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Documenting Design Thinking: Exploring the Use of an Online Engineering Design Process Log (EDPL) in Middle School Engineering (Work-In-Progress)

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Abstract

The engineering design process (EDP) is central to high-quality K-12 engineering instruction, yet research has shown that students often struggle to systematically document and reflect on their design work in ways that capture iteration, decision-making, and integration of science and mathematics concepts. This Work-in-Progress paper presents preliminary research on the implementation of an online Engineering Design Process Log (EDPL) in the context of middle school engineering classrooms. The EDPL, which was iteratively designed and refined as part of a broader engineering curriculum development effort, provides an online platform where students record and reflect on their progress through the stages of the engineering design process. The EDPL prompts students to articulate problem statements and design requirements, brainstorm and evaluate potential solutions, document prototype testing, and reflect on final designs and the design process.

This paper summarizes research conducted in one 8th-grade engineering class at a large suburban middle school during the first semester of a year-long project in which student teams participated in a real-world design challenge: create a 3D printed product or prototype to improve the day-to-day life of the elderly or someone with a disability. The study is guided by the research question: To what extent and in what ways can an online engineering design process log support student engagement in the engineering design process and project-based learning? Data sources include teacher interviews, classroom observations, and analysis of student EDPL entries gathered over the course of one semester. Preliminary analysis indicates high levels of sustained engagement with the EDPL across the duration of the project. Although use of the EDPL during class sessions was somewhat inconsistent, review of EDPLs confirms that students used the log on a consistent basis, with groups continuing to utilize the EDPL outside of class time as they engaged in project work. The platform's structured prompts appeared to help students revisit earlier design stages—particularly problem framing and evaluation—areas that are often overlooked or underemphasized as students engage in the engineering design process. Observation field notes and teacher interview data further suggest that the EDPL supported both individual accountability and collaborative sense-making, helping students connect their hands-on building activities to broader engineering design concepts and principles.

Findings from this research will inform both ongoing refinement of the EDPL and teacher professional learning supports for integrating reflective tools into middle-school engineering classrooms. Ultimately, the study seeks to contribute to a growing body of research on digital innovations for student engagement and learning within project-based engineering education.

Facilitating the engineering design process (EDP) is widely recognized as a priority for high-quality engineering instruction, fostering engagement in authentic problem solving, application of science and mathematics, and development of engineering habits of mind [1]–[3]. National frameworks emphasize the EDP as an iterative, reflective, and evidence-based process in which learners define problems, generate and evaluate solutions, test and refine designs, and communicate reasoning [4], [5]. When implemented with fidelity, engineering design has been shown to promote interdisciplinary learning and epistemic practices of engineering [6], [7]. Empirical comparisons of student and expert designers further illustrate that experienced designers spend more time on problem scoping and transition iteratively across design stages—features of design expertise that students must learn to make visible in their own work [15].

Despite its importance, research consistently demonstrates that students struggle to systematically document and reflect on their design work. Analyses of engineering notebooks, journals, and portfolios frequently show an emphasis on final products or activity descriptions rather than reasoning underlying design decisions, iteration, and trade-offs [8], [9]. Students may record what they built without articulating why design choices were made, how evidence informed revisions, or how constraints shaped the design process [10]. As a result, documentation often fails to capture the iterative nature of authentic engineering design. Failed ideas, abandoned concepts, and incremental refinements are often omitted from records, limiting opportunities for reflection and learning from failure [9], [12]. Yet productive engagement with design failure—including teachers' explicit framing of failure as iterative information rather than student shortcoming—is increasingly recognized as central to engineering learning at the precollege level [16]. Without explicit instructional support, documentation may be perceived as a compliance task rather than as a tool for sensemaking and learning [8], [13].

Researchers have also developed digital tools to scaffold student metacognition during engineering design; for example, the Design Compass provides a graphical interface that prompts students to track their progress through design phases and supports peer discussion of design decisions [17]. To address these challenges, (authors) developed the Engineering Design Process Log (EDPL), a structured digital design journal designed to support students' documentation of iteration, decision-making, and evidence-based reasoning across the EDP [14]. Findings from classroom implementations of an early version of the EDPL indicated that it supported organization and increased visibility of the design process for teachers; however, students continued to experience difficulty documenting iteration and reflection, particularly under classroom time constraints [14]. This prior work informed subsequent refinement of the EDPL. Based on empirical findings and teacher feedback, the EDPL was iteratively revised to improve the user experience and functionality of the EDPL, provide new capabilities for teachers to monitor and assess student engagement with the EDPL, and more explicitly foreground and support design thinking, decision-making, evidence use, and revision over time. The current version provides space for students to document each stage of the design process, along with instructions to scaffold students' EDPL entries.

