2023 Annual Conference & Exposition
Baltimore Convention Center, MD | June 25 - 28, 2023
The Harbor of Engineering Education for 130 Years
ASEE
Paper ID #38249

Analysis of Engineering Undergraduates' Confidence with Hands-on Tasks – Preparation for Collaborative Manufacturing Environments in the Era of Industry 4.0

Xiaoou Yang, University of Georgia

Xiaoou Yang is a PhD student from College of Engineering, University of Georgia. She is also a graduate research assistant in Dr. Beshoy Morkos's Model Group. Xiaoou Yang got her bachelor's degree in Mechanical Engineering in May, 2019 at Florida Institut

Ashlyn Claire Floyd
Mr. Logan Alexander Smith, University of Georgia

Logan Smith was born in Athens, GA and raised in Marietta, GA. He received his Bachelors in Mechanical Engineering from UGA in 2022 and is currently pursuing a Masters of Science in Engineering with a Mechanical Engineering emphasis at UGA under the advisement of Dr. Beshoy Morkos. He won the NSF/ASME Student Design Essay Competition as well as the CIE Poster Competition at ASME IDETC/CIE 2022. Logan is currently pursuing a research interest in Human-AI interaction. Outside of engineering, he enjoys live music events, football, gaming, and traveling.

Dr. Beshoy Morkos, University of Georgia

Beshoy Morkos is an associate professor in the Department of Mechanical and Civil Engineering at Florida Institute of Technology where he directs the STRIDE Lab (SysTems Research on Intelligent Design and Engineering). His lab currently performs research

Analysis of Engineering Students' Perception towards Hands-on Tasks – Preparation for Collaborative Workplace in the Era of Industry 4.0

Abstract

Many engineering students are expected to become skilled and experienced in solving practical hands-on projects before they graduate. For students without formal engineering experiences (co-ops, internships, full/part-time jobs) this is often achieved through courses such as capstone design, cornerstone design, and in labs. The need for engineers with hands-on exposure will only increase as we experience a revitalization of manufacturing and the emergence of Industry 4.0. However, we currently do not know students' hands-on ability as it varies between majors and students in the context of Industry 4.0. To address this, a study of engineering students is necessary to assess their readiness for hands-on projects.

This paper presents an analysis of engineering students' perception towards hands-on tasks. In this study with students at the Uiversity of Georgia, we collected quantitative interview data from 30 students across four engineering majors by using Likert scale survey questions. We compared students' majors, perceptions, experience, and the courses they completed related to hands-on projects. The results showed that some perception factors, such as frequency, familiarity, and confidence, are not always directly proportional. Additionally, many students did not feel prepared or confident to work in manufacturing environments in preparation for Industry 4.0. Further, students formal engineering experiences contributed more to their confidence in hands-on projects than curricular experiences. This study serves as a foundation for further investigation into the relationships between perception factors and the development of instruments to support student success and better prepare engineering students for the various sectors of industry.

Keywords: Industry 4.0, future manufacturing, hands-on skills, perception disparity, engineering student development.

1. INTRODUCTION

Being capable of solving hands-on tasks is required for engineering students in their career paths [1]. The Fourth Industrial revolution, so-called Industry 4.0, is under implementation in many manufacturing enterprises. Further, we have witnessed many countries set manufacturing goals for Industry 4.0 implementation within the next decade.

Industry 4.0 is reshaping the construction of our ecosystem, reconceptualizing its operation and interconnectivity. Emerging technologies are seen as the trigger for Industry 4.0, also known as the "digital revolution," "smart factory," and "advanced manufacturing" [2]. To meet industrial needs, human workforce development has been identified as a top challenge due to the impact of digitalization. Although Industry 4.0 significantly impacts the labor market, it has been confirmed that a skilled human workforce is in high demand to keep pace with Industry 4.0 [3,4]. As a result, training the human workforce should not be neglected, and putting human development at the center is key to the success of Industry 4.0 [5], [6].

The human workforce must be equipped with advanced technical skills and maintain well-being while facing challenges in this revolution. Technical skills in Industry 4.0 include but are not limited to, mechanical engineering for design and manufacturing, civil engineering for managing and maintaining, electrical engineering for building and performing, and computer engineering for programming and troubleshooting. These technical skills are all hands-on in nature and prompt students to think creatively and develop experimental skills. Engaging in hands-on tasks can enhance the retention of information, strengthening connections with the learning content and triggering the development of additional skills [7]. Hands-on experience related courses offered in universities benefit engineering students' cognition development through engineering design processes [1]. The benefits of hands-on training contribute to human workforce development and support the advancement of Industry 4.0. Qualifying for hands-on skills prior to starting a career is gaining increasing attention. Hands-on skills training is typically divided into two categories: external training and interpersonal training. Many universities offer a wide range of engineering courses that include hands-on practice [8], and most engineering students seek out hands-on skill growth and industry experience through co-ops, internships, or part-time or full-time jobs outside of school [9].

Previous studies suggested that the under-preparation for lack of hands-on skills among engineering students may be due to a discrepancy between their perception and the reality of available resources. The vast amount of resources for improving hands-on skills suggests a disconnect between what is perceived and what is available. "There are, it has been said, two types of people in the world. There are those who, when presented with a glass that is exactly half full, say: this glass is half full. And then there are those who say: this glass is half empty [10]."

