Beyond "Hoopla": Mitigating Drawbacks of Competitive Design in Engineering Design through Scenario-Based Learning

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Abstract: Engineering design courses often leverage competitions to boost engagement. However, this study argues that a high-stakes competition can inadvertently undermine core learning objectives by incentivizing students to prioritize points over process, reducing complex design decisions to mere gestures of justification. A common pedagogical challenge is that students often perceive these projects as exercises in *building*—applying skills to win—rather than as exercises in *designing*, which requires the synthesis central to high-level engineering practice. This study investigates whether a Scenario-Based Learning (SBL) framework, “Burdell, Inc.,” can bridge this gap by shifting student focus from a competition-centric mindset to a process-oriented, professional identity. The scenario was explicitly designed to counterbalance the competition’s pull by casting students as interns accountable to stakeholder needs, not just a scoreboard.

To facilitate this transformation, we implemented a rich SBL framework in our summer 2025 sophomore-level mechanical engineering course, casting students as interns at a design firm. Using Bloom’s Taxonomy as a priori codes for analyzing end-of-course interview transcripts, we identified a stark dichotomy in student outcomes. Students who bought into the professional scenario demonstrated cognitive engagement at the *create* and *evaluate* levels, demonstrating an understanding of design tools as essential for synthesis and justification. Conversely, students who resisted the scenario operated at the *apply* level, dismissing the process as “a lot of hoopla stuff” and focusing narrowly on competition points. This correlation demonstrates that the scenario’s efficacy in achieving high-level learning objectives is directly mediated by the student’s psychological buy-in, which acts as the crucial catalyst for re-contextualizing abstract tools into desired engineering processes. Becoming a designer, not just a builder, requires this cognitive shift.

Our findings indicate that SBL must be deliberately framed to elicit the buy-in that re-contextualizes tasks from simple application to authentic creation. We introduce the concept of a “pedagogical container” to describe a robust SBL framework that manages, rather than eliminates, the tension between a competition and learning goals. We conclude that the critical task for educators is not to avoid competitions, but to deliberately frame SBL experiences that foster the buy-in required to make the container effective, thereby ensuring the competition serves as an environment for—rather than a distraction from—systematic design thinking. These results will help educators design SBL experiences that not only simulate professional environments but also effectively foster the cognitive shift necessary for students to internalize a designer’s mindset.

1. Introduction: The "Create" vs. "Apply" Gap in Design Education

In engineering education, there exists a persistent chasm between the sophisticated design processes taught in the classroom and the "tinker-and-test" approaches often adopted by students. This gap is particularly pronounced in competitive project-based courses. Here, the compelling goal of winning often creates a "competition-centric" mindset. In this frame, the scoreboard becomes the primary stakeholder, and the systematic design tools essential to professional practice are frequently dismissed by students as academic "hoopla": unnecessary overhead that distracts from the "real" work of building a winning machine. The prevalence of competitions is understandable. A significant body of literature on Competition-Based Learning (CBL) rightly highlights its power to boost engagement, create memorable "bonding" experiences, and provide a clear, tangible outcome for students and institutional outreach alike. This paper situates Scenario-Based Learning (SBL) as a deliberate pedagogical framework, which we name a "pedagogical container," to Competition-Based Learning (CBL), investigating how SBL may mediate the competition-centric mindset commonly observed in design courses.

However, this creates a fundamental pedagogical conflict. A common pedagogical challenge is that students often perceive these projects as exercises in building—applying known solutions to win—rather than as exercises in designing, which requires the synthesis and creation central to high-level engineering practice. This often manifests in a noted lack of creativity in student designs and, correspondingly, weak written justifications for their decisions, as they converge on a few proven, competition-optimal solutions without a deeper logical process. The very extrinsic motivation that makes competitions engaging can undermine the intrinsic motivation required for deep engagement with the learning outcomes relating to legitimate systematic processes within the field. This is not a new observation; as Newstetter (1998) noted in an earlier analysis of this very course [1], students often remained unmotivated by scenario-based learning and treated the course as merely a means to a grade. While Newstetter focused on the failures of the scenario itself, this paper seeks to complicate her assessment by investigating how the competition's influence affects SBL's pedagogical outcomes. Therefore, the key question is how the competition structure cues students into a performance-oriented frame, and what redesign strategies can shift their engagement toward the systematic design practices the design project is intended to cultivate.

To address this, we implemented a rich SBL framework in the context of a fictitious company, "Burdell, Inc.," designed to act as a pedagogical counterweight to the competition. By casting students as interns in a design firm accountable to stakeholder and supervisor avatars [2], the intervention aimed to re-contextualize the design tools from academic exercises into professional instruments thereby helping students make the cognitive leap from thinking of engineering as building to engineering as designing.

