

Cultivating Reflective and Communicative Engineers: A Narrative Approach to Design Education

1. Introduction

Engineering students enter college with varied backgrounds, prior experiences, and cultural perspectives. This variability can influence how effectively they engage in design problem-solving and teamwork during early engineering courses [1]. Among the competencies that bridge these differences, communication—both written and oral—is a foundational skill that supports teamwork, design articulation, and professional readiness. The ability to clearly articulate design intent, justify technical decisions, and collaborate across disciplines is central to engineering practice and professional readiness [2].

However, traditional engineering curricula often delay explicit communication instruction until upper-level courses, leaving first-year students without structured opportunities to connect technical reasoning with rhetorical purpose. The resulting gap can hinder students' abilities to experience their design thinking and connect previous writing and communication instruction to discipline-specific needs [3]. This gap is reflected in baseline survey data collected from 150 first-year students enrolled in ME 1670 prior to the intervention.

This study explores the use of digital storytelling as an early intervention to address this gap. Our implementation in ME 1670: Introduction to Engineering Graphics and Design embeds communication directly within the design process by requiring students to narrate their design journey—contextualizing cultural inspiration, design constraints, and decision-making. In the second phase of this intervention, students also learn to decode more advanced reasoning by analyzing senior Capstone projects and using those insights to inform their own teach designs. This approach aims to foster reflection and articulate reasoning from the first year onward, employing pre- and post-activity reflection tools to measure gains in communication. By foregrounding communication as a form of design thinking, the course cultivates students' ability to reason like engineers—to connect justification, evidence, and context in both individual and collaborative work.

1.2. Literature Review

1.2.1 Intro to Communication for Engineers

Engineering, historically rooted in technical problem solving, increasingly demands communication as a complementary professional skill set, central to effective design, analytical performance, and professional development. The ability to communicate ideas concisely and clearly is a highly sought-after skill that has been echoed for decades by employers and educators alike, in several verbal and non-verbal forms [4]. Keyvani and Grahame report that practicing engineers spend over 50% of their day engaging with a multitude of technical and non-technical audiences, including other engineers, clients, stakeholders, government agencies, and support personnel; therefore, versatility and proficiency in written, oral, and graphical communication abilities are indispensable to high-functioning collaborative environments [2]. These findings emphasize that success as an engineer is not merely a matter of technical execution, but also requires clearly articulating ideas, translating advanced concepts to diverse audiences, and reflecting on calculated design processes and decisions.

1.2.2 Role of Communication in Industry Practice

The emergence of mass globalization, coupled with the prevalence of the digital age, has notably shifted the baseline skillsets of incoming students pursuing an education in engineering design [1]. The dramatic shift towards digitization and online collaboration has further compounded the value of clear, error-free communication for efficient execution of complex projects over digital mediums [4]. To address the discrepancies in student backgrounds, core design competencies ensure student success in industry and academic settings, given that any deficiencies are addressed early-on, through simple curricular interventions and corrective actions.

Goff and Terpenney found that there exists a considerable gap in academic versus industry expectations, with employers reporting communication skills as the most frequently mentioned area of disconnect and a critical core competency requiring improvement for real world practice [1]. Similarly, a study conducted by Linvill et al. reports that effective communication within interdisciplinary teams streamlines how succinctly technical information can be "distilled" and conveyed to non-technical managers or stakeholders, though it is an area in which individuals are often insufficiently prepared. Employers emphasize the importance of highly-dynamic abilities, by which engineers can quickly perceive and adjust their communication strategies to accommodate different contexts or audiences— such as moving up or down levels of technicality, across tiers of management, or in parallel with other colleagues [5]. Wu et. al. reports that student communication skills play a significant role in engineering employability, with oral, visual, and intercultural communication skills as significant differentiators and predictors of employability, giving students a competitive edge [4].

1.2.3 Role of Communication in Engineering Education

While a keystone objective of higher education institutions is to prepare students for the workplace, many programs are reluctant to adapt their traditional courses to the requirements in the modern job market [4]. Communication modules are often presented to students in isolation from real-world applications and are frequently met with indifference by students that have not yet experienced collaborative problem-solving in a competitive, industrialized environment. This decontextualization leaves students unable to appreciate the interdependence that exists between analytical thinking and expression when progressing towards a technical goal [3].

