A Review of Photovoice-Based Entrepreneurial-Minded Pedagogical Interventions in the Engineering Classroom: Definitions, Benefits, and Challenges

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Introduction

Innovation, design, and entrepreneurship are economic drivers promoting competition and growth worldwide, many of which would only exist with well-established continuous improvement. Entrepreneurship is a field of study that involves discovering, evaluating, and exploiting opportunities [1], and thus, an entrepreneurial mindset can be described as the inclination to discover, evaluate, and exploit opportunities [2]. To stay a leader in the global economy, innovative pedagogical interventions are needed to promote an entrepreneurial mindset in students, particularly engineering students (who work at the forefront of design, technology, and new product development). One such pedagogical intervention is photovoice, which has been widely used in educational, social science, health, and non-traditional literature [3] as a research approach to problem-solving through the use of photo (e.g., image) and voice (e.g., narrative reflection). Photovoice is based on three primary goals: 1) enable individuals to reflect on existing issues and evaluate their strengths and weaknesses, 2) promote critical dialogue through group discussions, and 3) initiate a call to action to drive social change. In recent years, photovoice has been extensively used in engineering education research to examine student experiences (e.g., first-year, mental health, motivation, and challenges) [4-8] and, more recently, has gained traction to promote entrepreneurial thinking in undergraduate engineering classrooms [5-12].

While photovoice has been gaining momentum in engineering education research, there are still gaps, especially in the way photovoice is used in engineering classrooms. First, existing studies [9, 10, 12-15] showcase using the photovoice method as an individual/independent learning practice within undergraduate engineering classrooms. While current photovoice-based pedagogical interventions in engineering classrooms enable individual reflection, limited collaboration, engagement, and application, opportunities for further expansion as a pedagogical approach exist. For example, in some studies [5, 8, 10, 12, 14], participants were primarily required to complete a photovoice reflection at the end of a project or the semester. This type of photovoice-based intervention did not allow participants to collaborate, engage, and apply their learning. Second, photovoice was developed with the intent to promote empowerment and examine social inequities, particularly in healthcare contexts [16-22]. Due to this intentional use of photovoice in the health sciences discipline, it has not been widely used in engineering education research. These gaps warrant further examination of the use of the photovoice method

beyond individual reflections to promote dialogue and drive social change within the engineering discipline.

To achieve this, a literature review was conducted to summarize and synthesize the use of photovoice to drive entrepreneurial action with respect to opportunity discovery, evaluation, and exploitation within the engineering classroom. The following research question was used to guide the study:

- *How have photovoice applications been used to promote opportunity discovery (curiosity), evaluation (connections), and exploitation (creating value) of opportunities in the engineering classroom?*

Methods and Analysis

A literature review was conducted to identify, evaluate, and interpret available research relevant to our research question. For this paper, the authors followed a 5-step literature search process (**Table 1**).

Table 1. Literature Search Process

Step	**Task**	**Details**
1	Define Search Criteria Based on the Research Question	This step included breaking down the research question into individual components (e.g., population, intervention, comparison, outcomes, and context).
2	Construct Search String	This step included using Boolean operators (e.g., ANDs and ORs) with synonyms, abbreviations, and alternative terms. The search string was categorized based on population, intervention, location, and discipline to obtain relevant results.
3	Search String Implementation	This step included entering the constructed search string into academic search engines.
4	Organize Literature Categorically	This step included examining all results. The search results were further sorted based on the scope of this study.
5	Map Literature to the Entrepreneurially minded framework	This step included mapping the 'engineering' literature to the EM framework. The framework contains three categories: (1) Opportunity discovery (curiosity) – photovoice-based pedagogical interventions in the classroom are limited to the participant's individual reflections. (2) Opportunity evaluation (connections) – photovoice-based pedagogical interventions in the classroom that enable participant discussions (e.g., sharing reflections with peers and instructors) (3) Opportunity exploitation (creating value) – photovoice-based interventions in the classroom that allow participants to create and initiate action plans to share with stakeholders. A non-applicable category was included to showcase results that did not align with the three definitions.