Factors such as life experiences, environment, and mental states can influence the formation of individuals' perceptions. People construct their realities based on their perceptions, which they believe to be true, but the subjective feeling of individual perception does not always reflect reality. Perception affects how people think, recall, interpret, comprehend, synthesize, and make decisions. Perception plays a critical role in determining human behavior and performance. Addressing the issue of perception factors through motivation can contribute to the holistic development of Industry 4.0.

Engineering students form perceptions about the difficulty of tasks they are assigned. For example, hands-on projects may be perceived as strenuous or tedious due to factors such as time constraints and project requirements [2]–[4]. The increased emphasis on hands-on modules in mechanical engineering has led to an increased workload, which may be perceived as increasingly heavy [11].

Researchers have found that students have experienced a 25% increase in workload and a 23% increase in work outside the classroom [11]. Hands-on tasks require students to have prior knowledge or an understanding of concepts, otherwise, the time constraint may hinder their completion. This was also noted in co-robotics hands-on activities, where it was found that students' interest in activities and perception of workload is dependent on their perception of difficulty, prior experience, and confidence level [12]. This has drawn attention to the need for further exploration in the field of engineering workforce development. The present paper examines the relationship between perception factors as prior research has indicated the importance of student's hand on experience [13]. To that end, we present the following research questions surrounding student confidence and self-perception surrounding hands-on project experience:

- What's the current confidence level, sense of importance, familiarity rate, and level of frequency of engineering students toward the hands-on project?
- What are the relationships between self-perception factors in the context of conducting hands-on projects among engineering major students?
- What impact does industry experience have on self-perception factors?

2. LITERATURE REVIEW

The literature review for this study is presented in this section. First, the introduction of Industry 4.0 and the role of humans in the current environment is provided. Then, the concept of hands-on tasks and the job responsibilities associated with hands-on tasks for four engineering majors are discussed separately. Finally, the general definition of perception factors and their definition in the context of this study are presented.

2.1 Industry 4.0

Industry 4.0 is transforming the economic system, driven by the proliferation of new technologies. From this perspective, Industry 4.0 can be seen as a digital transformation, in which traditional factories are becoming smart factories [14]. These technological advancements have significant social implications, particularly in the manufacturing sector, where there is a growing need for current and future employees to upgrade their skills and re-qualify for their jobs [15]. The successful implementation of Industry 4.0 therefore requires preparation of the future workforce to address skill development [16], [17]. Engineering students, who will work in the manufacturing industry, need to possess a set of competencies to understand the future of manufacturing. One of the most crucial skills that engineering students must develop is hands-on experience. For many engineering jobs that involve hands-on projects, students must be able to apply their theoretical knowledge to real-world situations in order to be successful in their careers. Engineering education recognizes the value of hands-on experience in problem-solving and knowledge application. By engaging in hands-on learning, students can apply the theories they have learned to dynamic challenges.

2.2 Hands-on Tasks

2.2.1 Importance of Hands-on Tasks for Engineering Students

One continual challenge of engineering programs is the ability to provide adequate training opportunities that prepare students before they start working, including the ability to perform hands-on tasks. Despite the world of engineering becoming increasingly more sophisticated with the implantation of Industry 4.0, practical ability and intuition remain important. Research has shown that, when asked to rate necessary graduate skills from 1-5, industry respondents have confirmed the importance of hands-on ability (mean value 4.35) along with communication (mean value 4.52) and teamwork (mean value 4.42) skills [18]. Students today are less likely to have grown up in rural environments, and therefore have probably had fewer opportunities to tinker and develop hands-on skills before their industrial careers [18]. Therefore, it is necessary for students to obtain hands-on skills. The implementation of hands-on tasks also has the potential to improve the recruitment and retention of students, especially among low-income and first-generation students[19]. In addition, self-efficacy with respect to hands-on tasks has the potential to enhance the enjoyment and interest in engineering. Students can obtain a deeper knowledge through the exploration of real-world problems [20], providing motivation when developing solutions.

2.2.2 The Meaning of Hands-on to Different Engineering Majors

In the field of mechanical engineering [21], working with the inclusion of the reverse engineering/redesign component allows them to learn the design methods while manipulating an actual product, as opposed to applying the methods only to abstract paper designs, as is sometimes done in original design projects. Civil engineers, as portrayed in previous research [22], lack adequate experience in preparing them for onsite projects as most of them find jobs in construction while computer engineering majors use software development as part of their hands-on tasks [23]. Lastly, it is justified that electrical engineers use a combination of hands-on electrical components while using computer science software as well [24]. As these are all into consideration, there is a wide range of job responsibilities with hands-on tasks per field of engineering. The estimation has been acquired through observation that 90% of mechanical engineers, 85% of civil engineers, 80% of computer engineers, and 70% of electrical engineers have hands-on tasks included in their criteria for job responsibilities.

2.3 Perception Factors

2.3.1 The Importance of Studying Perception Disparity

The effects that an individual's self-perception has on their performance in a task has been a topic of study for decades, such as the relationship between attitudes/beliefs and behaviors [25]. The different factors that make up an individual's perception of their abilities or experience, such as confidence levels, can affect various performance metrics when performing an assigned task. These factors can be considered in a multitude of fields, such as the effects of academic competence on academic performance [26], or performance metrics in engineering environments such as manufacturing. Individuals in the field of engineering identify and find an affinity for different features of a domain [27], and these differing affinities can influence competency and behavior when performing tasks in manufacturing environments. As a result, it is critical to consider a "perception-reality gap" as a factor that affects workplace performance, as well as have the ability to identify and analyze this gap.