This paper investigates the following research question: To what extent does psychological buy-in to a professional SBL scenario mediate a cognitive shift in students from lower-order thinking (Bloom's *apply*) to higher-order thinking (Bloom's *create*/*evaluate*) about engineering design? Using Bloom's Taxonomy as a priori codes for analyzing end-of-course interviews, we identify a stark dichotomy between students who adopted the "intern" identity and those who rejected it, offering a new explanation for the variable success of SBL in competitive environments.

2. Literature Review: Scenario-Based Learning (SBL) and Competition-Based Learning (CBL)

2.1 The Promise of SBL

A growing body of research suggests that scenario-based learning (SBL), which exists on a spectrum with problem-based and challenge-based learning, is a promising pedagogical approach. It immerses students in realistic, often ill-structured problems that mirror professional practice [3, 4]. What distinguishes SBL as a driver of higher-order learning is the way it restructures the cognitive demands placed on students. Ill-order- learning is the way it restructures the cognitive demands placed on students. Ill-structured problems require learners to define the problem space (often iteratively), identify structured problems require learners to define the problem space (often iteratively), identify- relevant constraints, weigh competing criteria, and justify their decisions. All these activities are aligned with the upper levels of Bloom's Taxonomy but are often omitted if a student team is fixated on simply building a functional mechanism. The theoretical foundation is robust, grounded in constructivist and experiential learning theories that posit students learn best by actively constructing knowledge through experience [5, 6]. The core purpose of SBL is to shift learning from knowledge acquisition to performance improvement, engaging students in a process that requires them to apply what they know to solve complex challenges [7, 8].

2.2 The Implementation Gap

Despite consensus on its purpose, the literature reveals significant divergence on how to define and implement SBL effectively. Definitions range from viewing scenarios as "stories about people and their activities" used for visualization [9] to "a realistic situation where a sequence of events is presented and possible choices allow the learning to reach an outcome" [7]. This conceptual ambiguity leads to a wide spectrum of implementation. Researchers generally fall into three camps: using real-world problems with real stakeholders, limiting the scenario to a singular assessment, or employing multi-assignment role-play with pretend stakeholders. The effectiveness of these approaches is highly variable and context-dependent [10, 11]. Furthermore, the choice of problem type is critical; problems that are either too well-structured or too ill-structured can be inappropriate, and "closed-loop" methods that include reflection and multiple cycles are most effective [4, 12, 13].

2.3 The Crucial Role of Motivation and Buy-In

The success of any SBL implementation is precariously dependent on student engagement, which is not guaranteed. Research consistently shows that student motivation hinges on the scenario's perceived authenticity and its relevance to their interests and experiences [6, 8]. If a scenario does not feel like it has a real-world application, students will not engage with the role-playing aspects [7]. An innovative concept described by De Bonte and Fletcher is "delight," the idea that students should find the challenge enjoyable and not a chore [14].

When students do buy in, the benefits extend well beyond engagement. Research consistently shows that well-designed scenarios accelerate the development of both technical and professional competencies by situating design decisions in authentic contexts rather than abstract exercises [5, 12, 4]. This mirrors findings that CBL environments promote both knowledge of application and prototype development [15]. Critically, SBL is shown to enhance students' ability to articulate complex concepts and engage with stakeholder needs, moving beyond mere identification to meaningful involvement [16, 17].

Ultimately, as multiple studies note, if students do not see value or delight in the experience, they are unlikely to fully engage, and teachers may face student resistance as they attempt to shift students from traditional, passive roles to active, self-directed learners [18, 19]. This directly points to psychological buy-in as a critical, yet under-examined, mediator that unlocks these positive learning outcomes.

2.4 Assessing Scenarios and Outcomes

The recommended methods for evaluating SBL's effectiveness are as varied as its implementations, but they consistently move beyond traditional exams. Researchers employ a multi-modal approach to assessment, using reflective journals, peer feedback, presentations, and essays to evaluate student learning [3, 20]. To assess the effectiveness of the scenario itself, researchers generally rely on qualitative methods like student interviews, focus groups, and surveys, often with codified responses for rigorous analysis [16, 10] . This aligns with the understanding that scenario-based design projects impact learning outcomes best when assessment is focused on the application of knowledge and the understanding of linking principles, rather than simple knowledge acquisition [3]. The effectiveness of a scenario is therefore evaluated through a mix of student perception and, most importantly, how effectively they can apply the course's learning goals.

2.5 Scholarly Tension: CBL's Tradeoffs

The use of competition in engineering education is a subject of active debate, creating a clear tension in the literature that directly informs the context of this study. A body of work advocates for Competition-Based Learning (CBL), highlighting its benefits for student engagement, motivation, and the development of practical skills [21, 22]. Proponents argue that competitions provide an exciting, memorable experience that increases student participation.

However, competing scholarly perspectives, particularly from fields such as psychology and education, caution that the competitive frame can introduce significant pedagogical trade-offs [23]. This view suggests that the intense focus on winning can inadvertently reframe educational activity, prioritizing the product and the outcome over the learning process itself. This aligns with the critical view derived from motivational theories such as Cognitive Evaluation Theory [24], which posits that strong extrinsic motivators can undermine intrinsic motivation for complex tasks. This tension is exemplified in the context of this very course by Newstetter [1], who found that students remained unmotivated for scenario-based learning and treated the course as just for receiving a grade. Newstetter's finding points to a "competition-centric mindset" where the external reward (grade/winning) becomes the sole stakeholder, potentially leading students to view supporting elements of the curriculum as secondary or even irrelevant.

