk Inventor, NX, etc) have similar capabilities. This has streamlined the design and drafting task. Drafting and documentation can be accomplished in just a fraction of the time it used to take when drafting on the board. Now, with the use of CADD software, focus centers around the design and less on the drafting and documentation.

Does this mean we won't need drafters anymore? Should we teach more drafting and engineering graphics in the engineering schools or should we teach more design and less drafting in the 2 or 4 year CADD programs.

These and similar other questions have encouraged us to design a survey and distribute it to the design and drafting professionals (practicing engineers) in industry as well as the professors of engineering design and CAD at colleges and universities (our participants from academia). In this paper, our goal is to understand the current trends in a variety of topics related to the teaching and applications of CAD. We will study the layout of the survey, the population who took the survey, and the results and discussion. In the appendix, the open ended comments are listed with identifying language removed. The important comments as related to this survey are underlined in the comments.

2. Survey and our Population

Our survey is designed to reflect the viewpoints of the professionals in both academia and industry in a variety of topics related to the CADD industry. Figure 2 shows the number of participants with regard to their profession.

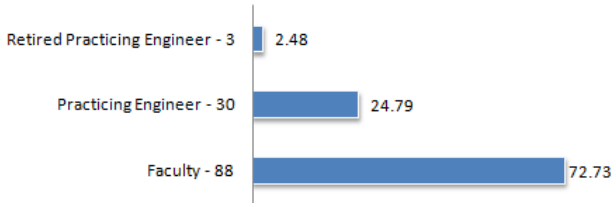

Figure 2 – The participants in our survey from both academia and industry

2.1. Participants from Academia (Faculty)

We surveyed the type of program in which our academic participants teach or conduct research. In addition, we asked whether or not our academic participants have ever taught engineering graphics in 2D or 3D. As demonstrated in Figure 3 (a,b,c), more than 55% of our academic participants teach in the Engineering Technology program, 20% in Engineering, and the rest in Industrial Technology, Applied Engineering, Technology Education, and others. Out of this population, 93% (or 80 participants) have taught Engineering Graphics.

When asking the order in which our academic participants learned Engineering Graphics, 81% responded that they learned 2D before 3D. The authors' previous research[2] on this topic shows that the students who learn Engineering Graphics (focused on multiview projections and missing views/lines) in a 2D environment develop higher spatial visualization skills than the students who learn Engineering Graphics in a 3D modeling space.

Q4. Select the type of program in which you teach (or have taught).			
Responses	**Count**	**%**	**Percentage of total respondents**
Engineering	18	20.69%	
Engineering Technology	48	55.17%	
Applied Engineering	5	5.75%	
Industrial Technology	7	8.05%	
Technology Education	5	5.75%	
Art	0	0%	
I teach in High/Middle School	0	0%	
Other	3	3.45%	
Other (please specify)	1	1.15%	
Total Responses	**87**		20% 40% 60% 80% 100%

(a) academic programs of the faculty members

Q6. Have you ever taught an Engineering Graphics (aka Technical Drawing/Drafting) class whether in 2D or 3D?			
Responses	**Count**	**%**	**Percentage of total respondents**
Yes	80	93.02%	
No	6	6.98%	
Total Responses	**86**		20% 40% 60% 80% 100%

(b) percentage of the academic participants who taught Engineering Graphics

Q8. Which item is true about your drafting/design training (official or unofficial training)?(attn: 2D means drawing multiviews/orthographic views of an object)(attn: 3D means drawing a Solid or Surface model of an object).			
Responses	**Count**	**%**	**Percentage of total respondents**
First I learned 2D; then I learned 3D.	71	81.61%	
First I learned 3D; then I learned 2D.	3	3.45%	
I only had 2D training.	12	13.79%	
I only had 3D training.	0	0%	
This question does not apply to me.	1	1.15%	
Total Responses	**87**		20% 40% 60% 80% 100%

(c) the order in which our academic participants learned Engineering Graphics

Figure 3 – Characteristics of our academic participants

2.2. Participants from Industry

We asked our practicing engineers to tell us about the type of industry they serve. The industries vary from automotive to aerospace and civil and construction trades. In addition, we asked participants to tell us about their Engineering Graphics training and the years of experience they have in board drafting, 2D design/drafting with CAD, and 3D design/drafting with CAD. As shown in Figure 4, most of our practicing engineers who took this survey were from construction and automotive industries. About 75% had learned design/drafting in 2D before learning in 3D. Additionally, more than 50% of our participants had 10 years or more experience in both 2D and 3D design/drafting.