2.3.2 Perception Factor Glossary

There are universal understanding of these factors and in the context of our experiment, we give a general definition first, and in our study, we designed a survey questionnaire using a 5-point Likert Scale, where we explain the definition in the context of our experiment.

Realistic perception: Realistic perception is what experience is currently present without the influence of a student's point of view. In this study, we investigate familiarity and frequency in particular.

Familiarity: In general, familiarity is the state of what is known and provides the basis for recognizing something as different as described in [28]. During our experimentation, familiarity is the state at which the students recognize whether they have or have not worked with hands-on tasks [29]. Though this can be perceived as a self-perception, it is identified as a realistic perception because it measures how much experience students have with working on hands-on tasks whether due to industry or classroom experience. Familiarity measures whether they have been exposed to hands-on tasks.

Frequency: According to Stohr-Hunt [30], frequency is said to be the amount of time of engagement in an activity. In this paper, frequency deals with the fundamentals of how often the students are exposed to hands-on tasks.

Self-perception: Self-perception is the development of how students judge themselves and their understanding of a topic. In this area of study, there must be an analysis of the student's confidence and level of importance to determine whether they believe, or perceive, that they have adequate skills to conduct hands-on tasks currently and in the future.

Confidence: As stated, confidence depends on the amount and strength of the evidence supporting the answer chosen [31]. In the context of our experiment, for each answer chosen, dependent on the zero to five scale, the students are able to justify their confidence level by listing courses at the University of Georgia where they have gained hands-on experience in manufacturing to provide evidence for their confidence level rating.

Importance: Importance is the student's perception of how important they perceive on having adequate hands-on skills in their careers, while in all of these cases hands-on projects are defined differently in each field of engineering. The level of importance in this study is measured on the zero to five scale mentioned previously as well as if the students believe they will use these skills in their designated field of study (i.e. mechanical, electrical, computer, and civil engineering). Importance is the increase in generalities as students work on a series of tasks where they become more common to build a highly specific and concrete form between all students [30].

The perception factors mentioned above align closely with the affective domain of Bloom’s taxonomy. The affective domain focuses on the attitudes, values, and interests of learners and is devided into 5 subdomains; receiving, responding, valuing, organization, and characterization. The two factors of realistic perception, familiarity and frequency, fall into the subdomain of receiving. This subdomain is characterized as being aware of the existence of certain ideas or phenomena. The two factors of self-perception, confidence and importane, correspond with the valuing subdomain. This subdomain pertains to the ability for learners to see the worth of something and express it.

3. METHODOLOGY

This study was conducted among students from four engineering majors using a survey questionnaire. The questionnaire was designed within the scope of the study and statistical analysis was used to explore the correlations between perception factors.

3.1 Matrix

This study is designed to examine the perception of engineering students towards hands-on tasks in the context of Industry 4.0. A perception matrix – shown in Figure 1 - was created, consisting of four key factors that are closely related to hands-on tasks: familiarity, frequency, confidence, and importance. These factors are classified into two categories: realistic perceptions (familiarity and frequency) and self-perceptions (confidence and perception of importance). The matrix provides a foundation for exploring the relationship between perception factors and developing strategies to support the growth and development of engineering students.

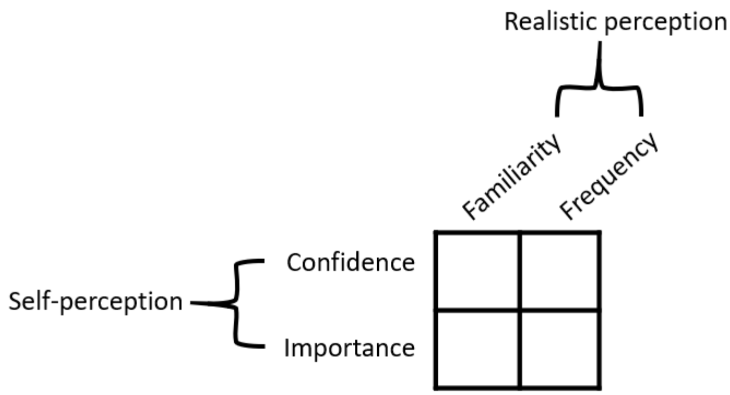

Figure 1 Matrix of Perception Factors

3.2 Survey Protocol Development

The research instrument in this study is a survey questionnaire consisting of 10 questions. The survey aims to capture the participants' internal consistency between past experiences and the current environment, as well as their perspectives. The choice of using a survey was driven by the research questions focused on understanding the participants' attitudes and judgments. The survey questions were based on the identity capital model, which includes four variables (self-esteem, purpose in life, locus of control, and ego strength) [32]. The first five questions are demographic items, while the remaining five questions, related to the participants' subjective responses towards hands-on projects, are used for the analysis in this paper (as shown in Table 1). Participants' responses were rated on a five-point Likert scale, with 1 representing the lowest level of agreement and 5 the highest. The survey questions relating to each perception factor and experience-related questions are outlined below.

Table 1:Perception Survey Questions

Perception Factor	Survey Question
Confidence	How confident do you think you are with hands-on tasks (i.e., putting the parts of tools together using equipment) in the engineering field?
Importance	Do you think it is important for engineering students to be skillful at carrying out the industry-related task?
Familiarity	Please rate your familiarity with your ability of conducting hands-on tasks.
Frequency	How often do you take part in hands-on tasks in your engineering education experience?
Experience	Have you worked outside the campus in the industry?

