The Intersection of Mindfulness and Hand Sketching: Developing Problem-Solving Skills in Engineering Students

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Introduction

Problem-solving is a fundamental aspect of engineering education. Across all engineering disciplines, the ability to approach, analyze, and resolve problems is a central activity and a key skill for success in the field. Despite its importance, limited research focuses on improving engineering students' problem-solving skills. One reason for this is the demanding technical curriculum that fills much of students' schedules, leaving little time for targeted development of problem-solving strategies. As a result, problem-solving is often included as part of broader engineering courses rather than being explicitly taught and practiced as a specific skill.

At the same time, research has shown that engineering students face higher stress levels, putting them at significant risk of mental illness compared to the general population [1], [2]. For this reason, mindfulness has been integrated into engineering education, initially to support mental well-being. Subsequent studies have revealed that mindfulness also enhances learning outcomes [3]. Meanwhile, hand sketching has long been a fundamental tool in engineering, significantly contributing to problem-solving and overall learning. However, limited research examines the intersection between these two practices' benefits. This paper aims to explore the common advantages that mindfulness and hand sketching offer in enhancing problem-solving skills among engineering students. Specifically, it seeks to answer the research question: What are the mutual benefits of mindfulness and hand sketching in improving engineering students' problem-solving skills?

Background

Problem-solving is a multi-faceted process of identifying challenges, analyzing them, and finding practical solutions. According to McGuire [4], problem-solving is a self-directed cognitive and behavioral process that helps individuals adapt to challenges in daily life. Heppner and Krauskopf (1987) describe it as a series of steps that involve thinking, emotions, and actions to reach a goal [5]. Behaviorist theories suggest problem-solving is a learned behavior reinforced through experience [6]. Cognitive theories focus on mental strategies, such as using prior knowledge and problem-solving techniques. Another approach, the situational theory of problem-solving, highlights the role of communication in problem-solving and suggests that motivation and perception influence how individuals approach problems [7].

Building on the cognitive and behavioral aspects of problem-solving, mindfulness has emerged as a practice that can enhance an individual's ability to navigate challenges effectively. Mindfulness has been understood and practiced differently depending on the time and place. It originated in Asia and had deep roots in ancient traditions. In the 1960s and 1970s, people from Western countries began learning about mindfulness practices and brought them back to practice and teach in their own cultures. As mindfulness spread to different parts of the world, it adapted to fit various cultural contexts, leading to many different definitions. Zen master Thich Nhat Hanh, a revered Buddhist educator, defines mindfulness as " showing us what is happening in our bodies, emotions, minds, and the world" [8]. Another widely recognized definition comes

from Kabat-Zinn, who frames mindfulness as "paying attention in a particular way: on purpose, in the present moment, and nonjudgmentally" [9].

Expanding beyond cognitive strategies like mindfulness, visual representation techniques such as hand sketching are valuable problem-solving and idea-development tools. Hand sketching, or freehand drawing, creates visual representations without using precise instruments or digital tools. It is a fundamental technique for quickly capturing and communicating ideas [10]. In modern engineering education, the role of hand sketching has significantly decreased due to the introduction of advanced technologies such as computer-aided design (CAD) and other digital tools. However, hand sketching remains an essential skill that plays a critical role in visualizing ideas and solving problems.

Historically, practices involving the hand and focused attention have embodied mindful qualities in both Eastern and Western traditions. In ancient China, calligraphy was practiced with disciplined attention to brushwork, breath, and posture. The process demanded full engagement of the body and mind, creating a rhythm that encouraged presence and internal stillness. Rather than being limited to aesthetic expression, calligraphy was seen as a path to self-awareness and balance. In the West, sketching developed as a central method of investigation and creative thought. Leonardo da Vinci and Michelangelo used sketchbooks to study anatomy, design mechanisms, and refine ideas through observation. Their drawings reveal a cognitive process that merged visual thinking with tactile engagement. Later artists, such as Vincent van Gogh and Edvard Munch, engaged in repetitive and expressive mark-making that mirrored their emotional states. For them, sketching became a means of reflection and emotional processing. In both traditions, the act of drawing or writing by hand created a bridge between physical action and mental focus. This integration of hand movement, attention, and emotion represents an embodied form of cognition—one that supports clarity, emotional regulation, and creative insight.

