Prominence of Conceptual Design with Computer-Aided Design Tools for Junior and Senior Product Designers

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Abstract

As the demand for more innovative products to help improve the lives of others increases, the product design industry continues to require more effective design methodologies. Conventional wisdom and research suggests that Computer-Aided Design (CAD) is a tool for detailed design, and is not appropriate for the conceptual phase of the design process. However, given new advances in cloud-computing and real-time synchronous collaboration, the ability to quickly digitally prototype unique concepts in CAD has never been easier. Given that new engineering graduates are part of the "digital native" generation, anecdotal evidence suggests these designers have a natural inclination and ability for this digital prototyping. Our study seeks to formally test whether a dichotomy exists between younger designers who are entering the workforce, and older designers who are veterans in product development, regarding the best-practices in CAD usage for conceptual design - "Conceptual CAD".

The paper begins with a critical review of the existing body of literature which advises the designer against Conceptual CAD. Next, we present the findings of a survey of professional product designers (spanning a variety of networks including LinkedIn and local product design think-tanks). We focus the analysis of the survey on differences in Conceptual CAD design practice by a variety of factors (e.g. years of experience with a given CAD tool, industry of practice, amount of time spent performing team vs. individual design actions, etc.), with the goal of identifying if correlation exists between designer age and inclination to use Conceptual CAD.

Our study reveals important implications for engineering educators. Newly graduated engineers have advanced comfort and abilities with digital tools, and a corresponding proclivity to perform Conceptual CAD. These preferences benefit from the features of modern CAD tools, including fast collaboration and sharing. Though current introductory CAD courses are sufficient at teaching students how to use CAD, there is a recommendation for more cohesion and CAD usage in advanced design courses. Allowing more usage of CAD in more comprehensive design driven courses, can allow students to more accurately simulate the product development process in industry, and thus reduce the education to industry application gap.

1.0 Introduction

As the demand increases for more innovative products to help improve the lives of consumers, the Product[1]/Industrial[2] Design Engineering (PIDE) industry continues to require more effective design methodologies [1]. The PIDE space has seen massive investment over the last few decades, and is poised to grow to a market capitalization of ~$62B USD by 2025 [2]. The growth of this sector has led to growing popularity and interest in large scale PIDE, and has instigated studies on how effective PIDE can allow organizations to create more innovative products [2], attain greater market share [3], and improve financial performance [4].

In conjunction with this interest, investment in the development of PIDE associated technologies like Computer-Aided Design (CAD), Additive Manufacturing, Generative Design and Product Lifecycle Management (PLM) Softwares have been critical to the innovation and evolution of design capabilities in the PIDE space. CAD, one of the cornerstones of the PIDE industry, has seen massive investment over the last few decades, and has been a critical contributor to the large growth of the PIDE industry [5]. Specifically, due to advancements in technology, CAD is becoming ubiquitous via the lowering barrier to entry for detailed design modelling, and as such, education of CAD in post-secondary institutions is now commonplace for designers/engineers. A recent example of the advancement of CAD can be seen in companies such as Autodesk and Onshape, who leverage cloud computing to develop software which can allow users to collaborate on CAD work and access their CAD files from any location [6].

Conventional wisdom and research suggests that CAD is a tool for detailed design, not appropriate for the conceptual phase of the design process[3]. However, given the new advances in feature development and real-time synchronous collaboration capabilities, the ability to digitally prototype unique concepts in CAD has never been easier. Given that new engineering graduates are part of the "digital native" generation and have a greater inclination to use technology for task fulfillment as opposed to senior generations, this paper hypothesizes that these designers have a natural inclination and ability for digital prototyping, as opposed to other historic non-digital practices [7] [8].

This research study seeks to formally investigate the underexplored topic of whether the long-standing tech-savviness dichotomy between junior/senior workers exists for designers in the Product Design industry [9]. Specific attention is placed on gathering data about the best-practices of CAD usage for conceptual design (Conceptual CAD) across these generations, with an ancillary aim to understand if usage of Conceptual CAD can motivate the development of more innovative products and if updates to the current education of CAD needed to match the norms of industry.

[1] *Product design* is defined as the process of ideating, designing and fabricating a product for users (Oxford)
[2] *Industrial design* (a branch of product design), integrates art and engineering for mass product development (Reeder, Kevin)
[3] *Conceptual design generation* is defined as the initial step in the prototyping of a final product (Slack, Nigel et al)

2.0 Background and Literature Review

2.1 Education of Conceptual CAD for Engineering Design Students

Importance of Conceptual CAD Education in Design Engineering
Currently, engineering (and in particular, mechanical engineering) continues to be one of the most popular professional degrees studied by students in undergraduate studies. In Canada alone, enrollments in engineering education have increased by ~4% year over year, with mechanical engineering (of which design engineering is a subset), being one of the most popular disciplines[10]. As the ever-evolving field of CAD continues to be a fundamental part of the PIDE industry and mechanical engineering design education, it is critical to ensure that future designers are receiving adequate education to reduce the time for students to become adept to industry standards [11]. Furthermore, as the process of design becomes increasingly collaborative and co-creative in the early stages, it is important to ensure the early facilitation of CAD usage through education is done with the current "tools of the trade" as suggested by Robertson et al, and how to leverage them in creative, non-individualistic design scenarios [7].

Current State of the Art for CAD Education and Gaps with regards to Industrial Needs
Today, getting knowledge or even certifications for skills from courses is more ubiquitous than ever before with the rise of students enrolling in university programs, certificate/diploma programs and engaging in Massive Open Online Courses (MOOCs) [12]. Though there has been some research into the industrial perspectives on CAD education, there have not been many recent studies into the specifics of design curricula at different institutions, and how they reflect the current needs of the PIDE industry. After evaluating the design engineering course offerings from top universities in Canada, USA, Germany and Japan (University of Toronto, Massachusetts Institute of Technology, Technical University of Munich and University of Tokyo, respectively), it is evident that there is no-single CAD course, but rather a breadth of courses that students can elect to take as part of their undergraduate degrees [13] [14] [15] [16].

In order for CAD education in engineering to be up to par with industry needs, Ye et al. recommend focus on the theory, pros/cons and computer literacy which presuppose CAD education, so that designers can pick the best tool for the design task(s) [11]. Dankwort et al. suggest there should be less emphasis on the education of the tool itself, and more focus on how the tool integrates with the entire product development lifecycle [17]. Through a cursory reading of the design courses at the institutions mentioned above, there is no explicit requirement for these courses to ensure deliverables of conceptual designs, let alone, conceptual designs which are created in CAD [13] [14] [15] [16]. For introductory courses, Brown's shows empirically that students who enroll in the introductory CAD classes can find them unengaging, which can act as an impediment to further seeking to practice CAD in future design scenarios [18]. Furthermore, due to the limited scope of many of these courses, there is not a major emphasis on using the myriad of features available for the product design lifecycle (indicated in the figure below). This is circumvented by professional experience or internship requirements, wherein the students have the opportunity to engage in real world engineering experience prior to graduation.