3.3 Research Subject and Data Collection

The survey questionnaire consisted of 10 questions and was designed to assess the students' perceptions of familiarity, frequency, confidence, and importance related to hands-on tasks in engineering. The survey was administered to 30 students from 4 engineering majors at the University of Georgia. Participants were divided into 10 groups of 3 students each and were asked to fill out the survey items based on their subjective opinions and individual experiences. The responses were rated on a five-point Likert scale, ranging from 1 (lowest level of agreement) to 5 (highest level of agreement). The survey aimed to measure the participants' perceived levels of the four perception factors and provide insights into the relationships between these factors.

3.4 Data Analysis Method

Multiple methods are used to address different research questions. Survey answers for each perception factor are collected from every participant and are put into plots. Scatter plots are used to visualize the data locality, data clusters for each major can be compared through scatter plots. Correlation coefficient analysis is a statistical method used to quantify the relationships between factors, we used this analysis to examine the dependency of perception factors and determine the amount of change in one perception factor as a result of the other's change.

4. RESULTS

This section listed all the analyses in our study. We first use scatter plots to cluster the data points for four engineering majors, this clear way of visualization makes it accessible to find the distinction between all the majors. Then we adapt correlation analysis to explore the relationships among all the perception factors. Lastly, a comparison was made to test the impact that industrial experience has on students' confidence levels.

4.1 Distribution Analysis

Plots on the left side display the distribution of all the data, with different majors represented by separate colored circles. The plots on the right side show the mean value distribution. The horizontal and vertical axes represent the different perception factors that were measured, and the numbers on the axes represent the Likert Scale responses to those factors.

By comparing the mean values of all the plots, it can be seen that computer engineering students have the highest level of confidence in conducting hands-on projects, followed by civil, mechanical, and electrical engineering students. They also have the highest level of self-perceived importance in conducting hands-on projects, followed by electrical and mechanical engineering students. Civil engineering students have the lowest level of self-perceived importance. When it comes to familiarity with hands-on projects, computer engineering students still rank the highest, followed by civil and mechanical engineering, with electrical engineering ranking the lowest. In terms of the frequency of conducting hands-on projects, computer engineering students have the most experience, followed by electrical and civil engineering, while mechanical engineering students have the fewest experiences.

As seen in Figure 2, the levels of confidence in conducting hands-on projects and familiarity with hands-on projects are relatively equal, indicating that there is no gap (based on the sample size in this study) between self-perception and reality when considering individual experiences. Figure 3 compares the level of confidence with the frequency of doing hands-on projects and data in this plot shows that, apart from electrical engineering, students from the remaining three majors have a lower frequency of exposure to hands-on projects compared to their levels of self-confidence. By examining Figure 4, students from mechanical, electrical, and computer engineering all perceive hands-on projects as important, which can be interpreted as having higher expectations for hands-on projects than their level of real-life familiarity, with the exception of those in civil engineering. Figure 5 presents the comparison between the self-perceived importance of doing hands-on projects and the actual frequency of involvement in hands-on projects, and it is evident that all students consider hands-on projects to be important, but have fewer opportunities than they expect. The collective ranking list for the four perception factors among the four majors is presented in Table 2.