Recent work at our institution [25] shows that students often treat prototypes as demonstrations of merit, seen by students as evidence of accomplishment rather than instruments of inquiry. This performative orientation implies a fixed mindset [26, 27] and aligns with performance-approach goals in the Achievement Goal Theory Matrix [28], where the emphasis is on proving ability rather than developing it. In contrast, purposeful prototyping, in which prototypes are used to challenge assumptions, test hypotheses, and inform design trade-offs, embodies a growth mindset, mapping to mastery goals that prioritize learning and iterative improvement. When competitions dominate the frame, prototypes risk becoming symbols of completion rather than epistemic tools, reinforcing the misconception that "having a prototype" equals "having designed." To counter this, educators can embed structured reflection and scenario-based scaffolds, shifting students from a defensive posture of excellence to an exploratory posture of growth.

Therefore, a key challenge in the literature is not simply whether to use competitions, but how to implement them in a way that preserves the core learning objectives related to systematic process and professional identity. The SBL framework of "Burdell, Inc." was designed as an intervention to address this precise challenge by embedding the competition within a richer professional narrative.

2.6 Synthesis and Gap Identification:

The scholarship provides a strong foundation for using SBL, highlighting its potential for engagement and skill development. However, it also reveals critical uncertainties. The field lacks a unified framework for implementation and, most importantly, an explanation for the variable student engagement observed in practice. The literature identifies the symptoms—students who resist scenarios and prioritize grades or competition—but lacks a framework for diagnosing the root cause.

SBL offers more than an engaging narrative context. It is a cognitive mechanism that shifts students from viewing design tools as academic exercises to recognizing them as essential instruments for making and defending engineering decisions. However, the extent to which SBL successfully fosters higher-order learning depends heavily on whether students adopt the scenario's professional frame as the meaningful context for their work. When that framing is accepted, students tend to engage in synthesis, justification, and iterative refinement. When it is not, their engagement with design tools often remains procedural or superficial.

Our study builds upon this foundation by proposing and testing psychological buy-in as the crucial mediating variable. By analyzing student outcomes through the lens of Bloom's Taxonomy, we move beyond asking if SBL is effective to explaining why its effectiveness is so uneven, thereby addressing a significant gap in the understanding of SBL in competitive, project-based environments.

3. Theoretical Framework: Bloom's Taxonomy and Scenario-Based Learning

This study is framed by the integration of two theoretical perspectives: Bloom's Taxonomy, which provides the analytical lens to measure cognitive engagement, and the theory of Situated Cognition, which explains the mechanism through which Scenario-Based Learning (SBL) is intended to facilitate that engagement. Together, they form the basis for investigating how psychological buy-in mediates learning in a competitive design environment.

3.1 Bloom's Taxonomy as an Analytical Lens

To objectively analyze the cognitive skills students developed, this study uses Bloom's Taxonomy as a framework for coding and interpretation [29].The taxonomy categorizes cognitive learning outcomes into a hierarchy, from lower-order to higher-order thinking skills. For this research, the critical distinction lies between two key levels:

- **Apply:** At this level, students execute learned procedures to a familiar task. In the context of the design course, this manifests as building: the competent execution of steps to assemble a functional robot using known techniques and principles. The focus is on correct implementation.
- **Create:** This is the highest level of cognitive complexity, requiring students to synthesize elements to form a novel, coherent, and functional whole. In the context of this sophomore-level mechanical engineering course, this aligns directly with our definition of engineering design as a systematic, and iterative process that creatively applies scientific and mathematical principles to develop functional products or systems that satisfy specified needs and constraints.

Thus, while *apply* is manifested in building a robot, *create* is manifested in designing it—generating a new solution by hypothesizing, planning, and making justified trade-offs to satisfy stakeholder needs.