From a pedagogical lens, effective communication is central to design-based engineering education, greatly shaping how students learn to collaborate, reflect on their design decisions, and articulate technical reasoning. Strategic curricular interventions and structured communication activities require students to explain their thought processes, identify knowledge gaps, and refine their approach as designers, thus promoting metacognition and enhancing students' sense of ownership over their work [6]. In one study, McKenna and Hirsch reported significant gains in students' confidence, problem-solving abilities, and motivation in a first-year engineering design course that required students to build design, communication, and collaborative teamwork skills [7]. Haslam, Adams, and Gerrick found that introducing first-year engineering design students to the communication skills mirrored in capstone courses led to the

younger students demonstrating communication competencies equal to or surpassing their senior-level peers, while also developing a deeper engagement with the subject material. This work suggests that introducing students to the design process early on, with structured communication techniques is paramount, as first-year students tend to be more receptive to elementary ideas, motivated to engage in engineering challenges, and better prepared to communicate the key ideas of their work. In contrast, senior-level students lacking early exposure to this communication tend to fixate on the technical details and consequentially undervalue the importance of effective communication [8].

1.2.4 Digital Storytelling in Design

Most modern engineering programs traditionally rely on course-integrated activities such as technical reports, pitch proposals, presentations, and peer reviews to enhance communication skills within an engineering curriculum [9]. In recent years, however, the idea of leveraging multimedia and technology as educational tools to engage students and enhance performance has gained traction [10]. Digital storytelling is an approach that combines creative narrative techniques with multimedia and has been found to elevate student engagement and project-based learning, while allowing students to refine their critical thinking and technological literacy skills [11]. Mines and Mines recommend digital storytelling as a highly effective tool that enables students to apply their ingenuity as they research, brainstorm, organize, create, and present their stories. Introducing videos to the classroom helps convey and reinforce complex material, bridge the gap between theory and practical applications, and appeal to different learning styles, while increasing digital, global, visual, and informational literacy. One challenge, however, is that, to be effective, digital storytelling must be accompanied by other learning and instructional methods designed to intellectually engage students [10]. Compared to other disciplines where storytelling comes naturally, crafting meaningful stories in the context of engineering design takes tremendous effort, and can thereby catalyze higher levels of learning and thinking [12]. Another study supports this finding, suggesting that deep learning arises from the culmination of experience, reflection, abstraction, and active testing, enabled by story-based pedagogy [13]. Digital storytelling is known to stimulate student interest, reduce depersonalization, build ethical and emotional values, and foster intuitive learning of engineering principles, by encouraging students to understand factual material and think critically [12] [13].

Given the abundant overlap between technical communication, employability, and design education, there exists a ripe opportunity for an early-career introduction to meaningful communication modules, by integrating initiatives rooted in digital storytelling that interface effectively with the projects in this first-year design course. This study strives to map the digital storytelling intervention outcomes to student gains and enhancements in communication.

2. Contextual Framing: A Narrative Approach to Design Communication

In the context of engineering education, “narrative” and “storytelling” signal not only creative thinking, but structured ways of reasoning and communicating design logic. The term “narrative” refers to a cognitive framework that links actions to motives—how a designer connects constraints, trade-offs, and goals to justify decisions. “Storytelling,” by contrast, is the rhetorical

practice of communicating that logic to an audience through purposeful sequencing, emphasis, and framing.

This distinction matters because first-year engineering students often equate “good communication” with describing every procedural step. When they learn to organize communication around why a decision was made—rather than what was done—they begin to see engineering communication as a tool for reasoning. Our framework, therefore, positions “narrative” as the structure of cause-and-consequence in design thinking and “storytelling” as the communicative act that makes that reasoning visible. Embedding storytelling early in the curriculum cultivates reflective habits and prepares students to articulate design intent in later courses such as ME 2110: Creative Decisions and Design. This distinction between procedural description and narrative reasoning is reflected in post-activity survey results.

3. Implementation: Digital Storytelling in Solo and Team Projects

The narrative framework was implemented through two complementary design experiences in ME 1670: Introduction to Engineering Graphics and Design—an individual CAD & Culture project and a Team Design project. Both required students to create digital stories that narrated their design journey, but each emphasized a different dimension of design articulation.