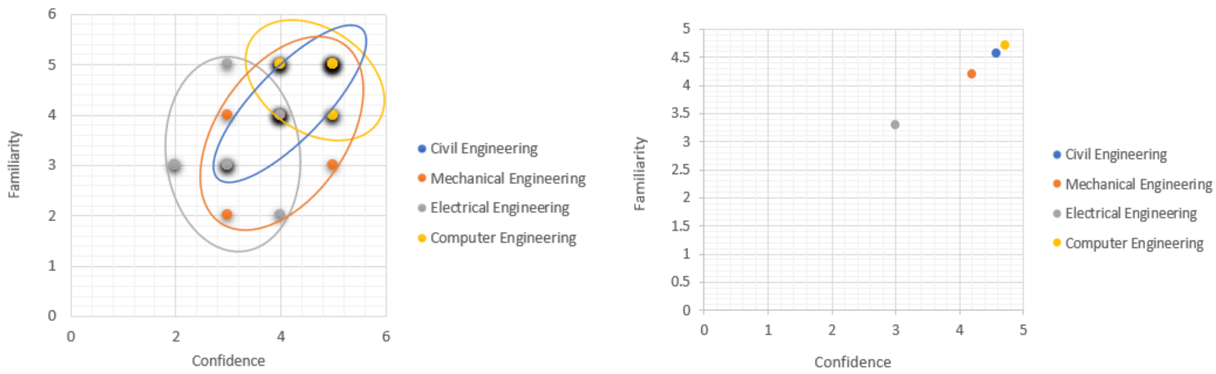

Figure 2: Confidence vs Familiarity Level Comparison

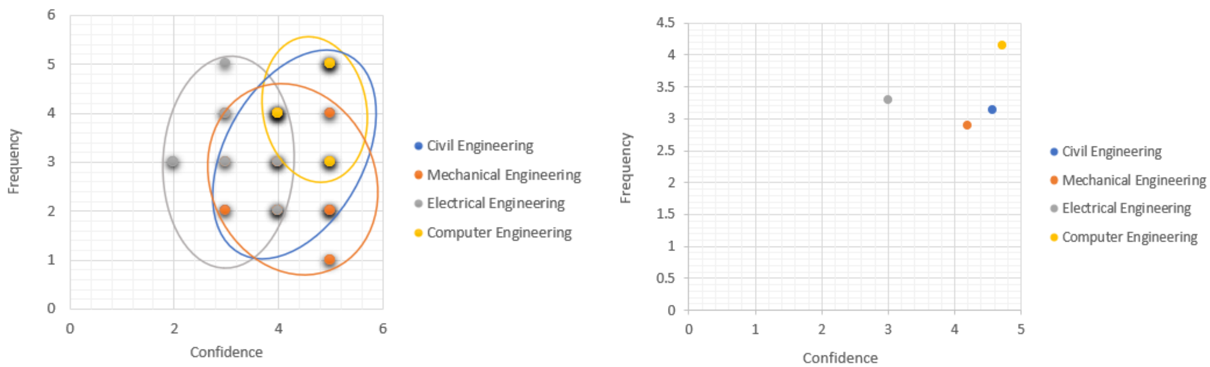

Figure 3: Confidence vs Frequency Level Comparison

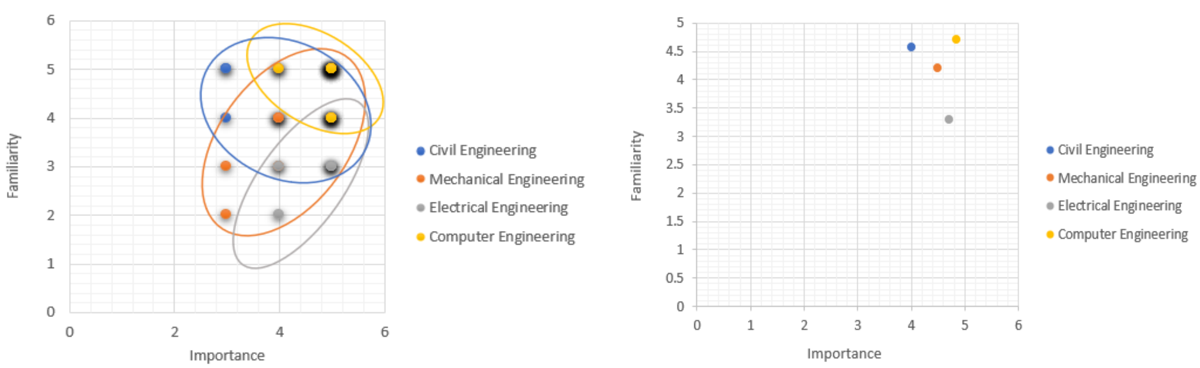

Figure 4: Importance vs Familiarity Level Comparison

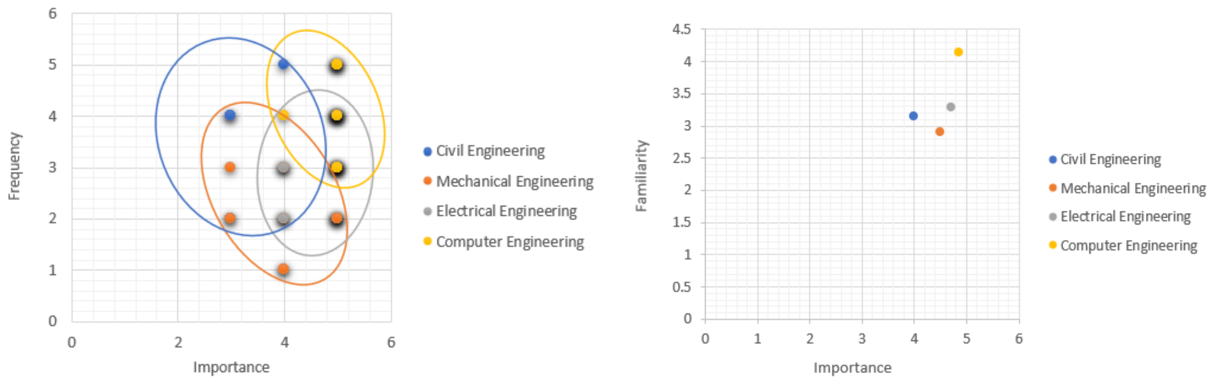

Figure 5: Importance vs Frequency Level Comparison

Table 2: Collective Ranking (Highest to Lowest)

Confidence	Importance
Computer Engineering	Computer Engineering
Civil Engineering	Electrical Engineering
Mechanical Engineering	Mechanical Engineering
Electrical Engineering	Civil Engineering
Familiarity	**Frequency**
Computer Engineering	Computer Engineering
Civil Engineering	Electrical Engineering
Mechanical Engineering	Civil Engineering
Electrical Engineering	Mechanical Engineering

4.2 Correlation Analysis

Correlation coefficient analysis is used to assess the strength of relationships (positively/negatively related, strongly/weakly related) between self-perception factors. Confidence and importance were isolated when analyzing their relationship with self-perception factors related to real-life experience (familiarity and frequency). Correlation coefficient (r) is a number between -1 to 1, the stronger the correlation is, the closer the correlation coefficient approaches to 1. When the correlation coefficient is a positive number, that means the high value of one factor tends to be paired with relatively high for the other factor, and vice versa. The correlation coefficient analyses for each engineering major are shown below.

Table 3 presents the correlation between confidence, familiarity, and frequency among civil engineering students. It is observed that confidence and familiarity (r=0.9107), and importance and familiarity (r=0.9266) are strongly related, while importance and frequency (r=-0.7240) are inversely related.