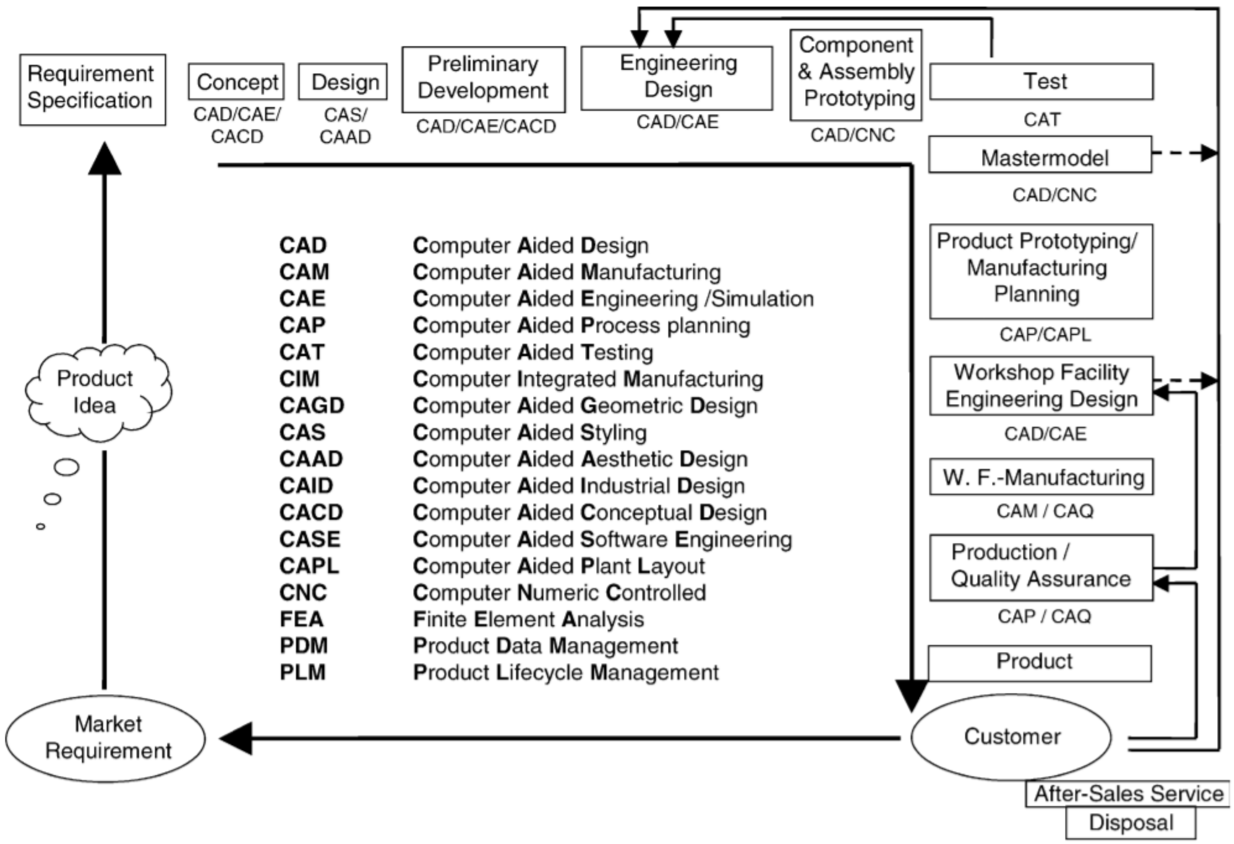


Figure 1: General Process Chain of Product Development and Associated Computer Aided Technologies from Dankwort et al. [17]

2.2 Modern Role of CAD Usage in Conceptual Design

Reeder introduced concept generation as the primary step in the PIDE process [19]. There are a myriad of tools which can be leveraged to approach the task of concept generation (or conceptual design), including but not limited to: sketching, CAD and foam prototyping, as outlined by Haggman et al. [8].

Benefits of CAD

Since product design is a group activity, the collaborative abilities of modern CAD softwares can allow for speedy collaboration in the early stages of design, and can reduce the overall product development lead time [8]. This efficiency can be further expanded into the downstream validation processes of FEA, DFMA, etc. and is favorable for both designers, analysts and manufacturers, as the details of the models can expedite the processes of the associated activities [20]. Furthermore, a newer and underrated advantage of CAD usage is the ability to explore generative design[4] and additive manufacturing techniques early on in the design process, and therefore eliminate a majority of downstream design optimization.

[4] *Generative Design* is the iterative optimization of a CAD model against input constraints and requirements (Autodesk)

Criticisms of Conceptual CAD

Criticisms towards conceptual CAD stem from inherent system shortcomings against conceptual design requirements. Elucidated by Dijk, these shortcomings include the lack of freedom, creative agility and programmatic structure inherently associated with the CAD ecosystem, which are contradictory to the "free-form" nature of conceptual design [21]. There is significant evidence to show that non-computational conceptual design methods (such as sketching) foster creativity, and that the utility of sketching in all stages of design is effective [22]. Furthermore, sketching is a useful medium of graphic thinking in exploratory design, and can allow grouping of information in an easily accessible format as opposed to text [22], [23]. Given that digital fluency is often seen as a generational phenomenon, we expect that the acceptance and value of Conceptual CAD may change over time, and thus we believe it is important to revisit this question with a generational lens. Specifically, this question is important to consider due to the rapid growth of the PIDE industry, and the significant advancements of CAD software in recent years. These advancements in CAD software have granted designers unprecedented design ability, as outlined by Buchal in a study that shows how CAD tools can be as effective as sketching in early design, and that greater improvements to the human factors of CAD can help it's uptake in the PIDE industry [22]–[24]. The inertia of not staying updated on the types of tools (and by extension CAD tools) which can benefit conceptual design, results in potentially major opportunity cost as illustrated in the figure below.

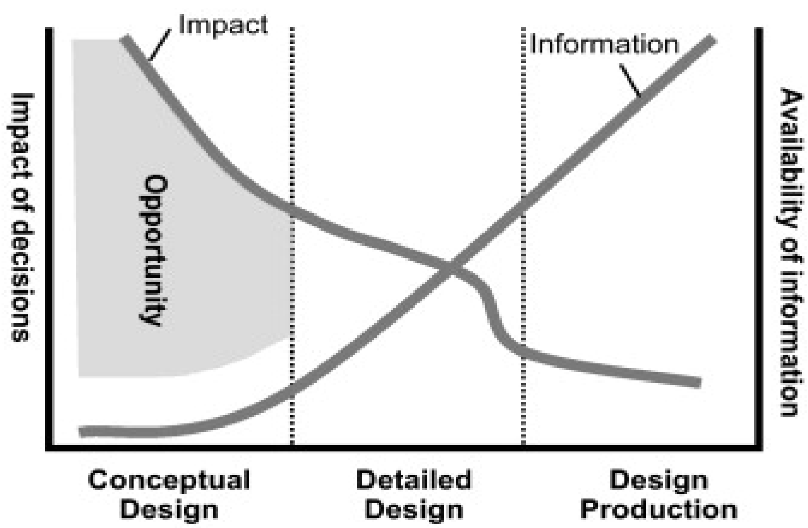


Figure 2: Relationship Between Design Stage, Impact of Decisions and Availability of Tools from Wang et al. [25]

2.3 Generational Difference in Product Design Technology Usage

After an exhaustive review of literature around differences of CAD technology between designers of different age groups, there are minimal studies focusing on the generational differences of designers in the design process. However, since the difference between technology adaptation in daily life and the workplace is a field studied, this portion of the literature review will focus on the general differences and similarities between technology adaptation between younger and more senior individuals, and what potential parallels can exist to the PIDE industry.