Q13. What industry do (did) you work for?			
Responses	**Count**	**%**	**Percentage of total respondents**
Automotive	8	25.00%	
Aerospace	6	18.75%	
Medical	4	12.50%	
Construction and building	9	28.13%	
Energy	7	21.88%	
Rail transportation or Ship building	1	3.13%	
Other	14	43.75%	
Total Responses	**49**		20% 40% 60% 80% 100%
Multiple answers per participant possible. Percentages added may exceed 100 since a participant may select more than one answer for this question.			

(a) the industries that our engineering participants work for

Q16. Which item is true about your drafting/design training (official or unofficial training)?(attn: 2D means drawing multiviews/orthographic views of an object)(attn: 3D means drawing a Solid or Surface model of an object).			
Responses	**Count**	**%**	**Percentage of total respondents**
First I learned 2D; then I learned 3D.	25	75.76%	
First I learned 3D; then I learned 2D.	3	9.09%	
I only had 2D training.	3	9.09%	
I only had 3D training.	1	3.03%	
This question does not apply to me.	1	3.03%	
Total Responses	**33**		20% 40% 60% 80% 100%

(b) the order in which our engineer participants learned Engineering Graphics

Figure 4 – Characteristics of our participants from industry

3. Reflecting the viewpoints of our academic participants

The followings are a few questions we asked our academic participants in order to learn their viewpoints on the topics related to Spatial Visualization, Engineering Graphics, and CAD. The participants in the survey were informed that "*2D is when students mainly learn how to develop orthographic projections of an object; 3D is when students mainly learn how to develop Solid or Surface models.*"

3.1. Spatial Visualization cannot be taught; you inherit it.

Responses	Count	%	Percentage of total respondents
Strongly Disagree	41	47.67%	
Disagree	25	29.07%	
Neutral	9	10.47%	
Agree	8	9.30%	
Strongly Agree	3	3.49%	
Total Responses	**86**		20% 40% 60% 80% 100%

Figure 5 – Responses

Figure 5 depicts a strong similarity on the viewpoints of our academic participants on the very important topic of Spatial Visualization that is a necessary skill for many engineering fields and

architects.[3,4] This figure shows that many faculty members believe that spatial visualization can be enhanced by education.

3.2. 2D-based Engineering Graphics classes are more effective in developing students' "Spatial Visualization" skills

Responses	Count	%	Percentage of total respondents
Strongly Disagree	6	6.98%	
Disagree	24	27.91%	
Neutral	21	24.42%	
Agree	25	29.07%	
Strongly Agree	10	11.63%	
Total Responses	**86**		20% 40% 60% 80% 100%

Figure 6 – Responses

A Gaussian distribution on the responses shows that there still exists a disagreement between the academic participants on the effectiveness of 2D-based Engineering Graphics classes.

3.3. Spatial Visualization is better developed when students learn 3D before 2D.

Responses	Count	%	Percentage of total respondents
Strongly Disagree	5	5.88%	
Disagree	26	30.59%	
Neutral	34	40.00%	
Agree	11	12.94%	
Strongly Agree	9	10.59%	
Total Responses	**85**		20% 40% 60% 80% 100%

Figure 7 – Responses

The skewness toward disagreement shows that a higher percentage of our academic participants would rather teach 2D before 3D, if spatial visualization is enlisted as an outcome in their Engineering Graphics course.

3.4. 2D drawing skills are only needed for Drafters and Not for Designers.

Responses	Count	%	Percentage of total respondents
Strongly Disagree	41	47.13%	
Disagree	40	45.98%	
Neutral	3	3.45%	
Agree	1	1.15%	
Strongly Agree	2	2.30%	
Total Responses	**87**		20% 40% 60% 80% 100%

Figure 8 – Responses

There is a similar view point among our academic participants that 2D drawing skills are needed for both drafters and designers.

3.5. Current trends in Industry (esp. multi-tasking) demands both 2D & 3D skills for Drafters & Designers.

Responses	Count	%	Percentage of total respondents
Strongly Disagree	3	3.41%	
Disagree	0	0%	
Neutral	8	9.09%	
Agree	46	52.27%	
Strongly Agree	31	35.23%	
Total Responses	**88**		20% 40% 60% 80% 100%

Figure 9 – Responses

Multi-tasking has been one of the strategies of a lean design and manufacturing environment in the 21st century. With the increased capability of the CAD software, a design engineer can both design and prepare production drawings in a single station. Figure 9 demonstrates that the majority of our academic participants agree that, due to multi-tasking, both our engineering and drafting/design students will need both 2D and 3D skills.