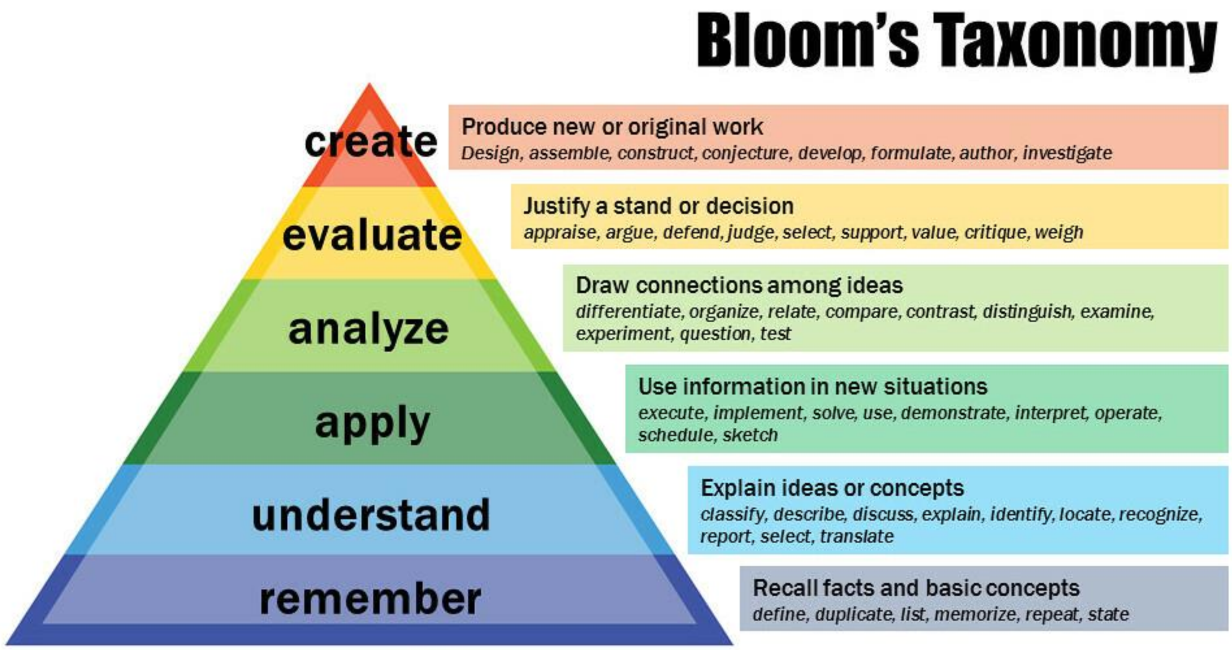

Figure 1 Bloom's Taxonomy from [29]

This framework provided the a priori codes for our thematic analysis of student interviews. Interview questions were explicitly designed to prompt metacognition and elicit language indicative of these cognitive levels, allowing us to classify students' perceived engagement with the design process as either product-centric (*apply*) or process- and justification-centric (*create/evaluate*), with the key goal of assessing students' metacognition concerning design tools.

3.2 The Psychological Journey: The Conscious Competence Model

The cognitive shift coded using by Bloom's Taxonomy is accompanied by a parallel psychological progression. The Conscious Competence model [30] describes four stages learners pass through:

- **Unconscious Incompetence:** The learner is unaware of a skill gap ("I don't know what I don't know"). In the design course, this is the student who doesn't realize that systematic tools exist or have value; they believe building is designing.
- **Conscious Incompetence:** The learner recognizes the skill gap and their own deficiency ("I know what I don't know"). This is a critical, if uncomfortable, turning point where the need for a tool like an FMEA becomes apparent.
- **Conscious Competence:** The learner can use the skill deliberately with effort ("I can do it, but I have to think about it"). They are consciously applying the design tools step-by-step.
- **Unconscious Competence:** The skill becomes second nature ("I do it without thinking"). While true mastery is the long-term goal, the immediate aim of the course is to move students from *Unconscious Incompetence* to *Conscious Competence* in using systematic design processes.

3.3 Scenario-Based Learning and Situated Cognition

Scenario-Based Learning is the pedagogical intervention tested in this study, and its theoretical underpinning is found in situated cognition [31]. This theory posits that learning is fundamentally situated within a specific context and culture; knowledge is most effectively acquired when used in authentic activity. SBL operationalizes this principle by creating a "situated learning environment"—the fictional design firm "Burdell, Inc." This scenario is not a decorative narrative, but a designed context intended to make the culture and practices of professional engineering meaningful. By acting as "interns," students are, in theory, learning to be designers through participation in a simulated community of practice where tools have purpose and actions have consequences for stakeholders.

3.4 Synthesis: An Integrated Framework for Analyzing Cognitive Engagement in Situated Contexts

We synthesize these two frameworks to create an integrated lens for analyzing student learning. The situated context of the SBL scenario is designed to be the catalyst that propels students through the psychological stages, which is then evidenced by their cognitive engagement. The table below outlines this integrated mapping, forming the basis of our analysis.

Table 1: Integrated Theoretical Framework: Mapping Psychological Buy-in to Cognitive Engagement in a Situated SBL Context

Psychological Stage	Pedagogical Catalyst (Situated Cognition)	Cognitive Evidence (Bloom's Level in Student Language)
Unconscious Incompetence -> Conscious Incompetence	The scenario introduces authentic stakes and consequences, revealing the gap between "building" and "designing."	Shift from describing only the product (**Apply**) to acknowledging the need for a process.

Conscious Incompetence -> Conscious Competence	Legitimate peripheral participation: Using design tools to meet stakeholder demands.	Executing a tool with understanding of its purpose (**Analyze**). Justifying decisions via stakeholder needs (**Evaluate**).
Conscious Competence (Fully Situated)	Construction of a professional identity through authentic activity.	Synthesizing a professional ethos to argue for a design solution (**Create**).