Findings and Discussion

In response to the research question, 'How have photovoice applications been used to promote opportunity discovery (curiosity), evaluation (connections), and exploitation (creating value) of opportunities in the engineering classroom?', a preliminary literature review was conducted to identify and evaluate gaps in the literature and synthesize research. The preliminary review included categorizing the literature based on population [undergraduate], location [university], intervention [use of photovoice to promote discovery (curiosity), evaluation (connections), comparison [disciplines], and outcome [EM-based literature mapping how photovoice has been used to promote entrepreneurial thinking/mindset among participants]. The findings were grouped into three primary themes based on a preliminary literature review.

Theme 1: Discipline-based implementation of photovoice

Based on the search string results (**Figure 1**), the disciplines that apply photovoice extensively were the Health Sciences and the Social Sciences. This finding is attributed to the fact that healthcare and social sciences research primarily use qualitative research methods to understand behaviors, patterns, and lived experiences and explore community needs [23-25]. In contrast, engineering, known to be more of a quantitatively driven discipline, has a lower quantity of applications than health sciences and social sciences.

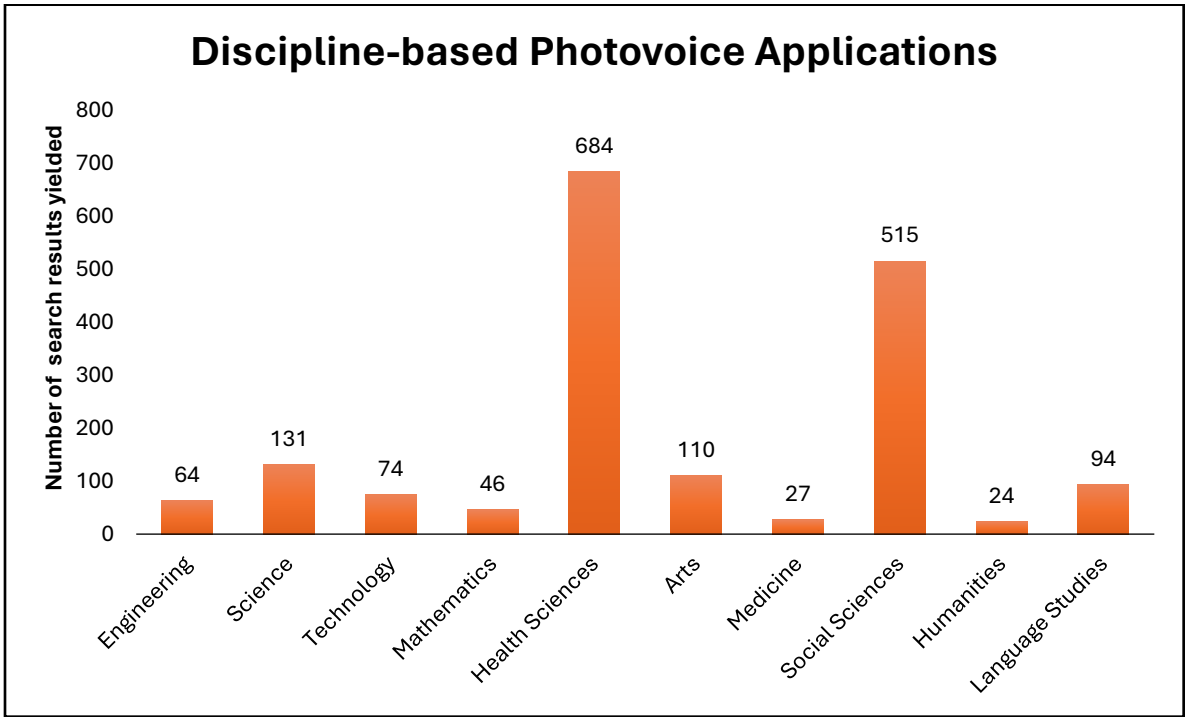

Figure 1. Search String Results

Theme 2: Photovoice-based pedagogical interventions in the engineering classroom

Based on existing literature, engineering educators primarily include photovoice reflections as part of a semester-long project or administer it at the end of the semester for summative assessment purposes. This finding is attributed to the fact that photovoice is implemented as a

reflective learning strategy instead of an active learning practice. For this paper, the table mentioned below (**Table 2**) is exploratory and only includes a few examples to showcase the current use of the photovoice method in engineering classrooms.