The current pilot study examines how the refined version of the EDPL (insert URL) supports students' documentation of engineering design processes in K–12 contexts. This Work in Progress paper summarizes preliminary research conducted in one 8th-grade engineering class to gain insight into the research question: To what extent and in what ways can an online engineering design process log support student engagement in the engineering design process and project-based learning?

Methods

This study draws on multiple qualitative data sources to examine how the EDPL was enacted within an eighth-grade STEM classroom. Data sources included a teacher interview, classroom observations, and analysis of student EDPL entries collected over the course of the fall semester of the 2025-26 academic year. Together, these sources provided complementary perspectives on instructional context, classroom practice, and student documentation of the engineering design process.

Curriculum and School Context

The study took place in a suburban middle school in the southeastern United States during the fall semester of the 2025-26 school year. The focal classroom was part of a specialized STEM program within the school. Students apply to participate in the STEM program, which supplements disciplinary coursework with an integrated STEM course emphasizing authentic, project-based learning. By eighth grade, students have typically participated in the program for two years and have prior experience engaging in extended design-based STEM projects. During the semester of data collection, students enrolled in the STEM course (n=47) were working on the Make:able challenge, a 3D printing and assistive technology design challenge (https://www.makeablechallenge.com/). The challenge enlists students in designing a 3D-printed product or prototype to improve the day-to-day life of the elderly or someone with a disability. The project emphasized empathy-driven design, iterative development, and communication of design decisions, and served as the primary curricular context in which the EDPL was implemented.

The participating teacher was a white male veteran educator with 22 years of teaching experience, including 12 years teaching engineering at the middle school level.

Participants and Positionality

The focal class enrolled 47 eighth-grade students who, by application to the school's specialized STEM program, had typically completed two prior years of project-based STEM coursework, representing a self-selected and academically prepared subset of middle-grades students rather than a general population sample. Disaggregated student demographic data are not reported in this work-in-progress; we acknowledge this as a limitation and plan to incorporate such information in continued analysis. The research team comprises educational researchers external to the classroom alongside members of the team responsible for developing the EDPL. We acknowledge that our investment in the tool shapes our interpretive frame, and approached the data treating documentation as a practice that shapes—rather than neutrally records—students' design thinking, interpreting patterns of use accordingly.

Teacher Interview Data

The participating teacher was interviewed near the end of the semester. The interview lasted approximately 40 minutes and followed a semi-structured protocol focused on the teacher's goals for EDPL use, perceptions of its instructional value, integration with existing classroom routines, and challenges encountered during implementation.

In addition to the end-of-semester interview, the researcher engaged in brief informal conversations (approximately 5–10 minutes) with the teacher during each classroom observation visit. Detailed field notes were used to create an interview memo summarizing key themes.

Classroom Observations

Five classroom observations were conducted over the course of the fall 2025 semester. Observations were scheduled during eighth-grade STEM class periods dedicated to student project work, when EDPL use was most likely to occur. Although the number of observations was limited by scheduling constraints—including school events and changes to students' daily schedules—the observations were distributed across the semester to capture variation in project activities and EDPL use over time.

Observation data were collected using a semi-structured protocol that included open-ended field notes as well as checklist items indicating whether specific aspects of EDPL use were observed (e.g., logging in independently, entering information across EDP stages, collaborative use, or visible confusion or frustration). To support continuity across observations and allow for deeper insight into student practices, observations focused on three focal student groups whose project work was followed across multiple visits.

EDPL Analysis

EDPLs were reviewed for 10 students who had initiated use of the log and had at least one entry in the Ideate phase. This sample was selected to ensure that reviewed logs reflected active engagement with the tool rather than incomplete or unused accounts. Analysis of EDPL entries focused on: (a) completion across stages of the engineering design process, (b) patterns of log use as indicated by embedded change history data, and (c) characteristics of students' EDPL entries. This analysis was descriptive in nature and intended to characterize patterns of use during the first semester of the project rather than to assess learning outcomes.

Across data sources, engagement with the EDPL was conceptualized along behavioral and cognitive dimensions. Behavioral engagement was indexed by the frequency and timing of EDPL use, drawn from change-history timestamps in the log and from observation checklist items capturing whether students were observed accessing or contributing to the log during class. Cognitive engagement was indexed by the substance of EDPL entries—specifically, the specificity with which students articulated problem statements, requirements, and design rationale—and by observed instances of student-to-student or student-to-teacher dialogue referencing log content. Coding was descriptive and iterative; the lead author reviewed entries and field notes, generated codes capturing patterns of completion and entry quality, and refined them through repeated passes across the focal-group data.

Results

Findings from EDPL analysis, classroom observations, and a teacher interview converge to provide a coherent picture of how the log functioned within an eighth-grade STEM classroom during the first semester of a year-long engineering design project.