Table 3: Correlation Results of Civil Engineering

Factors	Confidence	Familiarity	Frequency	Factors	Importance	Familiarity	Frequency
Confidence	1			Importance	1		
Familiarity	0.9107	1		Familiarity	0.9266	1	
Frequency	0.8237	0.7811	1	Frequency	-0.7240	0.7811	1

As shown in Table 4, the correlation between confidence and frequency (r=0.0.8757), frequency and familiarity (r=0.8611) are closely correlated. It is also observed that importance and frequency (r=0.4783) have a relatively weak correlation, which is not considered related.

Table 4: Correlation Results of Mechanical Engineering

Factors	Confidence	Familiarity	Frequency	Factors	Importance	Familiarity	Frequency
Confidence	1			Importance	1		
Familiarity	0.7667	1		Familiarity	0.5340	1	
Frequency	0.8757	0.8611	1	Frequency	0.4783	0.8611	1

In Table 5, for electrical engineering students, the correlation between confidence and familiarity (r=-0.3273), confidence and frequency (r=-0.4296) are negatively correlated, while importance and frequency (r=0.8236), familiarity and frequency (r=0.8911) remain to be strongly tied.

Table 5: Correlation Results of Electrical Engineering

Factors	Confidence	Familiarity	Frequency	Factors	Importance	Familiarity	Frequency
Confidence	1			Importance	1		
Familiarity	-0.3273	1		Familiarity	0.7559	1	
Frequency	-0.4296	0.8911	1	Frequency	0.8236	0.8911	1

Table 6 shows the correlation results for computer engineering majors. The correlation between familiarity and frequency (r=0.8941) ranked the highest among the four engineering majors. Negative correlations were observed between confidence and familiarity (r=-0.2085), confidence and frequency (r=-0.3355), the same correlation type as those of electrical engineering students.

Table 6: Correlation Results of Computer Engineering

Factors	Confidence	Familiarity	Frequency	Factors	Importance	Familiarity	Frequency
Confidence	1			Importance	1		
Familiarity	-0.2085	1		Familiarity	0.7692	1	
Frequency	-0.3355	0.8941	1	Frequency	0.8976	0.8941	1

4.3 Comparison Analysis

Boxplot is used to demonstrate the distribution of data. In this study, we also compared the confidence level between students' groups with and without industry experience. As observed in Figure 6, the blue box represents the students' group with industry experience while the red box represents the students' group without industry experience. Two boxes cover the interquartile interval, the lower whiskers of both groups appear to be equivalent, while the median confidence level ("x") of the group with experience is higher than the one of the group without experience, same with the upper whisker.

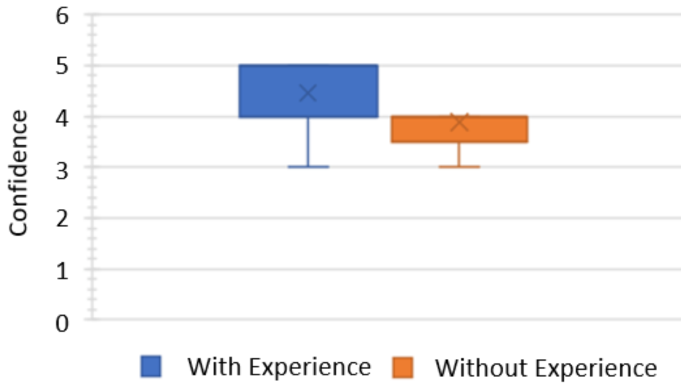

Figure 6: Importance-Familiarity Level Comparison

5. DISCUSSION

This study is conducted through civil, mechanical, electrical, and computer engineering major students. We collected the levels of four perception factors involved in hands-on tasks among engineering students at UGA, examined the relationships among the factors, and investigated the factor components that contributed to hands-on skills improvement. Three types of analysis answer three research questions separately, elaborated as follows.

By answering the first research question on current confidence levels, a sense of importance, familiarity rate, and the level of frequency of engineering students have towards hands-on projects was established. Computer engineering ranked the highest among all the perception factors. Computer engineering students are confident when doing hands-on tasks, they perceive hands-on tasks as important for their major, and tend to be familiar towards hands-on tasks as they take part in hands-on tasks regularly. On the other hand, electrical engineering students have the lowest confidence level and familiarity among the four. Students don't feel capable enough solving hands-on tasks and lack manipulation in hands-on tasks. Civil engineering students perceive hands-on tasks as not very important as the other three majors. This is primarily caused by the job responsibilities for civil engineers, as the proportion of hands-on tasks in civil engineering jobs is not as high as the other three engineering majors. Finally, mechanical engineering students ranked the lowest on frequency level, meaning mechanical engineering students had a higher expectation of getting hands-on experience than they received.

The second research question on what the relationships are between self-perception factors in the context of hands-on projects among engineering major students can be answered through correlation analysis. Results indicate that for civil engineering students, the more important they perceive, the more familiar they are with hands-on tasks and the more confident they are. It's interesting to see that importance and frequency are negatively related, which implies that the amount of exposure to hands-on tasks didn't meet students' expectations. It has been observed in civil engineering students that confidence, frequency, and familiarity reciprocate each other. Previous studies stated that they were not given enough hands-on experience that would appropriately qualify them for the workforce and where it did exist had limited association with future projects [33]. It is apparent that hands-on experience is dependent on the type of engineering in which students are considering. As hands-on tasks have developed in these different fields, mechanical engineers have experienced the greatest impact.