Table 2. Literature Categorization (Photovoice in Engineering Classrooms)

Type of Study & Purpose	**Participants (n) & Description**	**Duration of Study/Photovoice Intervention**	**Outcomes**
Exploratory: Examine the impact of active learning techniques embedded in a formalized mentoring program at an institution serving American Indian students [9].	n = 5 (4 male, 1 female); first-generation students, American Indian, low income, and pursuing Associate's degree in pre-engineering.	Semester long (4-5 months); data collected at the end of semester – photovoice reflections = 3 photos + narratives	Enhanced student satisfaction and increased student learning outcomes.
Work-in-progress, Pilot, Exploratory: Explore mental health experiences of engineering graduate students [5].	n = 8 (5 female, 2 male, 1 non-binary), four students identified as White, two as Black/African American, one as Asian/Asian American, and one as Hispanic/Latino and White. All are graduate-level students enrolled in various engineering disciplines.	Preliminary data reported (1 month). Data collected using a survey.	N/A
Exploratory: Examine the use of photovoice with entrepreneurial design projects as a high-impact practice in engineering technology education [12].	n = 13 (12 male, 1 female) sophomore-level students enrolled in the engineering technology program.	The project was 4 weeks, and photovoice metacognitive reflection was administered during the 4th week.	Enhanced student ability to elucidate project experiences.
Exploratory: Examine the integration of an entrepreneurial mindset in the engineering curriculum to	n = 7 (5 male, 2 female), enrolled in an upper-level undergraduate course offered at a satellite campus of a large research-focused university.	Semester-long nature-inspired podcast creation curriculum. Photovoice metacognitive reflection was administered at the	Student perceptions were identified and were aligned with a framework of motivation. Recommendations were offered for engineering educators to supplement

promote socio-technical communication skill development [14].		end of the semester (weeks 14 – 16).	traditional teaching practices with EM.
Exploratory: Examine and propose an approach for a virtual undergraduate research onboarding program to orient engineering students to the NSF REU [13].	n = 15 (7 male, 8 female) enrolled in engineering and engineering technology majors (from universities all across the United States). Out of the 15 participants, 11 were first-generation students.	The study examined the first week of the virtual onboarding program (40-hr). A photovoice reflection assignment was administered at the end of onboarding week.	Factors of motivation influencing student enrollment, persistence, and completion of the virtual onboarding program were identified.

Theme 3: Photovoice-based pedagogical interventions to promote the entrepreneurial mindset

Based on preliminary findings of the literature review and our definitions for opportunity discovery, evaluation, and exploitation (**Figure 2**), the current photovoice-based pedagogical interventions (n = 30) in engineering classrooms promote opportunity discovery (curiosity) where participant involvement is limited to the data collection process. This finding is attributed to the fact that photovoice has been known to be used as a community-based participatory research tool to explore issues affecting the well-being of the population [26-29]. Hence, it is not surprising to see engineering educators use photovoice as an opportunity for discovery in their classrooms.

