

# Work In Progress: Expert Feedback on Sketching Self-Efficacy Development

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**Abstract**—This is a WIP progress paper belongs to innovative practice section. According to Bandura, self-efficacy refers to “beliefs in one’s capabilities to organize and execute the courses of action required to produce given attainments.” Self-efficacy plays an essential role in skill development and engineering education. Sketching is a critical skill for engineering students, and it has various benefits, especially in developing spatial visualization skills. Sketching enables students to effectively communicate graphically, represent ideas, and brainstorm ideas, especially in the early design stages. No formal research has been conducted concerning the role of self-efficacy in learning to sketch. An instrument that measures sketching self-efficacy is beneficial for gaining insight into the levels of sketching self-efficacy of engineering students. A sketching self-efficacy instrument was developed for high school students, however it needs revision and validation for use in undergraduate engineering classrooms.

This work-in-progress study aims to revise the sketching self-efficacy survey instrument items based on expert feedback to ensure the validity of the instrument’s content. We have gathered feedback from nine engineering instructors from various disciplines who are experts in sketching on the items of the current sketching self-efficacy instrument. Our research question is: In what areas do engineering students need to develop self-efficacy in sketching according to engineering instructors, and how do these areas vary across mechanical and industrial engineering disciplines?

We conducted five interviews virtually and semi-structured through the Zoom platform. The interview transcripts were anonymized, cleaned, and loaded into qualitative data analysis software, MAXQDA. Qualitative content analysis was utilized to analyze the interview data. Based on the interview analysis results, we will discuss the recommended changes to the sketching self-efficacy instrument. Our final study will include psychometric analysis, such as exploratory Factor analysis and Confirmatory factor analysis, to test the instrument’s validity for college students.

**Index Terms**—sketching, assessment, interview

## I. BACKGROUND

Several studies have established the importance of sketching for engineering students as it enables students to communicate effectively, visualize & brainstorm ideas quickly, foster creativity, and enhance problem-solving skills [1], [2], [3], [4],

[5], [6]. Therefore, engineering students need to receive training in sketching, and be able to sketch confidently. According to [7], sketches are often assessed on accuracy, perspective, line quality, annotations, and aesthetics. Self-efficacy in sketching is rarely assessed, among various sketch assessment metrics. We believe that it is important to assess engineering student self-efficacy in sketching to gain an understanding of the impact of sketch training they receive.

Therefore, we developed an instrument to measure sketching self-efficacy and the sketching self-efficacy instrument is currently undergoing revision and validation. The instrument was validated in the past in the context of high school students [8]. We hypothesize that this scale is suitable for measuring the sketching self-efficacy of engineering students after appropriate revisions. As the first step in revising the instrument, our goal is to establish the content validity of the survey items by gathering feedback from sketching experts from different engineering disciplines on the individual survey items.

This study addresses the following research question:

- 1) “In what areas do engineering students need to develop self-efficacy in sketching according to engineering instructors, and how do these areas vary across mechanical and industrial engineering disciplines?”

## II. LITERATURE REVIEW

### A. Establishing content validity of survey items

One of the aspects of instrument validation is ensuring the content of the survey is correct. Getting the feedback of experts in respective fields is key to the process of scale development [9]. Their expertise can be of great value to ensure that the elements of the instrument accurately represent the factors that we intend to measure [9]. Identifying misleading and ambiguous items and removing or modifying them is a necessary step in the revision process [9]. Through this study, our goal is to establish validity of the survey instrument items by gathering feedback from engineering faculty at multiple institutions.

### B. Importance of sketching self-efficacy

According to Bandura, self-efficacy is "beliefs in one's capabilities to organize and execute the courses of action required to produce given attainments" [10]. In the educational context, several authors have studied the influence of self-efficacy on student learning; self-efficacy plays an important role in the motivation of students, as well as in the academic performance of students [11]. In engineering education, self-efficacy plays a critical role as self-efficacy is also connected to skill development, and preparing engineering students to be competent in the workforce [12].