Differences in Technology Use Between Junior and Senior Generations, and Potential PIDE Implications

As CAD becomes a commercial tool, which is sold to industry and academic organizations, there is an inherent competition between CAD platform owners to create a tool which can provide value and generate more market share. Anecdotally, as more designers who are entering the PIDE industry are younger and perform more tactical design work (as opposed to management, who are more senior and are focused with more managerial/oversight aspects), it would make sense that CAD tools would be more catered in features and experience towards more digitally inclined individuals. Volkom et al. suggest that the roadblocks which prevent senior individuals from integrating technology more in their daily life are aspects of user experience, and the fact that the use of certain technologies is not as habitual as it is for younger generations [26]. Similarly, Gill outlines that design tools which are not familiar to senior designers from their formal education, are not widely adopted by them because the time it takes to train to become accustomed to a new tool is high, and the typical organizational workshops are insufficient [27]. Partly in response to this and the rise of MOOCs, CAD providers who are continuously innovating their products for the PIDE industry, have made their own select courses which provide example based education for the usage of the tools [28].

Motivated by previous studies of generational preferences of technology in the workplace and the importance of CAD as a tool in the engineer's toolbox, this paper aims to explore generational topics related to CAD use.

3.0 Methods

A survey was created to gather cursory PIDE industry insights, from practitioners of varying ages, geographies, etc. The survey was aimed at design professionals (i.e. mechanical design engineers, product designers, industrial designers, etc.) from a variety of industrial sectors, and different age/experience groups. Prior to creating the survey, the research purpose and logistics were discussed, reviewed and approved by the research institution's research ethics board. The survey was specifically aimed at gathering non-specific demographic information, and evaluating whether there is a correlation between heuristics in CAD usage in the conceptual phase of design, and how these insights correspond to the designer's perception of product quality and collaboration effectiveness. The insights derived from this survey will be discussed with respect to the literature review to assess the recent state-of-art in Conceptual CAD for the PIDE industry, whether there is a correlation between age/experience and Conceptual CAD prevalence, and whether updates to design curricula need to be made to accomodate the evolution of the PIDE industry.

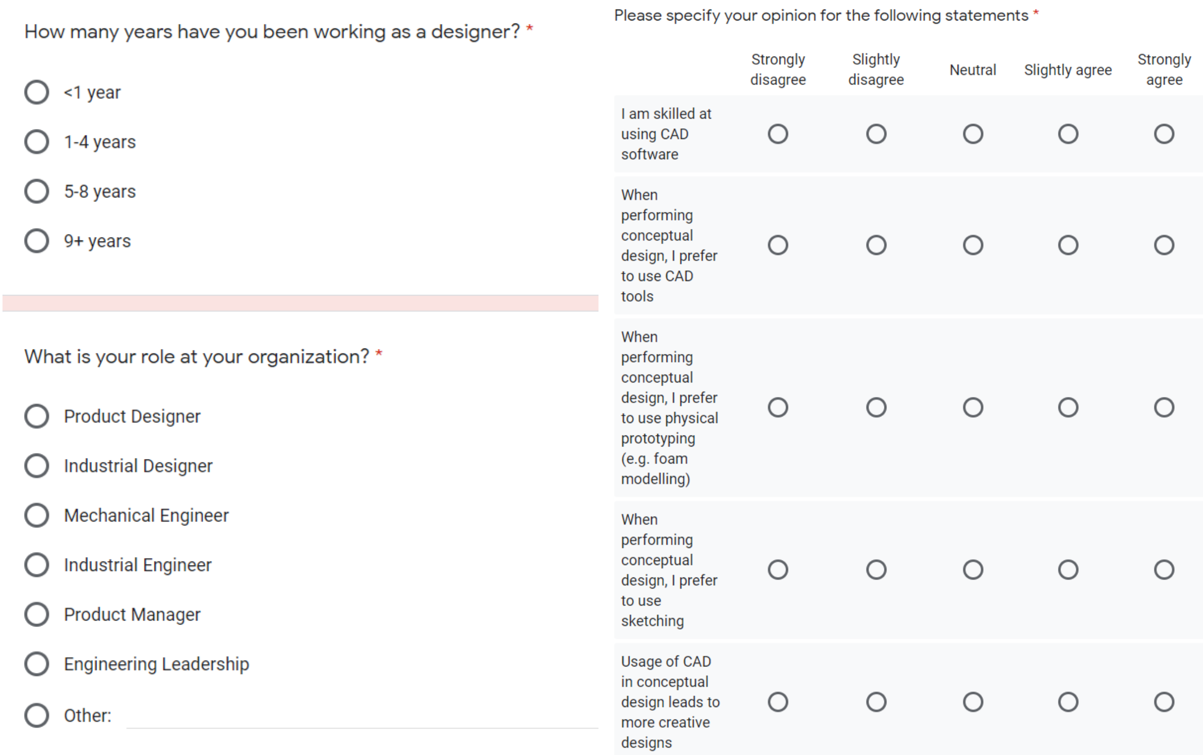
A pre-trial distribution of the survey was conducted with five respondents of varying demographics to identify any problems with the survey structure and nomenclature, before a final version was released. More specifically, the objective of the preliminary surveying was to get feedback on the lexicon used in phrasing of the questions, interpretation, and overall time to completion. Since revisions were made to the preliminary survey, and the preliminary respondents were informed afterwards about the intent of the survey, the data gathered in the preliminary survey is not included in the initial results.

3.1 Survey Distribution

This Google Form survey was distributed to industry contacts by email, and to groups of design professionals using the social medium LinkedIn. The survey post contained an anonymous link with an invitation to participate in the survey, and was viewed by ~370 individuals, and has 28 anonymous responses.