This integrated framework posits that psychological buy-in to the SBL scenario is the mechanism that enables this progression. A student who rejects the scenario will describe their work in decontextualized, functional terms focused on the competition (e.g., "We picked the power source that made the robot fastest"), demonstrating cognitive engagement at the *apply* level. Conversely, a student who buys into the scenario will contextualize their work within the professional narrative (e.g., "We used the decision matrix to balance the client's need for speed with their budget, which justified the more expensive motor"), demonstrating the synthesis, evaluation, and creation that define professional engineering design.

4. The "Burdell, Inc." Intervention: Designing for "Create"

4.1 Course Context and Pedagogical Challenge

This study was conducted within "Mechanical Engineering 2110: Creative Decisions and Design," a sophomore-level course at Georgia Tech. This course was designed to teach design alongside mechatronics through design competitions [32].

Informed by the pedagogical foundations of Challenge-Based Learning (ChBL) [15], we developed a scenario-based framework to investigate its core components within engineering design education. Distinct from Competition-Based Learning (CBL), Challenge-Based Learning emphasizes authentic problem-solving and collaboration, making the process itself the primary learning vehicle. In contrast, Competition-Based Learning frames success as outperforming peers, which can narrow focus to short-term tactics and extrinsic rewards. This distinction matters because CBL's performance orientation often undermines mastery goals, whereas ChBL naturally supports growth-oriented behaviors. A well-designed pedagogical context, such as Scenario-Based Learning, can help manage this tension by embedding competitions within a professional narrative that enhances perceived relevance and authenticity, key factors required for student buy-in.

Figure 2: An AI-generated depiction of the fictional town and setting of the scenario, Stormhaven, Coralina.

The competition theme was disaster relief, with robots being required to accomplish tasks themed to represent such real-world challenges as to “navigate flooded zones,” “clear debris,” and “deliver supplies” within a 40-second head-to-head match against other teams. Historically, this competition served as the dominant framing and primary metric of success in the course, fostering a competition-centric mindset where the scoreboard became the de facto stakeholder. In this framing, earned points were treated as the sole indicator of design effectiveness, overshadowing the authentic needs of scenario stakeholders [1]. This dynamic illustrates why psychological buy-in is so critical: without an authentic frame, students default to the simplest and most salient context, which is the competition.

SBL framing addresses this by embedding the contest within a richer professional narrative, ensuring that systematic design processes remain meaningful even when competitive pressures are present. To further counter this, a significant structural change was made: the final course grade was decoupled from competition performance, with the final ranking accounting for only 5% of the grade. Instead, assessment was shifted toward process-oriented assignments such as prototyping and testing logs, explicitly signaling that systematic process, not just victory, was valued.

4.2 Scenario Design: Immersion in “Burdell, Inc.”

To re-contextualize the student experience, we implemented a full SBL framework built around a faux design firm, “**Burdell, Inc.**” The narrative premise cast students as interns at this firm, tasked with responding to a request for proposals from the fictional coastal town of Stormhaven, Coralina, for a disaster response device.

The professional context was maintained through two supervisory audience avatars (as part of the scenario stakeholders)

- Jon Fox, the head design supervisor from **Burdell, Inc.**
- Kim Jones, a designer and supervisor of interns from **Burdell, Inc.**

Figure 3 Photo of life-size cutouts of audience avatars (Jon and Kim) placed in the classroom during student presentations.

All course assignments and major communications were delivered to students in the form of emails from Jon or Kim, maintaining the fictional, professional narrative throughout the semester (see Appendix 1, 2). Students were also provided with detailed stakeholder interview transcripts from five key stakeholders in Stormhaven, which articulated a complex set of needs, constraints, and priorities that went beyond the simple rules of the competition (see stakeholder interview transcripts in appendix

3). This was designed to introduce a more complex set of stakes centered on client needs and professional accountability, directly competing with the reductive stakes of the scoreboard.

4.3 Intended Cognitive Shift: Synthesizing Engineering Logic

The scenario was explicitly engineered to make the use of systematic design tools—such as House of Quality (HOQ), function trees, and morphological charts—a necessary part of the "intern's" job, thereby requiring the synthesis and evaluation central to Bloom's *create* level. We emphasized that deliverables such as design reports and presentations must use evidence derived from these tools to justify decisions. The intended shift was to move students' source of validation from "Will it get points?" to "Is my decision logically sound and justifiable to my supervisor and client based on our engineering analysis?" The ultimate goal was to train students in the legitimate logic of the field: how to make appropriate engineering claims and support them with appropriate rationales and analysis, thereby preparing them for the professional demands of future courses such as capstone and their careers.