The flowchart in Figure 1 below illustrates the sequence of activities in the digital storytelling interventions embedded within the projects of the design course. While both course projects follow a similar structure in terms of key activities, the individual project entails idea-to-prototype engineering, focused primarily on form design of a culture-inspired product, while the team project involves idea-to-functionality execution of real-world engineering projects focused on functional design. Because the individual project is largely an independent effort, students are encouraged to treat the culture they select as their client. In contrast, the team project situates students in a cognitive apprenticeship model, pairing each team with senior Capstone students and exposing them to completed Capstone reports and prototypes. This structure enables freshmen to study how experienced engineers make and support design arguments before attempting to apply those reasoning patterns within their own projects. The digital storytelling interventions—tasking students with producing engaging videos as a final project deliverable, in lieu of a traditional presentation—were adjusted to accommodate the nuances of the respective projects.

Sequence of Events in Digital Storytelling Intervention



Interventions Mapped to Key Activities in Course Projects

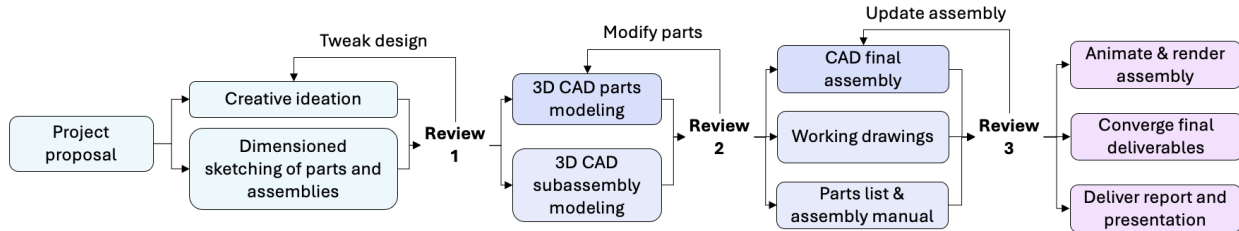


Figure 1. Flowchart of digital storytelling interventions across key activities in course projects

The intervention was implemented in a freshman-level cornerstone design course with 250 first-year students enrolled. Students were tasked with creating digital stories that narrated their design journey, including problem framing, ideation, prototyping, and iteration.

3.1 Individual CAD & Culture Project

The individual project asked students to treat their culture as their client and to design a small home décor object that reflected both aesthetic and cultural values, with the objective of producing a 3-minute-long vertical video detailing the design process, decisions, and ties to their chosen culture. This framing served two purposes. First, it encouraged empathy and user-centered thinking by asking students to articulate how values and traditions could inform design constraints. Second, it positioned students to justify their design decisions rather than simply recount their workflow. The digital story became the mechanism through which students practiced articulating their logic behind their design choices; explaining not just what they modeled in CAD, but why those features made sense for the context they defined.

As part of this intervention, students were provided with tools including step-by-step ideation guidelines, a design checkpoint, and storyboard outlines to support planning for the final video deliverable. The storyboard structure was central to this outcome. Instead of using “narrative” in a traditional storytelling sense—which can prompt superficial, chronological summaries—the storyboard guided students to organize their videos around three communicative moves: (1) establishing context and constraints, (2) unpacking technical reasoning, and (3) reflecting on decisions and implications, as shown in Figure 1. This framework trained students to see process-oriented communication as a form of argument: a coherent explanation of design reasoning supported by evidence, rather than a simple “first we did this, then that” recounting. In doing so, the intervention built metacognitive awareness of how design rationale is constructed, a skill that supports later coursework such as *ME 2110: Creative Decisions and Design*.

Looking ahead, the instructional team is developing an engineering storytelling repository to archive student videos and support a longitudinal study of how communication and design reasoning evolve throughout the curriculum. Storytelling interventions positioned communication as both a reflective and functional component of design learning. The individual “CAD & Culture” project helped students practice articulating design intent through personal reasoning. This dual structure allowed the instructional team to examine how students’ ability to explain design logic—rather than simply describe procedures—develops across design challenges.

3.2 Team Design Decoded Design Project

The second intervention extended storytelling to collaborative functional design. Branded as “Design Decoded,” this assignment reframed storytelling as acts of investigation and analytical transfer, rather than documentation. Teams selected either a Capstone-style mechanical design or a Sustainable Development Goal (SDG)-aligned design. The Capstone-style projects emphasized creativity, mechanism design, and animation of working systems, while SDG projects addressed low-cost, locally sourced solutions for global or community needs. In both tracks, students distributed modeling responsibilities, developed sub-assemblies, and created motion mechanisms, employing storytelling to create a short video as the final project deliverable.