3.6. Due to the advancements in the CAD software, nowadays, we need more Designers than Drafters

Responses	Count	%	Percentage of total respondents
Strongly Disagree	3	3.41%	
Disagree	17	19.32%	
Neutral	19	21.59%	
Agree	35	39.77%	
Strongly Agree	14	15.91%	
Total Responses	**88**		20% 40% 60% 80% 100%

Figure 10 – Responses

Normally, advancement in technology in the form of hardware or software affects the job market. Before CAD, a single design engineer needed a few drafters to produce detail and assembly drawings. Nowadays, with the advancements in the CAD software, the demand for just drafting has plummeted. Figure 10 demonstrates that about 55% of our academic participants agree or strongly agree that we need more designers than drafters due to the advancement in the CAD software.

3.7. Students ought to learn CAD in their Freshman year than later

Responses	Count	%	Percentage of total respondents
Strongly Disagree	1	1.14%	
Disagree	2	2.27%	
Neutral	9	10.23%	
Agree	38	43.18%	
Strongly Agree	38	43.18%	
Total Responses	**88**		20% 40% 60% 80% 100%

Figure 11 – Responses

There has been concern focused on dropout rates from engineering programs during recent years. Studies show that one major reason for dropouts is that freshman students lack the appropriate math and science background; however, many first year engineering students are required to take a number of science and math courses. In recent years, some engineering programs have been offering a "Freshman Engineering Design" course that has increased the retention rate. To that end, Figure 11 shows that about 87% of our academic participants agree or strongly agree that freshman students (engineering or technology) ought to learn CAD.

3.8. Nowadays, CAD softwares are so user-friendly that I do not require a Textbook.

Responses	Count	%	Percentage of total respondents
Strongly Disagree	13	14.77%	
Disagree	41	46.59%	
Neutral	21	23.86%	
Agree	11	12.50%	
Strongly Agree	2	2.27%	
Total Responses	**88**		20% 40% 60% 80% 100%

Figure 12 – Responses

Figure 12 show that only 14% of the faculties responded that they do not require a textbook in their CAD classes because of the increased user-friendliness of the software. Many software companies have tutorials in the form of videos that teach students how to use a particular software; yet, due to pedagogical requirements and a diverse population of students, many faculty member may rather require a textbook.

3.9. What are the best practices in teaching CAD (2D and/or 3D)?

Figure 13 (a through d) shows that project-based learning is the most favored method of learning CAD in comparison to teaching CAD by going through the icons, using the help and tutorials of the software, or watching training videos. A real-world project raises interest in students, prepares professionals who are self-starters and self-learners, and teaches students that many design projects are multi-disciplinary in nature and may demand an extensive amount of time, iterations, and effort.

Online teaching of CAD has also been growing; there are currently certificates and associate degrees offered through online education in a variety of drafting and design trades. Yet, there is no significant study on the effectiveness of teaching CAD through distance education. Online CAD training may be useful for students who are self-learners; students can take the entire CAD class online. In a face-to-face CAD class though, instructors may still ask student to watch the video demonstrations online and therefore, save the face-to-face class time for other learning activities and Questions/Answers. This may not work for students who demand constant observation and guidance, and in the long run, may discourage students from pursuing their degree. Figure 13(e) shows that almost 73% of our academic participants strongly disagree or disagree that online education of CAD is more effective than face-to-face.

(a). Teaching the software by going through the icons and explaining their applications			
Responses	**Count**	**%**	**Percentage of total respondents**
Strongly Disagree	6	6.82%	
Disagree	21	23.86%	
Neutral	16	18.18%	
Agree	40	45.45%	
Strongly Agree	5	5.68%	
Total Responses	**88**		20% 40% 60% 80% 100%

(b). Using the Help and Tutorial of the software			
Responses	**Count**	**%**	**Percentage of total respondents**
Strongly Disagree	4	4.55%	
Disagree	14	15.91%	
Neutral	26	29.55%	
Agree	41	46.59%	
Strongly Agree	3	3.41%	
Total Responses	**88**		20% 40% 60% 80% 100%