5. Methodology: Using Bloom's Taxonomy to Code Student Understanding

5.1 Research Approach and Participant Context

Our approach focused on a specific section of ME 2110: Creative Decisions and Design. The SBL implementation was conducted with the entire cohort of the summer 2025 session of ME 2110 at Georgia Tech, which had an enrollment of 18 students. Participation was voluntary, with no influence on course grades. A total of 10 students participated in the study, 8 men and 2 women, yielding a 55.6% response rate. The sole inclusion criterion was enrollment in this specific scenario-based iteration of the course. While the sample size limits statistical generalizability, it allowed for in-depth analysis, aligning with Bloom's Taxonomy, of the student experience, which was the goal of this exploratory study.

5.2 Data Collection: Post-Semester Micro-Survey and Interview

Following IRB approval of study design and instruments, students were included in the study. Data was collected via a two-part process. First, a brief micro-survey was administered via Qualtrics to gather data on students' prior experience with engineering design and scenario-based courses, Likert-scale ratings of their experience (e.g., "on a scale of 1-5, how would you rank your enjoyment of the course?"), and their recommendation for continuing the scenario-based approach.

Following the survey, semi-structured interviews were conducted to allow for an in-depth exploration of student experiences. The interviews, which lasted 15-20 minutes, were conducted one-on-one by the course Graduate Teaching Assistant (GTA) in a quiet campus location and were audio-recorded with consent. The interview guide included open-ended questions designed with alignment to Bloom's Taxonomy to encourage metacognition and probe the relationship between the scenario and course learning objectives, particularly regarding communication and design decision-making tools. The interview protocol was explicitly designed to elicit metacognitive reflection and language indicative of different levels of cognitive engagement, as defined by Bloom's Taxonomy. Sample questions included:

- "In what ways did the scenario affect your decision-making during the course?"
- "How did the scenario affect the way you developed content for your communication deliverables?"

- “Can you talk about how you used the scenario, if at all, to argue for your engineering decisions?”

All interviews were audio-recorded, transcribed, and anonymized prior to analysis.

5.3 Data Analysis: A Deductive Thematic Approach Using a Priori Codes

We employed a convergent mixed-methods analysis. The micro-survey data was analyzed using descriptive statistics (averages, standard deviations, percentages) to identify trends. We employed a deductive thematic analysis, using Bloom’s Taxonomy as a priori codes to analyze cognitive engagement.

Table 2: A Priori Codes and Linguistic Indicators

Bloom Level	**Operational Definition (Codebook)**	**Linguistic Indicators**	**Exclusion Criteria**
Apply	Execution of procedure without reference to stakeholder reasoning	“we had to…”, “we marked…”, “we used…”	Tangent discourse
Evaluate	Explicit justification using criteria, tradeoffs, or stakeholder needs	“because…”, “it made more sense given…”, “harder to justify…”	Pure procedural description
Create	Synthesis across constraints resulting in reframing or new understanding	Reflection on changing design logic, reconceptualizing purpose	Isolated evaluation without synthesis

Coding was conducted examining the linguistic intent of student statements, with each segment of participant discourse evaluated for evidence of procedural execution, justification, or synthesis. A detailed codebook defined each Bloom level through explicit linguistic indicators. “Apply” was assigned to statements describing procedural execution of tools without justification (e.g., “You had to… mark it on the morphological chart,” P1). “Evaluate” was assigned when participants invoked criteria, trade-offs, or stakeholder priorities to justify decisions (e.g., “It was more about convincing someone… our documents became argumentative in nature,” P9). “Create” was reserved for instances in which participants synthesized multiple constraints to articulate a reframed design logic or new understanding of the process (e.g., “That’s definitely one thing I learned—how different factors cause your original design to change over time,” P4). Multiple codes were permitted within a single transcript. Dominant cognitive orientation for each participant was determined based on the frequency and salience of coded segments.

Interview transcripts were coded using a structured, deductive process. In Cycle 1, the GTA independently coded transcripts using the Bloom-based codebook. In Cycle 2, the instructional research team reviewed coded excerpts, discussed discrepancies, refined definitions, and reached full consensus on coding assignments. This process emphasized alignment between operational definitions and textual evidence.

5.4 Positionality Statement

The authors recognize their dual roles as both instructors and researchers. As the architects of the “Burdell, Inc.” scenario, we held a vested interest in its success. To mitigate potential bias, the coding process relied on a structured, consensus-based approach grounded in the explicit framework of Bloom's Taxonomy, ensuring that the analysis reflected students' expressed experiences rather than the instructors' aspirations.

Bloom's Taxonomy was used as a structured heuristic to categorize metacognitive stance rather than as a comprehensive model of design cognition. We acknowledge that design reasoning is nonlinear and iterative; Bloom's was selected for its interpretive clarity in distinguishing procedural execution from justificatory synthesis within participant discourse.

6. Findings: A Dichotomy in Cognitive Engagement

Our mixed-methods approach revealed a clear dichotomy in student outcomes, demonstrating that the cognitive benefits of SBL are not universal but are mediated by psychological buy-in. This split is evident in both the quantitative survey data and the qualitative cognitive coding.