To prepare for this work, each team was assigned a past senior Capstone report and partnered with a current Capstone student mentor. Teams analyzed these exemplars to identify how more experienced engineers justified their design choices—what evidence, testing, and argumentation supported their decisions. The goal was not replication, but translation: to understand the reasoning structures that underlie effective engineering communication, and to adapt those principles to their own context. Their stories focused on articulating how those expert insights shaped their own team decision-making; for example, how design trade-offs balanced functionality, manufacturability, and user context. Each team produced a five-minute “episode” in the *Design Decoded* series, using visuals and narration to communicate how they learned from and applied professional reasoning models.

This storytelling activity builds on the earlier CAD & Culture project by shifting from individual aesthetic reasoning to collaborative functional reasoning. Whereas the first assignment emphasized how culture shapes design values, this team version highlights how professional exemplars shape design judgment. In both cases, storytelling is used as a tool to communicate why design choices make sense within specific contexts. Through this approach, first-year students begin to internalize the argumentative nature of engineering communication—seeing design not only as an act of creation, but as a form of evidence-based persuasion.

3.3 Peer Exchange and Repository Development

All videos were shared in peer-review sessions, allowing students to analyze how different rhetorical choices conveyed reasoning. During these sessions, students also discussed how expert

models influenced their design thinking, reinforcing the idea that effective communication involves recognizing and adapting disciplinary reasoning conventions.

The instructional team is developing an engineering storytelling repository to archive exemplary videos and enable longitudinal study of how communication and design reasoning evolve across the curriculum. Within this repository, the Design Decoded episodes serve as a record of how students interpret and apply expert reasoning early in their academic trajectory, providing data for studying the transfer of design communication practices.

4. Pre- and Post-Activity Reflections

To evaluate how storytelling influences communication and reflection, the instructional team developed pre- and post-activity surveys measuring self-perceived abilities in clarity, confidence, and reflective awareness. Likert-based survey items asked students to rate their confidence in explaining technical ideas, organizing complex information, and considering audience needs. Open-ended questions invited qualitative reflection on how storytelling affected their perception of design communication.

4.1 Survey Design and Administration

The pre-activity survey was administered prior to the start of the individual and team design projects and received 150 responses from a cohort of 250 students (60% response rate). The post-activity survey was administered after completion of both storytelling interventions and received 173 responses (69.6% response rate). Survey items were aligned with the cognitive and communicative goals of the interventions described in Sections 2 and 3, with particular attention to narrative organization, audience awareness, reflective reasoning, and collaborative communication. The team storytelling phase included prompts specific to the Design Decoded framework—asking students to describe what they learned from analyzing Capstone exemplars and how those insights affected their own design decisions in order to capture evidence of transfer and cognitive apprenticeship in action.

Preliminary results indicate that, in terms of communication, 85% of students reported feeling more confident expressing their technical ideas after using the digital storytelling techniques, compared to their pre-activity confidence levels. Given the tight interaction between engineering communication skills and employability, at a glance, these results indicate a notable change in enhancing student abilities for industry practice. Classroom observations indicate that students approached their video narratives with increasing attention to justification and audience. Many demonstrated greater ease explaining why design features met contextual goals, suggesting that the storyboard scaffold encouraged deeper reasoning. Table 1 below outlines the intended role and rationale of the storytelling interventions with respect to both course projects.

Table 1. Projected role of storytelling interventions, mapped to each course project

Assignment	Cognitive Function of Storytelling	Role in Design Cognition	Type of Reasoning Practiced
CAD & Culture	Storytelling as internal reasoning: using narrative to <i>surface and organize</i> one's own design logic.	Story helps students make sense of their decisions, connecting values and constraints through reflection.	<i>Interpretive and introspective reasoning:</i> "Why did I make this choice? What was I prioritizing?"
Design Decoded	Storytelling as externalized reasoning: using narrative to <i>analyze and emulate</i> how experts justify design choices.	Story becomes a tool for <i>reasoning through analogy and transfer:</i> making expert judgment visible, then applying it to new contexts.	<i>Analytical and comparative reasoning:</i> "How do experts make arguments, and how can I use that pattern?"

4.2 Baseline Communication and Reflection Profiles (Pre-Survey)

Pre-survey results indicate substantial variability in students' communication confidence and reflective practices upon entering the course. While 60% of respondents reported feeling confident explaining technical ideas to others, a notable proportion of students expressed neutrality or discomfort in related areas. Specifically, 42% of students indicated neutrality or disagreement when asked about their ability to organize complex concepts during communication, and 41% reported that reflection was not a consistent component of their design process. Similarly, only 54% of students reported an understanding of the importance of storytelling in communicating design ideas prior to the intervention, suggesting that many first-year students had not yet developed structured strategies for articulating design reasoning beyond procedural description. These baseline results reinforce the need for early, explicit communication scaffolds that help students connect design decisions to justification and context.