(c). Watching training videos (on Youtube, etc)			
Responses	**Count**	**%**	**Percentage of total respondents**
Strongly Disagree	4	4.65%	
Disagree	16	18.60%	
Neutral	26	30.23%	
Agree	34	39.53%	
Strongly Agree	6	6.98%	
Total Responses	**86**		20% 40% 60% 80% 100%

(d). Project-based learning of the CAD Software			
Responses	**Count**	**%**	**Percentage of total respondents**
Strongly Disagree	0	0%	
Disagree	1	1.14%	
Neutral	7	7.95%	
Agree	34	38.64%	
Strongly Agree	46	52.27%	
Total Responses	**88**		20% 40% 60% 80% 100%

(e). Online teaching of CAD is more effective than Face-To-Face			
Responses	**Count**	**%**	**Percentage of total respondents**
Strongly Disagree	36	40.91%	
Disagree	29	32.95%	
Neutral	21	23.86%	
Agree	1	1.14%	
Strongly Agree	1	1.14%	
Total Responses	**88**		20% 40% 60% 80% 100%

Figure 13 – Responses

3.10 What are the most important challenges in teaching CAD classes?

Responses	**Count**	**%**	**Percentage of total respondents**
Updating hardware	21	23.86%	
Updating software	38	43.18%	
Finding an appropriate textbook	29	32.95%	
Teaching to diverse population of students	47	53.41%	
Other (please specify)	16	18.18%	
Total Responses	**151**		20% 40% 60% 80% 100%

Figure 14 – Responses

Normally CAD classes are met in the computer labs. Therefore, the dynamics of the class and the appropriate pedagogy needed in a CAD class is very similar to a lab-based course. Figure 14 shows that our academic participants rated "teaching to a diverse population of students" the most important challenge when teaching CAD. Updating software due to the licensing requirements, service contracts, or any other reason has also been reported to be one of the most important challenges.

4. Reflecting the viewpoints of our industry participants

This part of the survey demonstrates the viewpoints of our practicing engineers on the topics related to CAD.

4.1. 2D drawing skills are only needed for Drafters and Not for Designers.

Responses	Count	%	Percentage of total respondents
Strongly Disagree	20	62.50%	
Disagree	10	31.25%	
Neutral	1	3.13%	
Agree	0	0%	
Strongly Agree	1	3.13%	
Total Responses	**32**		20% 40% 60% 80% 100%

Figure 15 – Responses

As demonstrated in Figure 15, our participants from industry also disagree that "2D drawing skills are only needed for Drafters." Comparing this result with Figure 8, there is a strong resemblance on the view points of the faculty and engineers on this topic.

4.2. Current trends in Industry (esp. multi-tasking) demands both 2D & 3D skills for Drafters & Designers.

Responses	Count	%	Percentage of total respondents
Strongly Disagree	0	0%	
Disagree	1	3.13%	
Neutral	1	3.13%	
Agree	14	43.75%	
Strongly Agree	16	50.00%	
Total Responses	**32**		20% 40% 60% 80% 100%

Figure 16 – Responses

Again, similar to Figure 9, we observe that our practicing engineers also believe that 2D and 3D CAD skills are needed for both designers and drafters. Therefore, when planning for curriculum updates, our engineering programs, mainly mechanical design, construction, and similar subjects, should incorporate both 2D drawing and 3D modeling in their program outcomes.

4.3. What is the best way to update your CAD knowledge?

Responses	Count	%	Percentage of total respondents
Watch videos online	15	46.88%	
Attend local reseller's workshop	6	18.75%	
Bring in a trainer	8	25.00%	
Through CAD books	15	46.88%	
Through help and tutorials of the software	16	50.00%	
Attend a class	22	68.75%	
Other (please specify)	12	37.50%	
Total Responses	**94**		20% 40% 60% 80% 100%

Figure 17 – Responses

We asked our practicing engineers to tell us about the methods with which they update their CAD knowledge. According to Figure 17, the most favored methods are: attending a class, through tutorials and helps of the software, watching videos online, using CAD books, bringing in a trainer, attending a workshop from their reseller, and others.