3.2 Design

The style of the questions was conversational and colloquial, so as to be easily interpreted given the international audience of the LinkedIn postings. After an initial consent page explaining the survey, the time required, and the privacy and security of the data, the questionnaire was presented in the following parts: 1) General demographic information: non-identifiable information about the individual filling out the survey. 2) Design infrastructure: information about the types of CAD tools used at the individual's organization and their experience using CAD tools in general. 3) Design Process: information to gain insight as to the type of collaboration dynamics which exist at the organization during the design phase. 4) Usage of CAD in Conceptual Design: questions to understand how CAD and other tools are used (if at all) during the Conceptual Design phase of the design pipeline of the individual's organization. A sample of questions from the survey can be seen in Figure 3 below.


How many years have you been working as a designer? *

- <1 year
- 1-4 years
- 5-8 years
- 9+ years

What is your role at your organization? *

- Product Designer
- Industrial Designer
- Mechanical Engineer
- Industrial Engineer
- Product Manager
- Engineering Leadership
- Other:

Please specify your opinion for the following statements *

	Strongly disagree	Slightly disagree	Neutral	Slightly agree	Strongly agree
I am skilled at using CAD software	○	○	○	○	○
When performing conceptual design, I prefer to use CAD tools	○	○	○	○	○
When performing conceptual design, I prefer to use physical prototyping (e.g. foam modelling)	○	○	○	○	○
When performing conceptual design, I prefer to use sketching	○	○	○	○	○
Usage of CAD in conceptual design leads to more creative designs	○	○	○	○	○

Figure 3: Sample Survey Questions from the 1st and 4th Part of the Survey, respectively

3.3 Analysis

The survey responses were exported from Google Forms, to Google Sheets and downloaded as a .csv file. This .csv file was loaded into Microsoft Excel as the primary vehicle for the analysis. The analysis began by making an assortment of pivot tables from the master data to summarize key demographics, including: age, gender, country, industrial sectors, years of experience, primary CAD tools used, etc. Correlations between variables were identified using the pandas library in Python.

4.0 Initial Results and Insights

4.1 Overview of the Dataset

The Tables 1 and 2 below outline the summary statistics from the demographic and design process related questions asked to the respondents, respectively. Figures 4 and 5 show distributions of the age distributions of the respondents, and the types of CAD softwares used by individuals in their product development workflow. ~85% of responses were taken from individuals from North America, with over 67% of them being mechanical engineers by role categorization. As well, the data is more skewed towards the respondents being in the start of their career (mid-late 20s). These were mostly as a consequence of the respondent recruitment approach. Implications of this bias are discussed below in section 5.1.

Table 1: Summary Statistics of Demographic Information

Years Spent in Role		
Variable	**Count**	**Percentage of Total**
<1 year	2	7.14%
1-4 years	10	35.71%
5-8 years	6	21.43%
9+ years	10	35.71%
Grand Total	**28**	**100.00%**
Role at Organization		
Variable	**Count**	**Percentage of Total**
Engineering Leadership	4	14.29%
Industrial Designer	2	7.14%
Industrial Engineer	1	3.57%
Mechanical Designer	1	3.57%
Mechanical Engineer	19	67.86%
Product Designer	1	3.57%
Grand Total	**28**	**100.00%**
Industry of Practice		
Variable	**Count**	**Percentage of Total**
Aerospace	1	3.57%
Automotive	3	10.71%
Consumer goods	2	7.14%
Cosmetics	1	3.57%
Design consulting	3	10.71%
Energy	2	7.14%
Industrial/Chemical Engineering	1	3.57%
Machine design	11	39.29%
Medical devices	3	10.71%
Robotics	1	3.57%
Grand Total	**28**	**100.00%**

Table 2: Summary Statistics of Design Specific Questions

Number of Years of Experience with CAD Tools		
Variable	**Count**	**Percentage of Total**
<1 year	1	3.57%
1-4 years	10	35.71%
5-8 years	6	21.43%
9+ years	11	39.29%
Grand Total	**28**	**100.00%**
Amount of Time Spent on Individual Design		
Variable	**Count**	**Percentage of Total**
<1 hours	2	7.14%
11-15 hours	8	28.57%
1-5 hours	6	21.43%
16-20 hours	5	17.86%
6-10 hours	7	25.00%
Grand Total	**28**	**100.00%**
Amount of time Spent on Team Design		
Variable	**Count**	**Percentage of Total**
<1 hours	1	3.57%
11-15 hours	5	17.86%
1-5 hours	11	39.29%
6-10 hours	11	39.29%
Grand Total	**28**	**100.00%**
Amount of Time Organization Spends on Conceptual Design		
Variable	**Count**	**Percentage of Total**
<20%	3	10.71%
20-39%	5	17.86%
40-59%	7	25.00%
60-79%	8	28.57%