According to [13], it is common for students to experience a lack of confidence in sketching leading to a decline in motivation to practice sketching; improving student's sketching self-efficacy can lead to improved motivation to practice sketching, and thereby positively contributing to sketching skill development. Training students to be proficient in sketching involves not only training them to sketch but also making sure that their confidence in sketching also improves [13], [14]. Students experience an inhibition to sketch; in other words, they lack self-efficacy in sketching, which should also be addressed as part of sketch training, which most often focuses only on the development of sketching skills [14]. Sketch training needs to ensure to enhance students' self-efficacy in sketching along with skill development. Thus, there is a need for a survey instrument to measure the sketching self-efficacy of students. Our study aims to revise an existing survey instrument we developed to measure sketching self-efficacy.

### C. Instrument to measure sketching self-efficacy

The current instrument to assess sketching self-efficacy has 13 items which is a representation of the three factors that include: Self-efficacy concerning sketching practically to solve problems, communicating with others, and brainstorming ideas; Self-efficacy concerning sketching specific objects; Self-efficacy concerning sketching to create, express ideas, and use one's imagination [8].

One of the items in the first version of the survey was sketching a person; sketching a person is not important for engineering students to learn. The next version of the instrument has replaced it with sketching a portrait. In this study, we have used the second version of the instrument. Hence, it has sketching a portrait instead of sketching a person. Also, note that the term drawing has been replaced by sketching in the survey instrument in our study. The term sketching is more fit for our purposes, and we prefer using it instead of drawing in the context of our study. Sketching is a form of drawing and that causes no conflict in terms of what is being conveyed. Please see Table 1.

## III. METHODS

### A. Participants

Participants in this study consisted of five engineering faculty members belonging to three four-year institutions, namely Texas A&M University, Georgia Institute of Technology, and San Jose State University located in Texas, Georgia,

TABLE I  
SKETCHING SELF-EFFICACY INSTRUMENT ITEMS

|   |
|---|
| Sketching to communicate with others                  |
| Sketching to express myself                           |
| Sketching to generate creative ideas for a project    |
| Sketching when under pressure to come up with an idea |
| Sketching to explain or teach a concept to others     |
| Sketching something from my imagination               |
| Sketching to think through a problem                  |
| Sketching a 2D object                                 |
| Sketching a 3D object                                 |
| Sketching a portrait                                  |
| Sketching a product                                   |
| Sketching a vehicle                                   |
| Sketching a building                                  |

and California, respectively. Three are from the Mechanical engineering department, and two are from the industrial engineering department. Engineering instructors who are involved with courses requiring students to know sketching in some form or instructors who have the expertise to teach sketching were recruited through contacts; emails were sent asking them about their willingness to participate in our study. The faculty members who expressed their willingness to participate in our study were interviewed. All of our participants have experience in sketching.

### B. Qualitative analysis

The interviews were conducted virtually through the Zoom platform. The entire interview lasted around forty-five minutes to an hour. Getting expert feedback on the survey instrument was a small portion of the entire interview and, for this study, we utilized just that section of the interview data. The interview transcripts were anonymized, cleaned, and loaded into a qualitative data analysis software, namely MAXQDA. Qualitative content analysis was utilized to analyze the interview data [15]. Follow-up questions were emailed to a few instructors after we noticed a few missing areas in the interview transcripts. Those responses were added to the interview transcript data.

## IV. RESULTS AND DISCUSSIONS

Below are the results of content analysis of the interview data. The feedback from experts about each item in the survey instrument is included:

### *The use of sketching for communication*

*Mechanical:* All three instructors agreed that sketching is very important for communication purposes and that sketching is a powerful communication tool.

*Industrial:* One of the most important aspects of learning to sketch is to be able to communicate effectively through sketches, it is crucial from an engineering design perspective. One of the primary focus of sketch training is for students to learn to communicate ideas effectively. A picture is worth a thousand words, a common saying, is true, that if one can visualize an idea, people respond to that compared to if one just talks about ideas. One of the industrial design instructors spoke about being part of multi-disciplinary meetings that

included marketing, salespeople, and engineers, where he would sketch ideas on a large sketch pad and share them with others.