4.4. What are the most important challenges for the CAD users in the future?

Responses	Count	%	Percentage of total respondents
Updating hardware	10	30.30%	
Updating software	13	39.39%	
Learning new capabilities of CAD software	17	51.52%	
Dealing with the software's bugs	9	27.27%	
Cost of software	17	51.52%	
Cost of getting a degree	6	18.18%	
Other (please specify)	6	18.18%	
Total Responses	**78**		20% 40% 60% 80% 100%

Figure 18 – Responses

Figure 18 shows that "learning new capabilities of CAD software" and "cost of software" will continue to be among the most important challenges for the CAD users. As educators, if we streamline the training courses and, in the classrooms, prepare self-learners who know the resources and how to find information, then, "learning new capabilities of CAD software" may not be such an important challenge. Updating software and then updating hardware are also considered important challenges for the CAD users.

5. Conclusion

We conducted this survey in order to understand the view points of both faculty and practicing engineers on a variety of contemporary topics related to the CAD industry. Highlights of a few findings are listed below:

- Increasing demand for multi-tasking in industry requires both 2D and 3D drawing and design skills for engineers and drafters.

- Our academic participants disagree that teaching 3D before 2D is effective in enhancing students' spatial visualization skills. This is in agreement with our previous research.[2]
- The need for designers is greater than the need for drafters due to the advancements in the CAD software.
- A majority of faculty are still in favor of requiring textbooks for CAD classes.
- Project-based teaching of CAD classes is the most highly rated method for the effective teaching of CAD classes.
- Being able to teach CAD to a diverse population of students is rated the most important challenge when teaching CAD.
- Attending a class is rated the most favored way for updating the CAD knowledge of practicing engineers.
- Learning new capabilities of the CAD software and the cost of the software have been reported the most important challenge of the CAD users in the future.

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Appendix A

A few selected comments from our practicing engineers on the topic of

CADD (computer-aided drafting and design)

“At one time, engineers considered producing drawings as a job that was for the worker bees. Almost as if the labor was beneath them, probably for good reason since a company could higher several draftsman for the price of one engineer. Then along came CAD. The idea was to make the drawing faster and increase the number of project completed over any given time period. Someone got the idea that all those draftsmen could be replaced by the engineer doing their own drawings. So today, an engineer spends a disparate amount of time doing the work formerly done by a draftsman and far less actually engineering. Think about the work for a second, near 90% of the drawing is cookie cutter work. This requires five years of university? Once it only took two years of college. Now consider that the new engineer, when entering a company has to be trained on whichever software that company uses. One has to wonder who is doing the cost/benefit analysis on this and what color the sky is in their world.”

“Time just has changed. Companies are cutting costs by firing all "unnecessary" people and merging their jobs together to first one who can do them. I'm one of the survivors, because I'm open to new "challenges” and I can do/learn things which are not my "basic profession", but I can do them easily and we don't have anyone else to do those tasks. I see the future (next 5 or 10 years) as a fight against cheaper labor in cheaper countries. But I also see it as a fight of skills.”

“I'm wondering whether the Engineers are doing drafting work, or whether the draftsmen are doing Engineer's work. Personally, I've always thought that the Design Draftsman had the knowledge to do the Engineer's job, but didn't get paid the rate; the Engineer is now expected to do the draftsman's job but feels it's beneath him. Simple solution: sack the engineer, train the draftsman properly and give him the proper salary.”

“New CAD people should be trained on the board first, at least 1 semesters of manual drawing. That would give them a good feel on how to set up a drawing and what is suppose to go on it. Learning this skill too would get them away from the "it looks good on paper" mentality and lets them think out what they are going to detail and not have the computer do it for you. I am one of those people who have gone from the board to 2d drafting to parametric design in my career which I consider myself lucky. It has been a good evolution.”

“Using CAD is not difficult for an "old" engineer, especially because now these softwares are full of wizards and libraries with millions of standardized parts. Let's take for example a bolted connection: with the CAD software we choose the holes, then bolts, nuts and washers... and "voila"! 1 minute maximum! Doing the same drawing by hand (line by line) will result in a better (and permanent) understanding of it. So, I fully agree with some "board/paper practice". Anyway, my opinion is that the engineers have to THINK and the draftsmen have to DRAW! Otherwise it is a pity of their mind.”

“My experience has been that it is hard to find a good detailer. After I make the 3D models, so much time is spent with drafters going back and forth to get the drawings right, that I may as well do them myself. Some of the companies I have worked for have been too cheap to pay for a decent drafter/detailer that can work with only a moderate amount of supervision. Thus the engineer can either spend time that would have otherwise been used for engineering on supervision or on creating drawings himself. Poor drawings cause a lot of problems with suppliers, manufacturing floor, QC/QA, etc., and cause a lot of follow on work for the engineer to clean up the mess.”