Mechanical engineering students have a higher correlation result between familiarity and frequency than civil engineering, for the reason that mechanical engineering jobs have a relatively higher level of physical engagement than civil engineering jobs. Students think it's important to do hands-on tasks, as importance and frequency in mechanical engineering are slightly associated. Similar to civil engineering and mechanical engineering students, electrical engineering students also perceive the more frequently they are involved in hands-on tasks, the more familiar they are. the reason being that most electrical engineers' responsibilities include doing practical technical tasks in support of engineering processes such as complicated system design, testing, and verification. However, the correlation results between confidence and familiarity, and confidence and frequency appear to be negative. This elucidated that first, for electrical engineering students, the more they practice hands-on tasks the less confident they are towards conducting hands-on tasks. This result reflected an effect called the Dunning-Kruger effect, which arises when a person overestimates their competence because they lack the necessary information and abilities in that field [34]. Second, same situation as civil engineering, electrical engineering students don't gain a reasonable amount of training experience as they expect to. Computer engineering jobs include but are not limited to designing and testing hardware for computers, creating software, and constructing computer systems. When it comes to programming and coding, this may cause an effect on the correlation between confidence and familiarity, as well as confidence and frequency. However, these two correlations are relatively weak, since fixing new errors when coding may occur at any time, which doesn't have a specific association with students' level of confidence. This was corroborated by computer engineering job responsibilities in Industry 4.0. Lastly, positive frequent practice prompts the increase in the level of familiarity, as the result between frequency and familiarity indicated.

6. CONCLUSION

From school to the workplace, engineering students who are skillful at solving hands-on tasks can feel easier to achieve their career transition, in addition, employers value this skill and tend to choose candidates with tangible experience since this can help cut down on the requirement for on-the-job training. It's crucial to develop the individual ability to fulfill complex requirements, including interpersonal skills to be self-motivated for lifelong learning in each domain, as well as to comprehend what the necessary abilities and career paths are, along with being familiar with the new technologies that emerge out of Industry 4.0.

Research on the effects of students' perception factors needs to be addressed, this study contributes to it by emphasizing the significance of each factor and how it is related to the others to advantage engineering students' hands-on skills. To leverage learning and student performance, our future work is to broaden the scope of this study by using a mixed methods approach to get eligible knowledge strategies of the fundamental attributes of eligible industrial skillsets.

REFERENCES

[1] S. Erol, A. Jäger, P. Hold, K. Ott, and W. Sihn, “Tangible Industry 4.0: A Scenario-Based Approach to Learning for the Future of Production,” *Procedia CIRP*, vol. 54, pp. 13–18, Jan. 2016.

[2] G. Reischauer, “Industry 4.0 as policy-driven discourse to institutionalize innovation

systems in manufacturing," *Technol. Forecast. Soc. Change*, vol. 132, no. February, pp. 26–33, 2018.

[3] F. Hecklau, M. Galeitzke, S. Flachs, and H. Kohl, "Holistic approach for human resource management in Industry 4.0," *Procedia CIRP*, vol. 54, pp. 1–6, 2016.

[4] F. Longo, L. Nicoletti, and A. Padovano, "Smart operators in industry 4.0: A human-centered approach to enhance operators' capabilities and competencies within the new smart factory context," *Comput. Ind. Eng.*, vol. 113, pp. 144–159, 2017.

[5] A. Alhloul and E. Kiss, "Industry 4.0 as a Challenge for the Skills and Competencies of the Labor Force: A Bibliometric Review and a Survey," *Sci*, vol. 4, no. 3, p. 34, 2022.

[6] X. Yang, A. Lim, A. Nicolaides, and B. Morkos, "Towards the Understanding of Nudging Strategies in Cyber-Physical-Social System In Manufacturing Environments." 14-Aug-2022.

[7] D. E. Aguilar Ramirez, J. Blinch, and C. L. R. Gonzalez, "An evaluation of visuospatial skills using hands-on tasks," *Exp. Brain Res.*, vol. 238, no. 10, pp. 2269–2277, 2020.

[8] H. A. AGLAN and S. FIRASATALI, "Hands-On Experiences : An Integral Part of," no. October, 1996.

[9] J. F. Binder, T. Baguley, C. Crook, and F. Miller, "The academic value of internships: Benefits across disciplines and student backgrounds," *Contemp. Educ. Psychol.*, vol. 41, pp. 73–82, 2015.

[10] T. Pratchett, *The Truth*, 1st Harper. New York: New York : HarperTorch, 2001.

[11] T. Joyce, I. Evans, W. Pallan, and C. Hopkins, "A hands-on project-based mechanical engineering design module focusing on sustainability," *Eng. Educ.*, vol. 8, no. 1, pp. 65–80, 2013.

[12] S. Ziaeefard, M. H. Miller, M. Rastgaar, and N. Mahmoudian, "Co-robotics hands-on activities: A gateway to engineering design and STEM learning," *Rob. Auton. Syst.*, vol. 97, pp. 40–50, 2017.

[13] D. May, B. Morkos, A. Jackson, N. J. Hunsu, A. Ingalls, and F. Beyette, "Rapid transition of traditionally hands-on labs to online instruction in engineering courses," *Eur. J. Eng. Educ.*, pp. 1–19, Mar. 2022.

[14] H. Kagermann, W. Wahlster, and J. Helbig, "Securing the future of German manufacturing industry Recommendations for implementing the strategic initiative Industrie 4.0: Final report of the Industrie 4.0 Working Group," National Academy of Science and Engineering, 2013.