#### ***The use of sketching for self-expression***

*Mechanical:* All three instructors agreed that sketching to express oneself is important.

*Industrial:* One of the instructors mentioned that expressing oneself visually is more important for artists and designers, rather than engineers. The instructor emphasized that, the focus of sketch training should be more on communicating ideas effectively rather than solely expressing oneself through drawings. However, the other instructor expressed that expressing oneself through sketching is very important.

#### ***The use of sketching for generating creative ideas***

*Mechanical:* All three instructors agreed that sketching for generating creative ideas is very important.

*Industrial:* According to the instructor, sketching to generate creative ideas is almost as important as communicating ideas through sketching. One generates ideas that one is going to communicate through sketching ideas. The whole process is iterative, where one does a series of sketches before finalizing an effective design or solution to a problem. Sketching for generating creative ideas is a skill that's needed for that developmental process and is, hence, very important. The other instructor also expressed that sketching is very important for generating creative ideas.

#### ***The use of sketching to generate ideas under pressure***

*Mechanical:* Mechanical engineering instructors expressed that sketching to generate ideas under pressure is an important skill for students.

*Industrial:* One of the instructors from industrial design had trouble fully understanding the concept of sketching under pressure to generate ideas. The other instructor mentioned that it is unknown if the pressure is an external or internal factor. If someone is forcing one to come up with an idea, like a boss or a teacher, versus if one is intrinsically motivated, where one puts pressure on oneself to come up with ideas. If the person is intrinsically motivated, sketching under pressure is important; otherwise, it's unimportant.

#### ***The use of sketching for teaching and explaining concepts***

*Mechanical:* All three mechanical engineering instructors mentioned that sketching for teaching and explaining concepts is very important.

*Industrial:* Sketching to teach or explain a concept to others is very important, according to an instructor. According to the other instructor, sketching to explain or teach a concept to others is related to the communication of ideas to others and is very important.

#### ***Sketching something from imagination***

*Mechanical:* All three mechanical engineering instructors mentioned that sketching something from imagination is very important.

*Industrial:* Sketching something from imagination is crucial for creativity and innovation in engineering design and other engineering disciplines. Sketching from imagination can significantly aid the process of idea generation and sharing

ideas with others. Drawing something from one's imagination was described as the essence of what designers do. It involves imagining a solution to a problem and then representing it visually. The expert highlights that this skill is crucial for designers as they progress in their training, moving from drawing existing objects to drawing something that exists only in their minds. This ability to draw from imagination is considered a fundamental skill for designers as they work towards creating innovative and original solutions.

Sketching from imagination is considered very important regardless of the engineering discipline.

#### ***The use of sketching to think through problems***

*Mechanical:* All three mechanical engineering instructors agreed that sketching to think through problems holds great significance.

*Industrial:* Sketching is used as a tool for problem-solving in various disciplines. The instructor mentioned the importance of sketching to think through problems as part of the iterative problem-solving process. Sketching through a problem allows designers to explore different solutions and work towards refining ideas visually. The instructor suggested sketching through a problem, which is a key skill set designers should possess. According to the instructor, at some point in the process, designers transition from sketching on paper to sketching on a digital platform to refine the details of their solution. Sketching helps to think through a problem, not only to visualize concepts but also to explore different solutions and communicate them effectively. This can significantly aid in demystifying complex problems and generating innovative solutions. The practice of sketching could contribute to enhancing the overall creative process.

The use of sketching to think through a problem is a highly crucial skill irrespective of engineering discipline.

#### ***Sketching 2D Objects and 3D Objects***

*Mechanical:* All three mechanical engineering instructors mentioned sketching 2D and 3D objects as a very important skill.