Analysis of student EDPL showed engagement with early phases of design, including problem definition, ideation, and—in some cases—initial articulation of requirements and evaluations. The specificity with which students defined design problems and requirements varied across groups, with some groups using the EDPL for initial brainstorming of projects meeting the requirements of the Make:able challenge (e.g. "must use Fusion 360", "must assist end-user in day-to-day life") while others defined the specific problem they sought to solve. Problems identified by groups included the ergonomic challenges for people with scoliosis, mobility challenges in blind dogs, and strength/manual dexterity challenges limiting an elderly client's ability to perform tasks such as opening jars. Entries related to prototyping, testing procedures, test results, and reflection were relatively sparse. Classroom observations and the teacher interview helped contextualize this pattern. During the fall semester, many student teams were still engaged in research, ideation, or early development activities, with prototyping and formal testing planned for later phases of the project timeline. The teacher confirmed that EDPL data collected during the first semester represent an early snapshot of a longer design trajectory.

EDPL access and expectations were established in an early class session near the beginning of the semester. Students did not experience challenges logging into the EDPL and student groups were observed immediately and spontaneously adding entries to the first "Identify the Problem" section of the log, without explicit instruction from the teacher. Following this initial session, the teacher intentionally assumed a facilitator role, allowing students' project work to proceed independently with little intervention other than answering student questions and engaging in student-initiated dialogue about project ideas. At the same time, EDPL use was most apparent when the teacher gave brief reminders to students about the importance of using the log to document their design process. Additionally, EDPL use was less frequently observed during class periods focused on hands-on building, coding, or CAD work, with some students mentioning that they used the log outside of observed sessions. For example, as one group was brainstorming ideas and working on design sketches for an assistive device for blind dogs, one student was overheard stating, "I'll add that one into the EDPL after school so we don't forget it." Reviewing change log data confirms that, while the majority of EDPL entries were made during designated class time, there were a few instances of students updating logs as they continued to work on projects outside of class.

As alluded to in the example above, students often engaged in open-ended brainstorming and early sensemaking in physical STEM journals before using the EDPL to document clarified problem statements, refined concepts, and requirements. In some cases, students also relied on alternative documentation tools and workbooks associated with the *Make:able* challenge, resulting in parallel or duplicated documentation efforts. This fragmentation may help explain limited, sporadic use of the EDPL by some groups and why later stages of the engineering design process were underrepresented in the EDPL logs themselves.

Teacher interview data further illuminate the role of the EDPL as a reinforcing rather than driving structure in the context of this particular project. The teacher described the EDPL as valuable for promoting organization, intentionality, and accountability, particularly because entries were graded for participation and periodically reviewed. At the same time, EDPL use was not yet fully integrated into systematic formative assessment practices, due in part to a team-teaching model and the continued centrality of physical journals. Thus, while the EDPL reinforced students' awareness of the engineering design process, it did not fundamentally reshape instructional decision-making in real time during observed class sessions.

Discussion and Implications

Findings from this pilot study suggest that the refined EDPL supported students' documentation of early engineering design work but did not yet capture the full iterative design process during the first semester of implementation.

In the context of this 8^{th} grade STEM project, the EDPL appeared to function as a structure for organizing and consolidating design thinking once ideas became more refined. Implications for tool design and instruction include the need for stronger supports that foreground revision and iteration, closer alignment between documentation and assessment practices, and intentional embedding of tools like the EDPL within classrooms that explicitly revisit the engineering design process.

A distinguishing feature of the curricular context studied here is that the Make:able challenge explicitly positions disabled and elderly individuals as the end users for whom students design, foregrounding accessibility as a central—rather than ancillary—dimension of engineering work. The problem framings observed in students' EDPL entries (e.g., ergonomic supports for individuals with scoliosis, mobility supports for visually impaired dogs, and dexterity-related supports for older adults) suggest that the log can serve as a space where students articulate and refine the user-centered framings that equity-oriented engineering education calls for. At the same time, structured documentation prompts can risk reducing nuanced engagement with end-user experience to compliance-oriented entries. Continued analysis should examine the specificity and stance of students' user-need framings and, where feasible, the extent to which student designs are responsive to feedback from disabled or elderly clients themselves. Embedding accessibility-centered framings into K–12 engineering documentation tools may be one mechanism by which engineering education can engage with equity from the earliest stages of design rather than as a downstream concern.

Conclusion

This work-in-progress study examined early use of an iteratively developed EDPL in an eighth-grade STEM classroom during the first semester of a year-long engineering project. Findings indicate that students primarily used the EDPL to document early design stages, while later phases were less visible due to project timing and instructional context. Continued analysis will examine how EDPL use evolves as students' progress into prototyping, testing, and revision phases later in the academic year.

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