80% or more	5	17.86%
Grand Total	**28**	**100.00%**

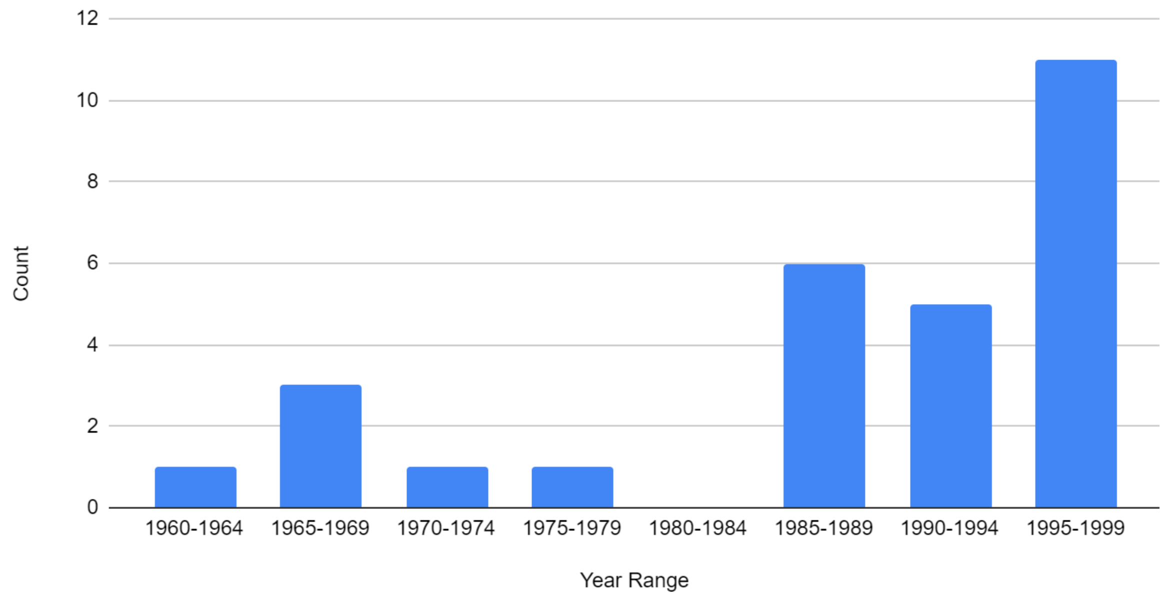


Figure 4: Respondent Year of Birth Distribution

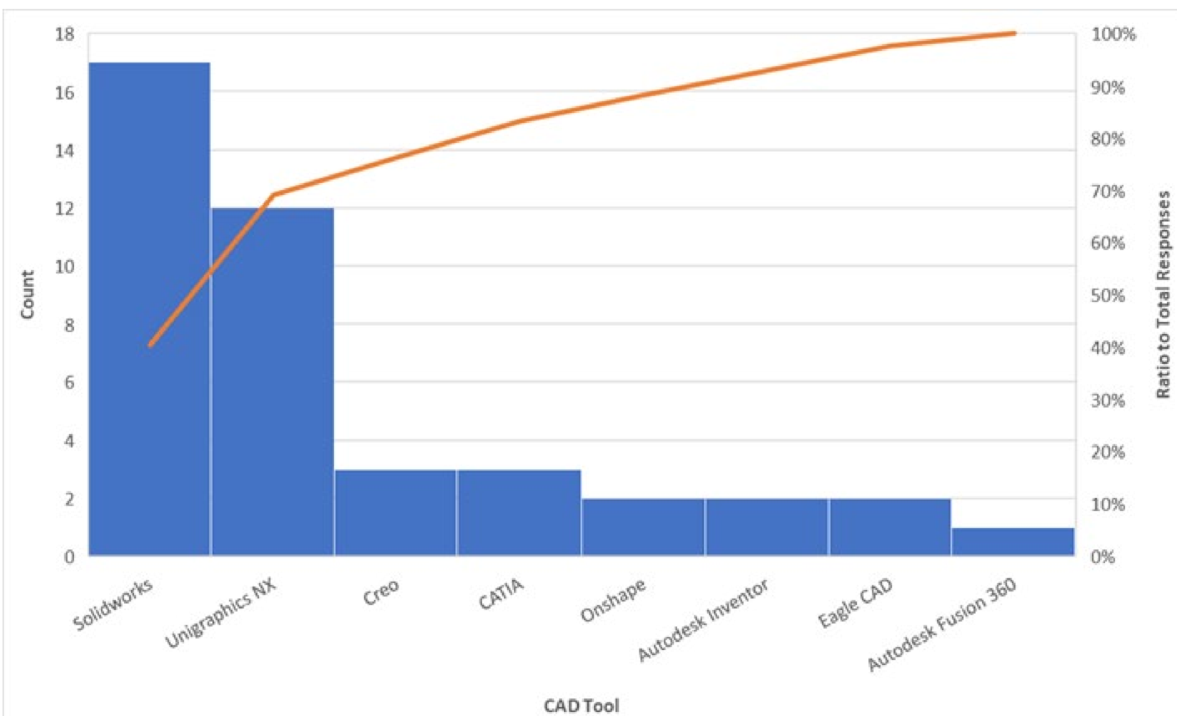


Figure 5: CAD Usage Pareto Chart

4.2 Characterizing CAD Competence and Efficacy in Conceptual Design by Age

The dataset showed interesting correlations between the efficacy of using CAD in conceptual design between demographics. As the older designers had more design experience than younger designers, it is unsurprising to see that in Figure 6, all respondents (with the exception of one) were either neutral, or were in agreement that they possessed competency in CAD. The data also shows that as the age of designers decreases, there is less average certainty in their competency to use CAD, however the total population (N=28), have a high degree of confidence in their CAD competency.

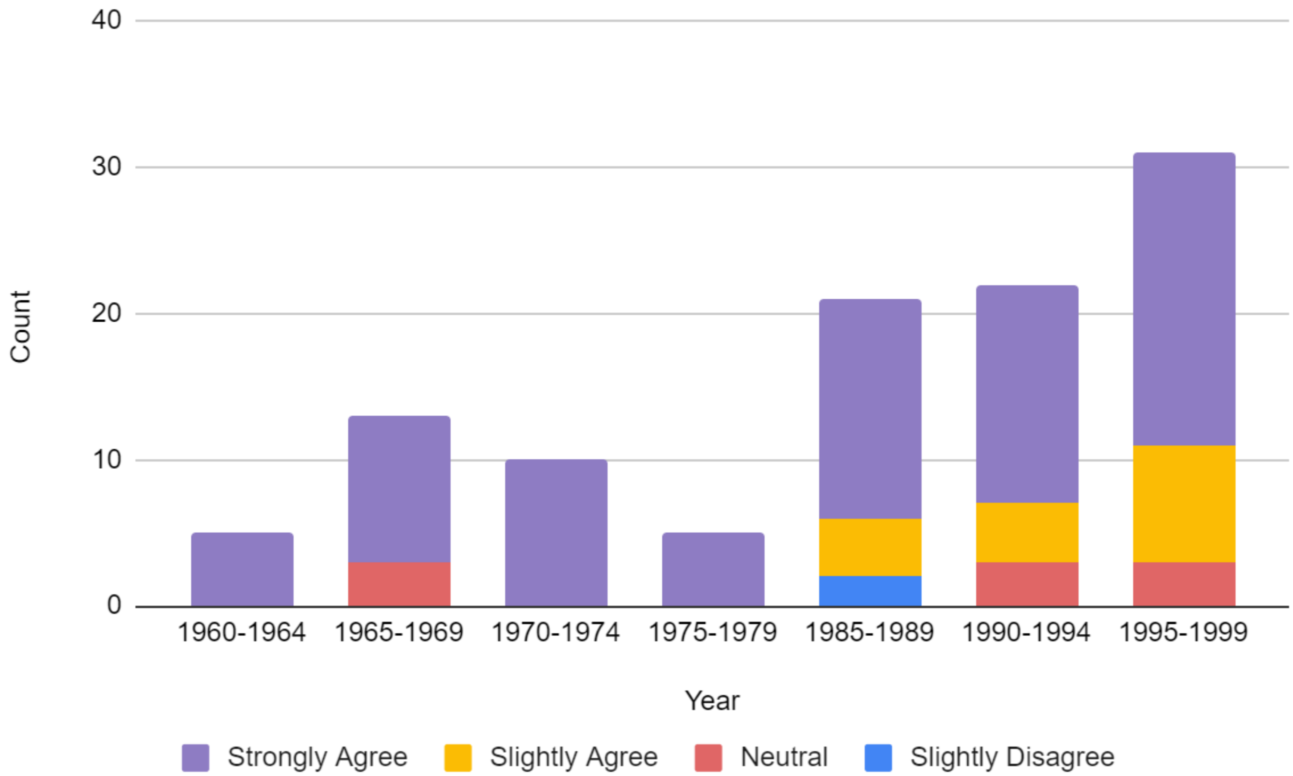


Figure 6: "I am skilled at using CAD software" where 1 = Strongly Disagree and 5 = Strongly Agree (Average Score from Respondents = 4.33)