6.1 Quantitative Perceptions: A Divided Cohort

The micro-survey results signaled a division in the classroom. While most students (70%) recommended continuing the SBL approach, a minority (30%) did not. This split is mirrored in the Likert-scale data:

- **Scenario Effect:** The average rating for how the scenario affected enjoyment was 3.1 (σ=1.1), and for engagement was 3.3 (σ=0.8). The standard deviations indicate a wide spread of opinions, confirming that the intervention was not uniformly received.
- **Contrasting Views:** Participants 2 and 10, for instance, rated the scenario's effect on their enjoyment as "2," while Participant 9 rated it a "5." This quantitative divide foreshadowed the stark qualitative dichotomy we discovered.

6.2 Qualitative Dichotomy: "Designers" vs. "Builders"

Analysis of interview transcripts crystallized a divide into two distinct cohorts: the "Designers," who bought into the scenario and operated at higher cognitive levels, and the "Builders," who rejected it and remained at the *apply* level.

Cohort 1: The "Designers" (Cognitive Level: Evaluate/Create)

These students used the SBL framework as a source of authentic constraints and validation. Their language is characterized by justification, argumentation, and synthesis, placing their work within the professional narrative of "Burdell, Inc."

- **Justifying with Stakeholder Needs (Evaluate):** Participant 8 demonstrated evaluation by critically analyzing stakeholder interviews to build appropriate justification: *"If you look closely, none of them actually said they wanted to provide power or remove debris... But they did say they wanted to save lives... That made it easier for us to argue why we chose to do the pet rescue... If we had chosen bridges or debris, it would've been harder to justify."*
- **Adopting a Professional Ethos (Evaluate):** Participant 1 internalized the role of a professional engineer, stating, "*[The scenario] probably helped my understanding [of the HOQ] a little bit, because I kind of humbled myself and be like, okay, this isn't why I think it's important; what I think it's important, it's the most difficult task. I had to go off of what the stakeholders thought was important, and so I really needed to be objective*

here, not just go to the stakeholders, but that's the real world, so I don't agree with them."

- **Synthesizing Process and Purpose (Create):** Participant 9 showed evidence of creation by synthesizing their experience into a new understanding of the design process itself: *"It was more about convincing someone—so most of our documents became argumentative in nature. And I think that's a good thing. I also realized it's okay to argue with your boss or stakeholders—it's part of the job."*

Cohort 2: The "Builders" (Cognitive Level: Apply/Understand)
Conversely, students who resisted the scenario described their work in functional, decontextualized terms. They viewed the competition as the only "real" context and the scenario as an artificial layer on top of it. They viewed the design tools as procedural hurdles and the professional narrative as irrelevant "hoopla," with the competition's scoreboard as their only true stakeholder. This mindset is perfectly encapsulated by Participant 2, who articulated a purely competition-centric view:

> *I think the House of Quality in this case for us literally did nothing... It was never about the stakeholders. The only stakeholder requirements that mattered were limitations on electronics and sizing... Obviously, those things—it was kind of just a lot of hoopla stuff... The thing that ended up being so important was speed, just because the way the format is laid out—if you don't get to the puppies immediately, you're done. You're done. So that was pretty much the only requirement that—actually—but I don't even think that was a stakeholder requirement. I just think that was kind of a competition thing.*

This quote is a direct manifestation of cognitive engagement at the *apply* level. The student is focused on executing the necessary steps to win points ("speed" "get to the puppies"). The systematic design tools ("House of Quality") are dismissed as irrelevant "hoopla" because they do not serve the perceived primary goal: victory. The stakeholder needs are explicitly rejected in favor of the "competition thing," demonstrating a clear lack of buy-in to the professional scenario.

Participant 3 also rejected scenario buy-in. This participant's responses illustrate cognitive stasis at Bloom's lower to mid-tier levels.

- **Focus on Procedural Application (Apply):** Participant 3 described how design tools were dismissed from consideration: "*Our team didn't really touch [the HOQ] after we made it, because it didn't affect how we geared our design toward trying to win the competition."*
- **Struggling with Cognitive Dissonance (Understand):** Participant 3 articulated the core tension but could not synthesize the two worlds, remaining in a state of conflict: *"It was confusing. We were writing as if we were building a prototype for Burdell and Stormhaven, but we were actually building a robot for a competition. They're related, but not one-to-one. So, it was hard to figure out what we were really supposed to write."* This student is evaluating the *situation* but not using the scenario to evaluate their *design*.

The "Builder" orientation is reinforced by a set of cognitive biases that predictably emerge in competitive, time-pressured environments, such as confirmation bias, risk-aversion, availability heuristic prioritizing highly visible competition tasks, and sunk cost fallacy. Despite the learning objectives of the course (subtitled “Creative Decisions and Design”), it is rare to find students in this cohort engaging in a truly open-ended, systematic design process. -pressured environments, such as confirmation bias, risk-aversion, availability heuristic prioritizing highly visible competition tasks, and sunk cost fallacy. Despite the learning objectives of the course (“Creative Decisions and Design”), it is rare to find students in this cohort engaging in a truly open-ended, systematic design process.