4.3 Post-Intervention Outcomes

4.3.1 Narrative Organization, Audience Awareness, and Reflection

Post-survey results show marked gains across multiple dimensions of communication and reflective reasoning following the storytelling interventions. After completing the projects, 85% of students reported increased confidence expressing technical ideas, and 85% indicated improved ability to organize and present design ideas using narrative techniques. These gains align directly with the storyboard-based narrative structures introduced in both projects, which emphasized purposeful sequencing over chronological recounting.

In terms of audience awareness, 87% of students reported greater attentiveness to audience needs when communicating design concepts, and 88% indicated that the storytelling activities prompted deeper reflection on their design decisions. Together, these results suggest that narrative framing supported students in moving beyond procedural explanations toward more intentional, audience-aware communication of design logic.

4.3.2 Identity, Collaboration, and Transfer

Results also highlight the role of storytelling in supporting identity-driven and collaborative design reasoning. After the CAD & Culture project, 68% of students reported that their personal background contributed meaningfully to the storytelling process, reinforcing the project's emphasis on values-based constraint definition and reflective articulation of design intent. In the team-based Design Decoded project, 84% of students reported increased confidence working in interdisciplinary or diverse teams, and 84% indicated stronger connections with peers through collaborative storytelling activities. These outcomes align with the cognitive apprenticeship model described in Section 3, in which students analyzed expert Capstone reasoning and transferred those patterns into their own collaborative design decisions.

4.4 Synthesis of Findings

The survey results suggest that digital storytelling supports multiple dimensions of early engineering development, including narrative organization, audience awareness, reflective judgment, and collaborative reasoning. Importantly, these gains were evident across both individual and team-based projects, indicating that narrative structures can support introspective reasoning. While these findings are based on self-reported measures, they provide initial evidence that embedding narrative-based communication early in the design curriculum can shape how students reason about and communicate engineering decisions—establishing habits that support later coursework and professional practice.

5. Ongoing Work and Future Directions

Current work focuses on refining the survey instruments, expanding digital-storytelling integration to other courses, and populating the storytelling repository. The next phase will analyze student perception data and explore how narrative-based communication correlates with measurable design-competency growth. Specific attention will be given to how analyzing expert design arguments supports reasoning transfer—a core skill for developing design autonomy. Long-term goals include tracing students' progression from individual reflection to collaborative justification, investigating how storytelling supports teamwork and empathy, and identifying transferable practices for other STEM curricula. Future implementations may formalize Design Decoded as a recurring student media series that showcases design reasoning across the undergraduate curriculum, linking early coursework with Capstone outcomes.

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Appendix 1: Pre-survey

I feel confident explaining technical ideas to others. Likert (Strongly Disagree; Disagree; Neutral; Agree; Strongly Agree)

I am comfortable presenting my design ideas in both written and oral formats. Likert

I find it easy to organize my thoughts when communicating complex concepts. Likert

I regularly reflect on my design decisions and their impact. Likert

I understand the importance of storytelling in communicating design ideas. Likert

I consider multiple perspectives when solving design problems. Likert

I enjoy working collaboratively on design projects. Likert

I feel that my background and experiences influence how I approach design tasks. Likert

I am aware of how communication affects teamwork in engineering contexts. Likert

What do you think makes a design idea compelling or memorable? Open-Ended

Describe a time when you struggled to explain a technical concept. What made it difficult? Open-Ended

Appendix 2: Post-activity survey

I feel more confident expressing technical ideas after using digital storytelling. Likert

I can better organize and present my design ideas using narrative techniques. Likert

I am more aware of my audience when communicating design concepts. Likert

The storytelling activity helped me reflect more deeply on my design process. Likert

I now see storytelling as a valuable tool in engineering communication. Likert

I am more thoughtful about the decisions I make during design projects. Likert

The activity helped me connect more meaningfully with my peers. Likert

I feel that my unique background contributed to the storytelling process. Likert

I am more confident working in interdisciplinary or diverse teams. Likert

How did digital storytelling change the way you think about design? Open-Ended

What was the most valuable part of the storytelling activity for you? Open-Ended