*Industrial:* One of the industrial design instructors expressed confusion regarding the concept of sketching 2D and 3D objects. It was also mentioned that sketching a 3D object is more important than sketching a 2D object. Drawing a 3D object implies that the object already exists, and what already exists is represented through a sketch. Sketching 2D and 3D objects happens less, and it may become important when designing something that interfaces with something that already exists. In the case of designing a product that interacts with another object, such as an appliance or an automobile, sketching a 3D representation of the existing object can be beneficial for generating ideas and solutions. In design scenarios where knowing spatial relations and interactions with already existing objects is crucial for the design process, sketching 3D objects becomes essential. The other instructor was not exactly sure of the interpretation of sketching a 2D or 3D object. The instructor expressed that if sketching a 2D object means sketching a square, it's very important, and if sketching a 3D object means sketching an object such as a

cube, that's very important. Sketching both the square and the cube must be done with fluidity.

#### **Sketching portrait**

*Mechanical:* Two of the mechanical engineering instructors mentioned that drawing a portrait is important.

*Industrial:* According to an instructor, sketching a portrait is not at all important for designers. According to the other instructor, sketching a portrait is more like fine art. If one wants to draw a portrait of someone sitting and record their picture, that's not really important. Sketching as a portrait, as it may not be necessary, is not important.

#### **Sketching product**

*Mechanical:* All three mechanical engineering instructors mentioned that sketching a product is important.

*Industrial:* The importance of sketching a product varies depending on the engineering discipline one is from and one's specialization. In the field of Industrial design, sketching a product is seen as a product of one's imagination, and it can be anything and is not limited to physical goods such as a coffee cup. In the context of mechanical engineering, a product could be described as gears, transmissions, or energy systems like combustion chambers. Another instructor also mentioned that sketching a product is very important in industrial design.

#### **Sketching building**

*Mechanical:* All three mechanical engineering instructors mentioned that sketching a building is important.

*Industrial:* Sketching a building is a task that is typically undertaken by architects, and it is also an area of expertise of the architectural profession. The other instructor also mentioned that sketching a building is important for architects. Thus, sketching a building is not as important for industrial designers.

#### **Sketching vehicle**

*Mechanical:* All three mechanical engineering instructors mentioned that sketching a vehicle is important.

*Industrial:* The importance of sketching a vehicle depends on the engineering discipline; for example, transportation designers must know how to sketch a vehicle; transportation designing is a subset of industrial design. Knowing how to sketch a vehicle is directly linked to work for those working in car companies or transportation companies; conversely, it is not as crucial for engineers whose work does not involve sketching a vehicle. Another instructor mentioned that it's not important for product designers unless they are in automotive design.

Some of the items on the sketching self-efficacy instrument are important for all engineering disciplines, while the importance of some other items, such as vehicles, buildings, portraits, and products, can vary based on engineering discipline.

## **V. CONCLUSIONS**

Through this study, we gained feedback on the survey instrument items intended to assess sketching self-efficacy. The expert feedback included instructors from mechanical engineering and industrial engineering disciplines. We acknowledge that the experts were self-selected based on contacts,

and this might cause a potential bias. The five instructors we interviewed in this study have established the role of sketching as a communication tool, self-expression tool, idea-generation tool, imagination tool, and problem-solving tool. Sketching specific objects is discipline-specific, and all engineering students are neither expected to be proficient nor are expected to gain self-efficacy in sketching specific objects. These specific objects include sketching a vehicle and building. The items, such as sketching under pressure to generate creative ideas and sketching a portrait, are best removed due to the confusion they caused. Sketching a product, 2D and 3D objects needs to be re-examined and modified if necessary.

## **VI. FUTURE WORK**

The instrument must undergo further statistical procedures, such as factor analysis, to validate the constructs. Additional sketching experts from other engineering disciplines will be interviewed. The revised version of the instrument needs to be distributed to engineering students, and further analysis, such as exploratory factor analysis and confirmatory factor analysis, must be performed to understand the statistical validity of the revised version. An instrument to measure the sketching self-efficacy of engineering students will benefit the engineering education community in various ways. Note that this is a work in progress paper, and we have presented only the initial results.

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