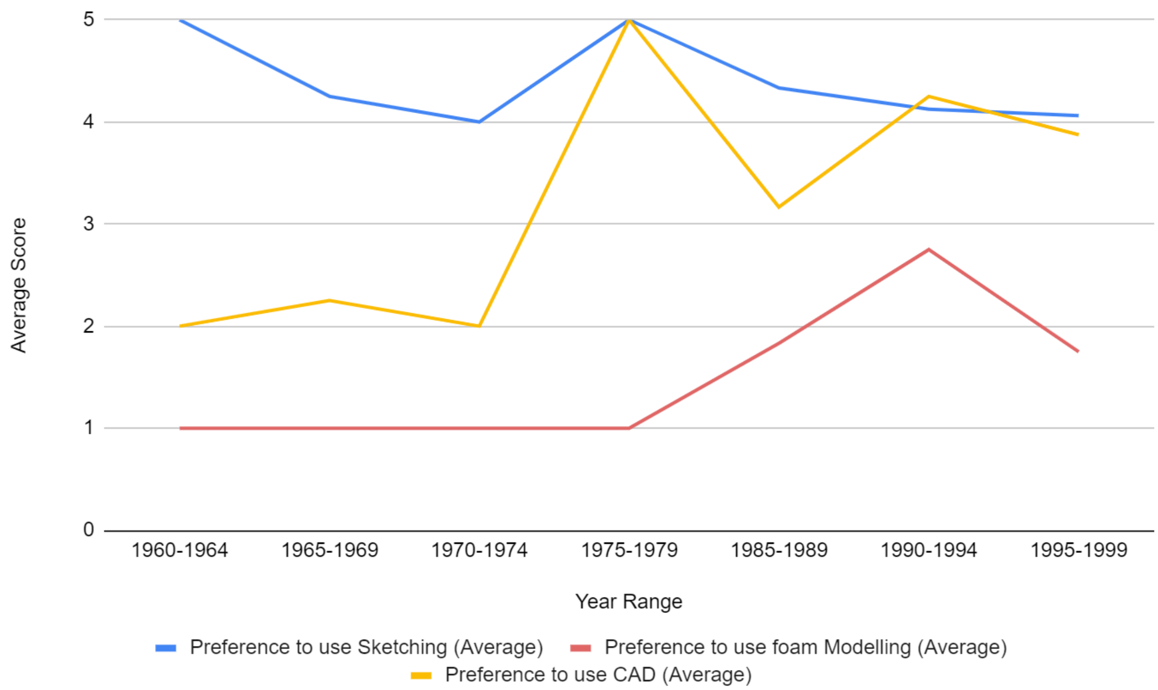


Figure 7: Choice of Tools in response to "I use this tool when performing Conceptual Design", where: 1 = Strongly Disagree and 5 = Strongly Agree (Average Overall Score for sketching, CAD and foam prototyping are: 4.14, 3.71, and 1.71, respectively)

4.3 Value of Conceptual CAD in the Product Development Process

Figures 8-11 below show responses of the respondents to questions regarding the value of CAD in the conceptual stage of the product development process. Figure 8 shows that though the majority of designers believe that Conceptual CAD can lead to more creative designs (through slight agreement), younger designers seem to more strongly believe that conceptual CAD can foster more creativity in the design process. Interestingly, there is a large amount of disparity between designers born between 1985-1989, wherein the highest reported "strongly agree" and "slightly disagree" responses occur within the dataset. It is postulated that this variance is attributed to the industry the designers operate in, and the amount of time the designers spend designing collaboratively.

As suggested by more recent literature, there is large agreement across the respondents that Conceptual CAD can result in better team facilitated design, as shown in Figure 9. The reason for this is likely due to the ability to show different views of the model and make rapid iterations with ease, whereas other conceptual design methods do not possess that fluidity. There were only two responses which disagreed with this sentiment. The individuals who reported slight disagreement were on the lower end of industry exposure, which could be a possible reason for the selection.

Figures 10 and 11 show almost unanimously that all respondents believe that Conceptual CAD can facilitate easier design iteration, and result in higher product quality, respectively. There is stronger agreement with these two statements in younger designers, however it appears that the surveyed population see the value that Conceptual CAD can bring to the overall product design process.

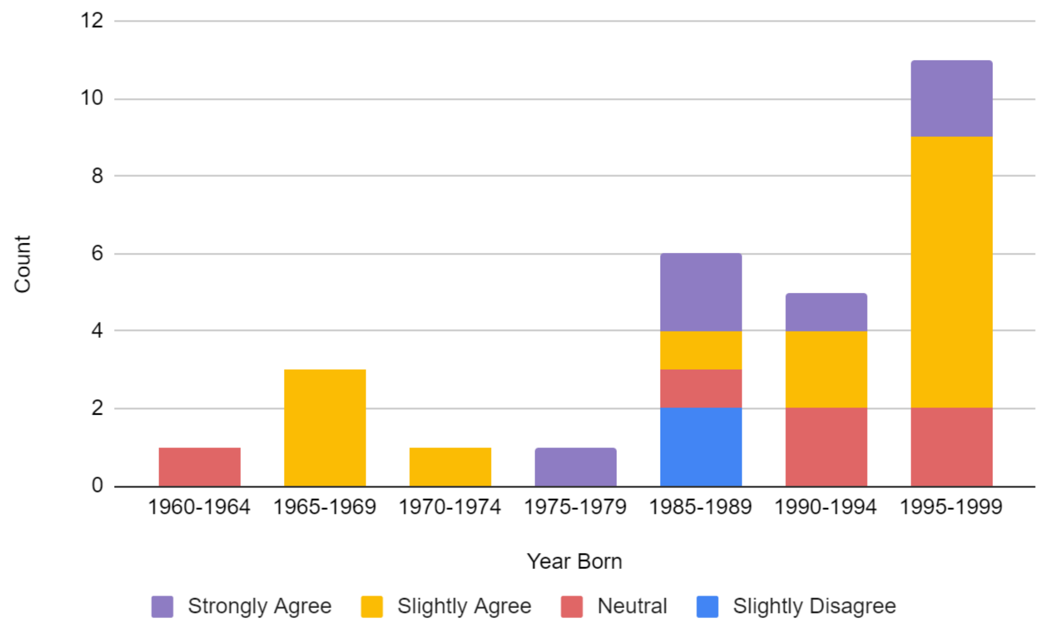


Figure 8: "Conceptual CAD leads to more creative designs" where 1 = Strongly Disagree and 5 = Strongly Agree (Average Score from all respondents: 3.85)