[15] A. O. Junior, H. Assumpcao, J. Queiroz, L. Piardi, J. Parra, and P. Leitao, "Hands-on Learning Modules for Upskilling in," pp. 1–6.

[16] X. Gong, R. Jiao, A. Jariwala, and B. Morkos, "Crowdsourced manufacturing cyber platform and intelligent cognitive assistants for delivery of manufacturing as a service: fundamental issues and outlook," *Int. J. Adv. Manuf. Technol.*, vol. 117, no. 5, pp. 1997–2007, 2021.

[17] X. Gong, R. Jiao, A. Jariwala, and B. Morkos, "Crowdsourced Manufacturing for Delivery of Manufacturing as a Service," in *2021 IEEE International Conference on Industrial Engineering and Engineering Management (IEEM)*, 2021, pp. 1617–1621.

[18] M. Miller, L. Bohmann, W. Helton, and A. Pereira, "AC 2009-1233 : DETERMINING THE IMPORTANCE OF HANDS-ON ABILITY FOR ENGINEERS Determining the Importance of Hands-On Ability for Engineers," 2009.

[19] E. Education, *International Perspectives on Engineering Education*, vol. 1. .

[20] H. A. Hallak, S. Ibrahim, and C. Low, "The Impact of Incorporating Hands-on Raspberry Pi Projects with Undergraduate Education in Boosting Students ' Interest in Scientific / Engineering Majors and Encouraging Women and Minorities to Advance their Integration in Practical Fields," no. October, pp. 7–14, 2019.

[21] D. Jensen, J. Wood, and K. Wood, "Hands-on Activities, Interactive Multimedia and Improved Team Dynamics for Enhancing Mechanical Engineering Curricula," *Int. J. Eng. Educ.*, vol. 19, no. 6, pp. 874–884, 2003.

[22] A. H. Behzadan, A. Iqbal, and V. R. Kamat, "A collaborative augmented reality based modeling environment for construction engineering and management education," *Proc. - Winter Simul. Conf.*, no. Levin 2008, pp. 3568–3576, 2011.

[23] K. J. Goldman, "A concepts-first introduction to computer science," *SIGCSE Bull. (Association Comput. Mach. Spec. Interes. Gr. Comput. Sci. Educ.*, vol. 36, no. 1, pp. 432–436, 2004.

[24] F. L. Severance, M. Suchowski, and D. A. Miller, "Benefits of a hands-on introduction to electrical and computer engineering," *ASEE Annu. Conf. Proc.*, pp. 5001–5010, 2003.

[25] J. Bem, "Self-Perception : The Dependent Variable of Human Performance 1," vol. 121, 1967.

[26] R. W. Stringer and N. Heath, "ACADEMIC SELF - PERCEPTION AND ITS RELATIONSHIP TO ACADEMIC PERFORMANCE," vol. 2, pp. 327–345, 2008.

[27] G. Potvin, "Disciplinary Differences in Engineering Students ' Aspirations and Self-Perceptions Disciplinary Differences in Engineering Students ' Aspirations and Self-Perceptions," 2013.

[28] H. L. Rheingold, "DEVELOPMENT AS l FAMILIARITy," pp. 1–17, 1985.

[29] B. Morkos, G. Palmer, and J. D. Summers, "A Study of Designer Familiarity With Product and User During Requirement Elicitation," *Int. J. Comput. Aided Eng. Technol.*, vol. 5, no. 2–3, pp. 139–158, 2010.

[30] P. M. Stohr-Hunt, "An Analysis of Frequency of Hands-On Experience and Science Achievement," *J. Res. Sci. Teach.*, vol. 33, no. 1, pp. 101–109, 1996.

[31] S. Lichtenstein, P. Slovic, B. Fischhoff, M. Layman, and B. Combs, "Journal of Experimental Psychology : Human Learning and Memory," *J. Exp. Psychol. Hum. Learn. Mem.*, vol. 4, no. 6, pp. 551–578, 1978.

[32] O. Te, "An empirical test of the identity capital model," pp. 577–597, 1997.

[33] A. M. Ghaly, T. K. Jewell, and F. A. Wolfe, "Perception versus reality in civil engineering education today," *ASEE Annu. Conf. Proc.*, pp. 11644–11660, 2003.

[34] D. Dunning, *The Dunning – Kruger Effect : On Being Ignorant of One ' s Own Ignorance*, 1st ed., vol. 44. Elsevier Inc., 2011.

[35] D. Shah, M. X. Yang, and B. Morkos, "Can empathy be taught? The results of an assignment targeted at improving empathy in engineering design," ASEE Annu. Conf. Expo. Conf. Proc., vol. 2020-June, 2020.

[36] S. Joshi, B. Morkos, P. Shankar, J. D. Summers, P. Joshi, S, Morkos, B, Shankar, and J. D. Summers, "Requirements in Engineering Design: What are We Teaching," in Tools and Methods for Competitive Engineering (TMCE 2012), 2012, p. No--38.

[37] B. Morkos, S. Joshi, J. D. Summers, and G. M. Mocko, "Requirements and Data Content Evaluation of Industry In-House Data Management System," in International Design Engineering Technical Conferences and Computers and Information in Engineering Conference, 2010, pp. DETC2010-28548.

[38] J. D. Summers and B. Morkos, "Requirements Evolution: Impact Of Functional And Non-Functional Change On Project Success," in ASME 2013 International Design Engineering Technical Conference, 2013.