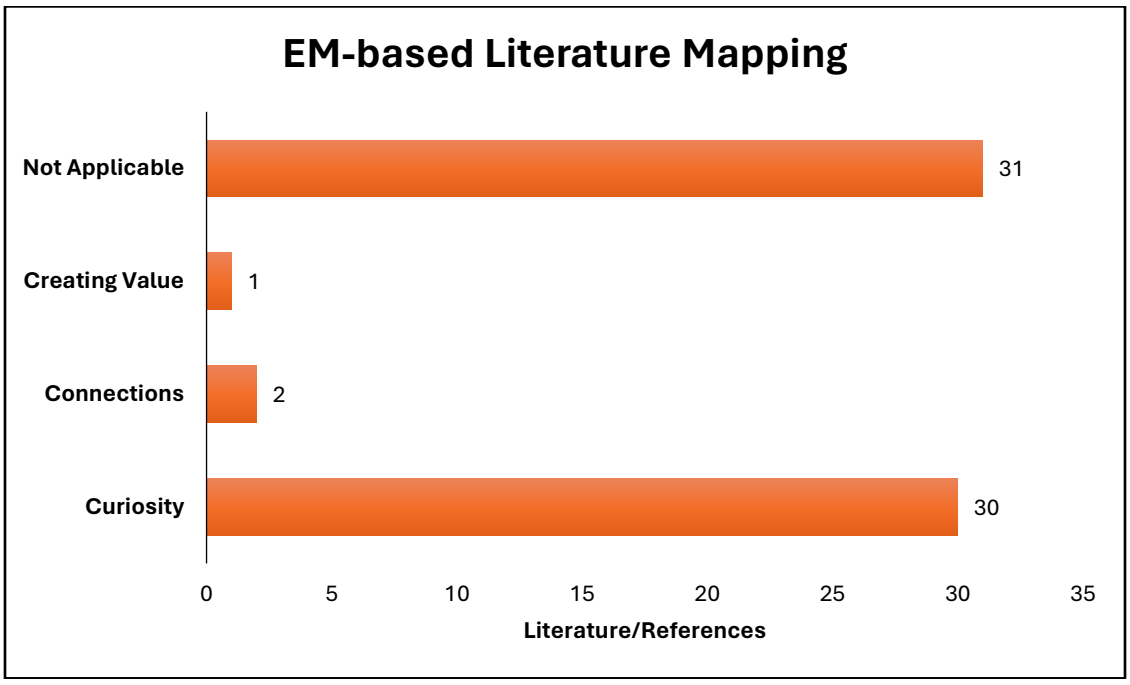

Figure 2. Entrepreneurially Minded Literature Mapping

Conclusion

Although photovoice-based pedagogical interventions have been used in engineering classrooms, gaps exist, especially considering the way photovoice has been integrated into the engineering curricula to promote opportunity discovery (curiosity), evaluation (connections), and exploitation (creating value). To address this gap, a literature review was conducted to identify and synthesize available research. In response to the research question posed in this study, 'How have photovoice applications been used to promote opportunity discovery (curiosity), evaluation (connections), and exploitation (creating value) of opportunities in the engineering classroom?', a preliminary literature review was conducted, and three primary themes were identified. For the literature review, a 5-step search process was used to identify relevant literature based on the scope of this study. After reviewing the literature, the findings were grouped into three primary themes: (1) discipline-based implementation of photovoice, (2) photovoice-based pedagogical interventions in the engineering classroom, and (3) photovoice-based pedagogical interventions to promote the entrepreneurial mindset. The preliminary results showcased in this study offer insights for engineering educators to consider while integrating photovoice-based pedagogical interventions in the engineering classroom.

To create a curriculum that infuses photovoice to promote entrepreneurially minded learning, engineering educators should consider offering students opportunities to engage in critical dialogue (e.g., sharing photovoice reflections in small or large group discussions). Furthermore, engineering educators should consider providing opportunities for participants to promote value creation (e.g., creating action plans and organizing photos and reflections to identify themes/problems). To effectively utilize photovoice to its fullest potential, extending the involvement of participants [students] is crucial (e.g., opportunities to discuss photovoice reflections with peers and instructors).

This study provides some noteworthy contributions. First, the preliminary findings and discussion enable engineering education researchers to identify and synthesize all existing research based on the chosen population (e.g., photovoice participants), intervention (e.g., use of photovoice to promote the entrepreneurial mindset, comparison (e.g., disciplines, type of participant, location), and outcome (e.g., review paper categorizing how photovoice has been used to promote entrepreneurial thinking/mindset among participants). Second, the results and discussion enable researchers to thoroughly review and analyze the literature across various settings and empirical methods. Third, the literature review results provide evidence that supports the intervention of photovoice and ensures its robustness and generalizability (e.g., replication/ and applicability) across a wide range of settings. Furthermore, our review provides guidance and recommendations for best practices to engineering educators.

For future research, engineering education researchers should consider implementing participatory action research methodologies such as photovoice in engineering education research and continue to investigate other visual research methods. Furthermore, engineering educators should consider using photovoice-based pedagogical interventions in their classrooms and examine best practices to utilize such interventions to promote entrepreneurially minded learning within engineering classrooms.

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