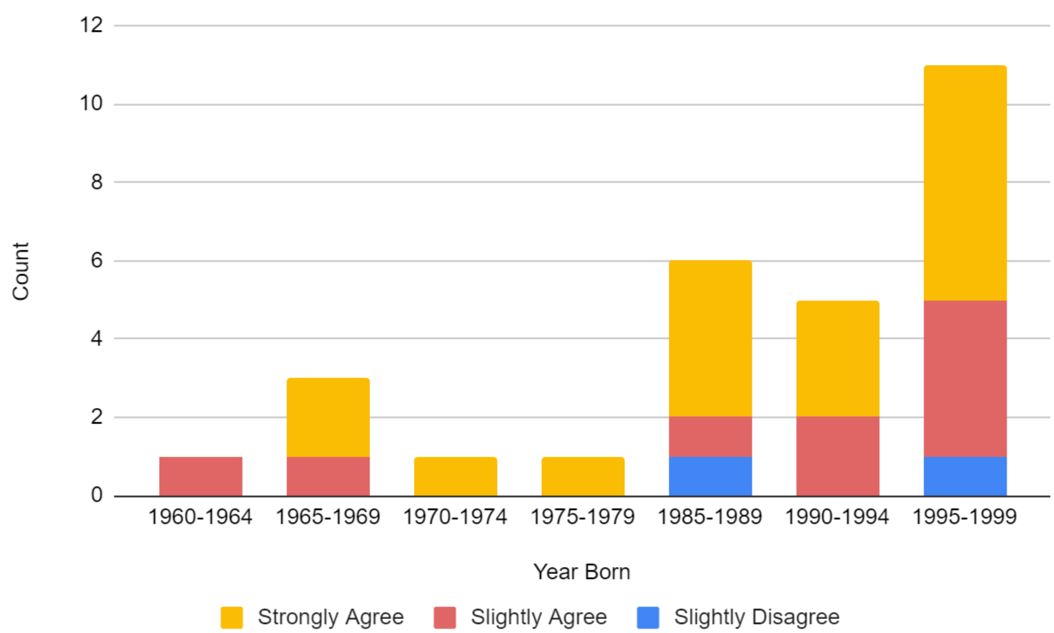


Figure 9: "Conceptual CAD leads to better team facilitated design" where 1 = Strongly Disagree and 5 = Strongly Agree (Average Score from all respondents: 4.54)

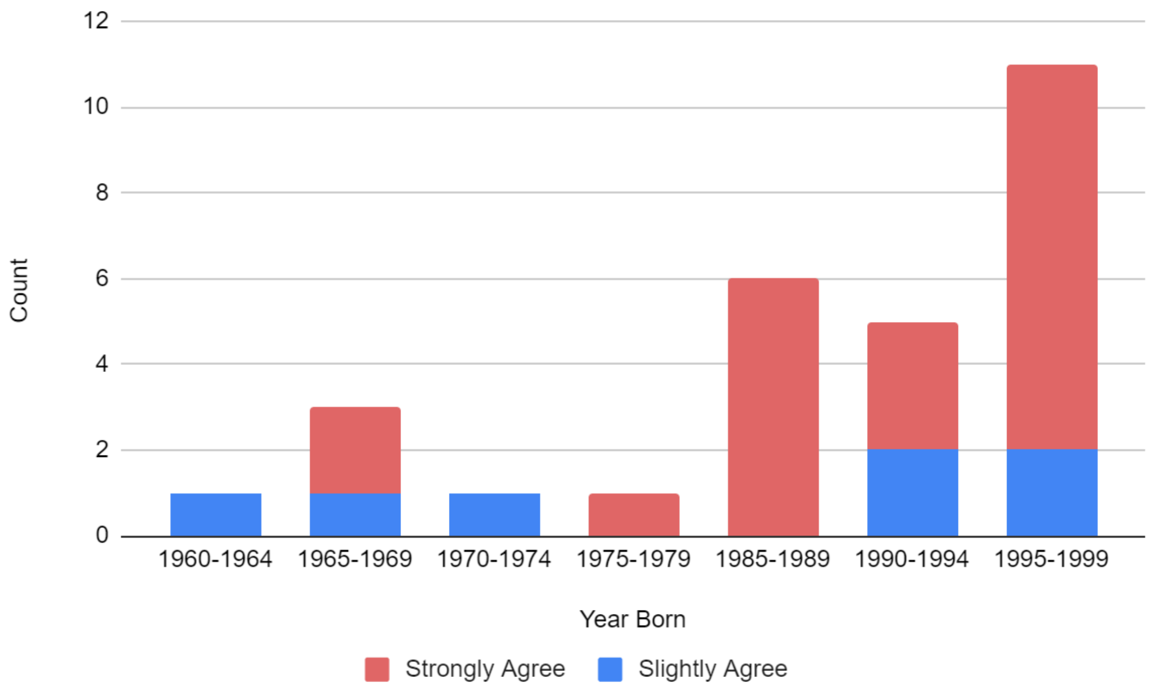


Figure 10: "Conceptual CAD allows easier design iteration" where 1 = Strongly Disagree and 5 = Strongly Agree (Average Score from all respondents: 4.75)

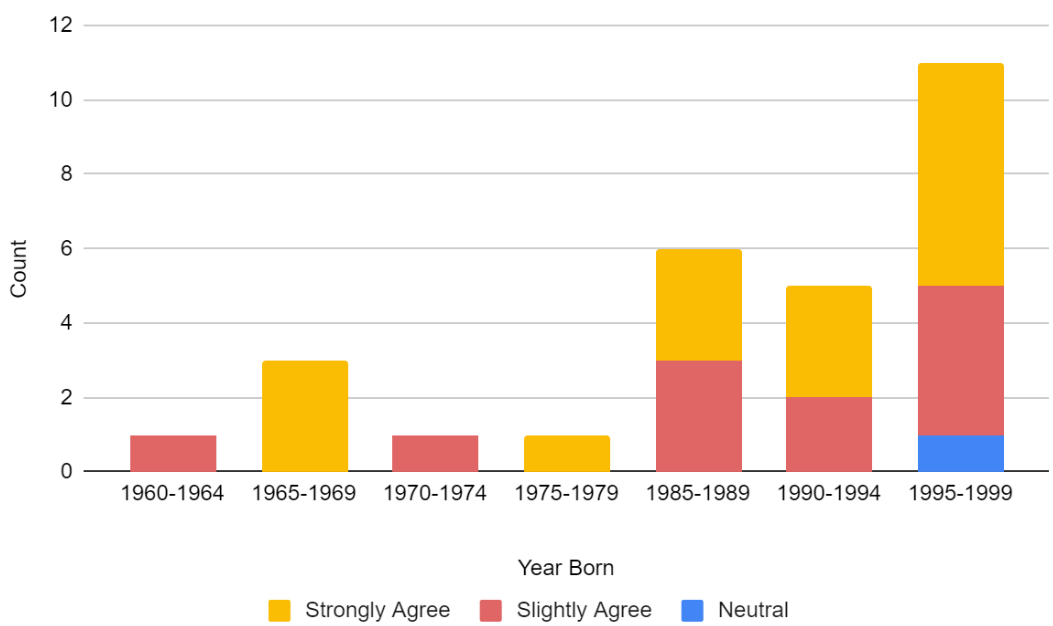


Figure 11: "Conceptual CAD leads to higher end product quality" where 1 = Strongly Disagree and
5 = Strongly Agree (Average Score from all respondents: 4.46)

5.0 Discussion

The Role of Conceptual CAD

Conceptual design is an integral part of the engineering design process, and CAD is a tool that is embedded within the process of product development. From both the review of literature, as well as the initial survey data, there appears to be general consensus between senior and junior engineers on the role of Conceptual CAD, with one notable difference - the proclivity to perform Conceptual CAD as a junior vs. senior designer.