Methods

To address our research questions, we identified three sets of keywords and conducted searches using IEEE Xplore, SCOPUS, ERIC, and Google Scholar to ensure a comprehensive collection of relevant articles. The three primary keywords were “problem-solving,” “mindfulness,” and “hand sketch.” Since we focused on the intersection of these topics, we first needed to establish a theoretical understanding of problem-solving, particularly in engineering education. For the first search string, we used “problem-solving,” “theory of problem-solving,” “engineering education,” and “engineering students.” This search yielded over 200 papers. However, since our goal was to explore problem-solving theory, we narrowed our selection to peer-reviewed journal articles, reducing the total to 36 papers. The second search string included “mindfulness,” “engineering students,” and “education.” Given the limited research on mindfulness in engineering education, we opted for “education” instead of “engineering education” to capture broader insights from general education and learning research. This search resulted in 52 articles. For the third keyword set, we initially used “hand sketch,” “engineering students,” and “problem-solving.” However, this search did not return any results. To refine our approach, we removed “problem-solving” and added “sketch” and “graphic,” which yielded nine relevant articles. We did not impose restrictions on publication dates or countries to ensure a diverse collection of perspectives across different cultures and time periods. After removing duplicates, filtering out

non-English papers, and reviewing abstracts, we identified 42 relevant articles that met our inclusion criteria.

The Mutual Benefits of Mindfulness and Hand Sketching in Improving Problem-Solving Skills among Engineering Students:

Enhancing Motivation

Motivation is the first step and a fundamental driver in the problem-solving process. The Situational Theory of Problem-Solving (STOPS) developed by Kim and Grunig (2011) explains that motivation is not just a personal trait but a situational factor influenced by problem recognition, involvement, and perceived constraints [7]. When individuals believe they can take action, they are more likely to engage in active problem-solving behaviors by seeking relevant information, evaluating solutions, and communicating with others to find a resolution. However, with low motivation, individuals may remain passive, avoid the problem, or rely on ineffective habitual responses [11]. From a cognitive problem-solving perspective, motivation enhances the ability to process and structure problems systematically. Motivated individuals allocate more mental resources to understanding a problem, breaking it down into manageable parts, and applying logical reasoning to find solutions [12]. Problem solvers with high motivation tend to persist through failures, adjusting their strategies and learning from mistakes rather than abandoning the task. Additionally, motivation is linked to the belief in one's ability to solve problems effectively. Research suggests that individuals confident in their problem-solving skills are more likely to engage in effortful and systematic approaches.

Mindfulness has been increasingly recognized as a mechanism for enhancing motivation, which is crucial for effective problem-solving. According to Self-Determination Theory (SDT), mindfulness promotes autonomous motivation, meaning individuals engage in problem-solving out of personal interest and a genuine commitment rather than external pressure [13]. When individuals practice mindfulness, they develop awareness of their internal states, thoughts, and emotions. These practices help them to engage in self-reflective and goal-directed problem-solving rather than reacting impulsively. Research shows that mindfulness reduces cognitive rigidity and makes individuals more open-minded and adaptable [3]. This is particularly beneficial in engineering education, where flexible thinking is essential for solving complex problems. Furthermore, mindfulness helps reduce distractions and stress, enabling individuals to remain focused and engaged with challenging tasks, thus maintaining motivation throughout the problem-solving process.

One key way mindfulness enhances problem-solving motivation is by reducing psychological barriers such as self-doubt, stress, and negative self-perception [14]. Mindfulness boosts self-esteem and self-efficacy, which is crucial for sustaining motivation in complex problem-solving tasks. When individuals approach problems with greater confidence and emotional stability, they are less likely to experience avoidance behaviors that hinder effective problem-solving. Moreover, mindfulness encourages nonjudgmental awareness, meaning individuals can assess their failures objectively rather than seeing them as personal shortcomings [15].

Hand sketching is a valuable tool that can boost students' motivation when solving problems. Research in education and psychology shows that drawing helps students engage with problems

more meaningfully by turning abstract ideas into visual representations [16]. Studies indicate that students who sketch while working through problems tend to feel more motivated because the process helps them express their thoughts and explore solutions creatively [17]. Research also shows that sketching strengthens the connection between understanding concepts and applying them to real-world problems. When students create diagrams or visual models, they build stronger links between what they have learned and how to use it [18]. This process makes problem-solving more engaging and enjoyable.

Improving Communication Skill

Engineers play a crucial role in addressing global challenges, especially as the world becomes more complex. Students need to recognize that problem-solving in engineering goes beyond simply finding the correct technical answers—it is about solving human problems. Engineers often work in multidisciplinary teams in professional settings, navigating technical complexities and organizational dynamics [19]. This is where mindfulness becomes a transformative tool in engineering education. Mindfulness promotes a deeper understanding of diverse perspectives by fostering self-awareness, emotional intelligence [20], and effective communication. Furthermore, practicing non-judgmental awareness encourages empathy and creates a supportive environment where team members feel comfortable sharing their ideas. This, in turn, strengthens collaboration and helps teams work more effectively to solve problems.