Factors Affecting Conceptual CAD Tool Usage

Unsurprisingly, it is clear that a designer's inclination to use CAD corresponds with the organization that the designer works for; particularly the amount of time spent doing conceptual design. Contrary to the literature reviews, which shows that design is becoming a much more collaborative process, the majority (~76%) of individuals report spending less than 25% of their working weeks doing design as a team. However, there seems to be a fairly uniform distribution between the amount of time that designers spend doing individual design. This can indicate peripheral tasks (e.g. meetings, fabrication, testing, etc.) which are necessary weekly tasks to the designer, but which do not fall under the conceptual design categorization of tasks.

Another critical factor which may influence the choice of CAD tool is the amount of experience with CAD tools, and their novelty to the designer. Since the data was collected via an anonymous online survey, the data collected was only interpreted from the response to the questions; no follow up questions could be conducted or delved into greater depth (covered more in section 5.1). Since the idea of evaluation of CAD competency from a survey cannot be done experimentally or through reviewing empirical data, the meaning of the data is defined by the interpretation of the question. This idea is explored by Ehrlinger et al, wherein it is found that there is a region of inverse correlation between an individual's confidence in understanding something and their actual competency (shown in Figure 11 below) [29]. This effect could potentially be why senior designers who report higher average competency in the tool, use the tool less for conceptual tasks; since the senior designers understand the advantages and limitations of Conceptual CAD, and when it is appropriate to use for certain design tasks. As well, another factor which may show why junior engineers are more inclined to use CAD despite having less average competence, could stem from the fact that CAD is a novel and digitally captivating tool to create designs. As such, designers who have less experience with CAD, may be more inclined to perform Conceptual CAD to practice and become more adept. This effect can also partly relate to why there is unanimous usage of sketching across all age groups. It is believed that since drawing is taught as a graphical representation medium since childhood, the innate ability to express ideas graphically through sketches extrapolates habitually into the PIDE space [30].

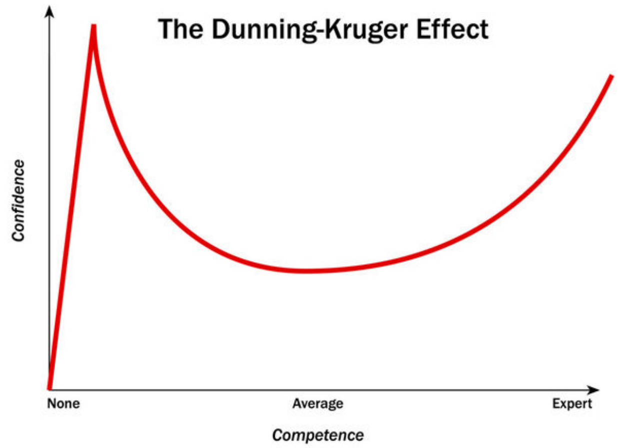


Figure 11: Dunning-Kruger Effect Curve [29]

Connection Between CAD Tools, Design Education Curricula and the Future of the PIDE Industry

The majority of respondents reported usage of Solidworks and/or Unigraphics NX for their design work, as opposed to other types of CAD software. This is likely because these softwares are market leaders in engineering product design, and are also taught to students in undergraduate studies, as confirmed by the post secondary syllabi review of design courses. Another question which comes from this is how often organizations change their CAD design packages, for more innovative/modern tools. Presumably, the process of changing a software across an enterprise, and onboarding/training new individuals to use the software is quite expensive (both in terms of human and monetary capital), and as such organizations may tend to stay with a CAD supplier for their design applications. Something which is of interest though out of scope for this study, is how different institutions select different CAD packages for educational purposes to students who are learning PIDE. As senior designers start to retire out of the PIDE industry, and more junior designers start to become the majority, it stands to reason that there will be bias in selection of enterprise CAD tools, since the relevant design skills that the junior designers will have will be with softwares they learned during their education. This presents an opportunity for both universities and CAD software companies to potentially change the market dynamics of CAD design through revitalization of the design curriculum. Though universities currently exhibit full design cycles across a variety of courses spread out in different semesters, it could be of major benefit for universities to integrate student extracurricular design teams as a part of the engineering curriculum. The ingrained collaboration required in design teams, as well as the cross-disciplinary interaction of students, academic mentors/advisors and industry sponsors, is the most realistic analogue to the full end-to-end design cycle currently present in an academic setting. In addition, since the competitive aspect of design competitions to create superior designs push students to explore new/creative design avenues, this aspect could be of great interest for future case studies to see how collaborative design engineering practices in student teams can extend to industrial implications. Furthermore, by teaching newer state-of-the-art tools, there will be more students who will learn these types of tools and thus inevitably dictate the market usage of all CAD tools, as these students start to populate the PIDE industry in a few years time.

5.1 Limitations of Results

There are some factors of limitation and error that must be taken into consideration, before assuming that any of the findings from the data are generalizable, or representative of the PIDE industry as a whole. As noted in the overview of the dataset, the respondents of the survey are predominantly Canadian males and the majority of responses were collected from mechanical engineers, as opposed to other types of designers or engineers.

Since the overall number of responses to the survey were not numerous, the predominant gender and occupational disparity may bias the findings of this survey, as the survey's findings are not a proper representative of designers/engineers in the PIDE industry. Future work will focus on capturing responses from a larger sample of designers, and test sensitivity of the results for over-representative variables. Further work into this study is being conducted by the research team to mature the findings from the current initial state, and it is encouraged that other researchers attempt to repeat the experiment to create more general findings in other diverse demographics.

6.0 Conclusions and Next Steps

This paper explored survey data associated with Conceptual CAD as it relates to the Product Development Process. Specific emphasis was placed on how different aspects (particularly around age and industry experience), related to how designers use Conceptual CAD. It was found that though senior engineers may have more average confidence in their ability to competently use CAD, junior engineers are more inclined to use CAD for Conceptual Design. There is general consensus across the surveyed population that CAD does have significant value for an organization's product development process, and using it in earlier stages can allow for quick iteration, collaborative team design and higher overall product quality. As more individuals are surveyed beyond these initial findings across more industries, demographics and geographies, the research team hopes to conduct more qualitative interviews to get a better understanding of the advantages and pain-points of Conceptual CAD, and recommendations towards design engineering education improvements. CAD is a bedrock of the PIDE industry, and as students and junior designers start to populate this industry and dictate the norms and standards, it is important to provide education to these individuals with the proper tools and frameworks to help innovate and bring products never imagined before.

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