Besides, hand sketching is a powerful tool for communication [21]. In collaborative settings, sketches serve as a shared visual language that enables teams to brainstorm and refine concepts more effectively. Engineers and designers often use sketches to explain technical concepts to clients, colleagues, or stakeholders who may not possess specialized knowledge. Breaking down complex ideas into simple visual representations and sketches ensures that everyone involved in a project can understand and contribute to the discussion. The informal nature of hand sketching makes it especially useful when quick adjustments and real-time feedback are needed. These on-the-spot sketches enable efficient decision-making and help prevent misunderstandings or errors. For example, a simple sketch on construction sites can clarify complex plans, prevent costly mistakes, and streamline project execution.

Fostering Creativity and Innovation

Creativity is key to effective problem-solving, helping students think beyond traditional solutions and develop new ideas. Creative problem-solving involves exploring multiple possibilities rather than focusing on a single correct answer [22]. This type of thinking allows individuals to approach challenges from different angles, making it easier to find innovative solutions. Another important theory, the Componential Theory of Creativity, explains that creativity is influenced by three main factors: skills in a particular area, the ability to think creatively, and motivation. When people apply creativity in problem-solving, they use their knowledge, curiosity, and critical thinking to develop original and effective solutions [23]. The Theory of Creativity adds that creative thinkers tend to take risks by pursuing new ideas that may not be immediately popular but have the potential to be valuable in the long run [24]. In education, encouraging creativity helps students become more flexible and resilient when dealing with complex challenges.

Mindfulness helps individuals become more aware and open to new ways of thinking [25]. It encourages people to focus on the present moment and reflect on their thoughts without judgment. Studies show that mindfulness reduces stress and improves mental flexibility, which makes it easier to think creatively [26]. When students practice mindfulness, they are less likely to get stuck in fixed thinking patterns and are more open to trying new approaches to problem-solving.

Hand sketching is another powerful tool for creativity by providing a simple and flexible method for expressing ideas [27], [28]. Sketching offers freedom for exploration and experimentation, unlike digital tools, which often require adherence to predefined processes and structured workflows. Students can quickly draft, revise, and iterate on ideas without the constraints imposed by software. This flexibility encourages innovative thinking and allows individuals to consider multiple solutions before settling on the most effective one. In collaborative settings, sketches serve as a shared visual language that facilitates communication, enabling teams to brainstorm and refine concepts more effectively.

Improving Focus and Attention to Detail

Focus and attention to detail are essential for practical problem-solving, especially in engineering, where accuracy and precision are crucial. Solving complex problems requires students to carefully analyze constraints, identify key variables, and ensure that every part of their solution is logically sound. A lack of focus can lead to mistakes, miscalculations, or overlooked details that may cause a design to fail or a system to malfunction. Deep thinking and sustained attention are necessary to break down challenges into manageable steps and make right decisions.

Mindfulness practice enhances focus by training individuals to be fully present and engaged in their tasks. Studies show mindfulness improves concentration by reducing cognitive distractions and enhancing working memory capacity [29]. When students practice mindfulness, they become more aware of their thoughts and can better direct their attention to the problem. This awareness helps them filter out irrelevant information and maintain a structured approach to problem-solving [30]. Furthermore, mindfulness has been linked to lower stress levels, which can improve focus and prevent mental fatigue [31]. By regularly practicing mindfulness techniques such as deep breathing or focused meditation, students can develop stronger cognitive endurance, allowing them to sustain their attention for extended periods and maintain accuracy in their work.

Hand sketching effectively improves focus and attention to detail, particularly in problem-solving and design-related tasks. When students sketch their ideas, they engage in a highly concentrated, hands-on process that requires precision and active engagement [32]. Unlike verbal or written descriptions, sketching forces individuals to carefully observe proportions, relationships, and small details that might be overlooked [33]. This process encourages deep thinking and prevents students from making quick assumptions about their solutions. Additionally, sketching is an external cognitive tool that helps clarify ideas and identify potential errors or missing components. By visualizing and refining their ideas on paper, students can develop better spatial awareness and improve their ability to pay close attention to critical details in complex designs [34].

Conclusion

Mindfulness and hand sketching in engineering education are promised as valuable approaches to improving problem-solving skills. Mindfulness helps students develop awareness and focus while sketching provides a way to visualize and refine ideas. This study highlights the importance of moving beyond purely technical instruction in engineering education. Modern engineering challenges require professionals who can think critically, adapt to new situations, and collaborate effectively. Mindfulness and hand sketching encourage these skills by promoting open-ended exploration, persistence, and the ability to work through complex problems with a clear and organized mindset.

Future research should explore effective ways to integrate these techniques into engineering curricula. Investigating their long-term impact on student learning, as well as comparing them to other problem-solving methods, will help educators refine their teaching strategies. Additionally, interdisciplinary studies involving psychology, design thinking, and cognitive science could provide further insights into their benefits and applications.

The ability to solve problems in engineering extends beyond technical knowledge—it requires creativity, adaptability, and clear communication. Mindfulness and hand sketching offer valuable tools to develop these skills, preparing future engineers to tackle real-world challenges with confidence and innovation.

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