By contrast, “Designers” demonstrate the cognitive leap that counters these biases and allows engagement at the higher Bloom’s levels of *evaluate* and *create*. This cohort is more likely to frame prototypes as inquiry tools for generating decision critical information, not just as deliverables. “Designers” were also able to make a stronger defense of design decisions by tying them back explicitly to customer requirements such as “number of puppy lives saved.” This demonstrates that psychological buy-in to the scenario is not a superficial preference but the mechanism that enables students to transcend a competition-centric mindset and engage in authentic design reasoning.-critical information, not just as deliverables. “Designers” were also able to make a stronger defense of design decisions by tying them back explicitly to customer requirements such as “number of

6.3 Corroborating Evidence from Mixed-Methods Triangulation
Answers from the survey corroborates the binary interview divide. Students we classified as “Designers” (P1, P5, P7, P8, P9) consistently reported that the scenario positively affected their decision-making and recommended its continued use. Those we classified as “Builders” (P2, P3, P10) were more likely to report “No” or “Somewhat” to these questions, confirming their disconnect from the SBL framework.[1]

7. Discussion: Explaining the Gap—From “Unconscious Incompetence” to “Conscious Competence”

The dichotomy between “Designers” and “Builders” provides an answer to our research question: the efficacy of Scenario-Based Learning in fostering higher-order cognitive engagement is not inherent to the scenario itself but is fundamentally mediated by the student’s psychological buy-in, which can be heavily affected when use in conjunction with Competition-Based Learning. This finding explains the variable success of SBL noted in the literature; it is not a uniformly effective pedagogical tool, but a powerful catalyst whose effect depends on a key reaction condition—the learner’s willingness to enter the fictional world. Our data demonstrates that buy-in, even if qualified, is the crucial mechanism that allows the SBL framework to re-contextualize the design process, insulating core learning objectives from the competition’s potent, yet often pedagogically reductive, appeal.

The language of the “Builders” and “Designers” maps directly onto the cognitive and psychological frameworks we established. The “Builders” saw the design tools as discrete tasks rather than integral components of a professional logic. This explains a common instructor observation of a “lack of creativity” in the course; students operating at the *apply* level are executing and adapting, not synthesizing something novel. Their poor logical justification in

[1] Participants 5 and 6 were outliers whose responses were self-contradicting—such as stating that they did not learn the design tools but later describing their correct use—and were therefore not included in either group.

reports is a direct result of not having engaged in the creative, trade-off reasoning that the tools are meant to support. Conversely, the “Designers” consistently demonstrated *evaluate* and *create* levels of thinking. They were not just building; they were designing creatively and could therefore justify logically.

7.1 Interpreting the Dichotomy Through an Integrated Lens

The language of the “Builders” and “Designers” maps directly onto the cognitive and psychological frameworks we established. The “Builders,” such as Participant 2 who dismissed systematic tools as “a lot of hoopla stuff,” were operating firmly within the *apply* level of Bloom’s Taxonomy. Their goal was the correct execution of steps to achieve a functional outcome: winning. They saw the design tools as discrete tasks rather than integral components of a professional logic.

Conversely, the “Designers” consistently demonstrated *evaluate* and *create* levels of thinking. Participants 8 and 9, for instance, did not just use tools; they wielded them rhetorically to “argue” and “convince,” synthesizing stakeholder needs into a coherent, justified design solution. This cognitive shift from application to creation and evaluation is the fundamental marker of the course’s desired learning outcomes.

This cognitive journey is best explained by the parallel psychological progression through the Conscious Competence model. The “Builders” largely remained in a state of unconscious incompetence regarding the systematic design process. The competition’s compelling, simplified narrative (win/lose) never created the cognitive dissonance required for them to realize that “building” was an incomplete version of “designing.” Because they did not buy into the professional frame, they never felt the inadequacy of their competition-centric approach. The “hoopla” was, to them, genuinely irrelevant.

The “Designers,” however, were successfully nudged into conscious incompetence by the SBL framework. The scenario, with its stakeholder interviews and supervisor avatars, made the complexities of professional practice tangible. It created a situation where simply building a functional robot was insufficient; they had to *explain and justify* their choices to a manager or client. This discomfort, as evidenced by Participant 1’s statement about having to “humble myself” and use “what the stakeholders thought was important,” catalyzed their engagement with the design tools, moving them deliberately toward Conscious Competence. They began to use the tools with an understanding of their purpose within a professional system.

7.2 The Catalyst of Buy-In and the Shield of Situated Cognition

The pivotal element that determined which path a student took was psychological buy-in. Buy-in is the catalyst that allows the situated context of the SBL to trigger the transition from unconscious application to conscious creation. It is the student’s voluntary acceptance of the scenario’s “rules of the game,” which in turn allows the principles of situated cognition to take hold.

The table below synthesizes this entire process, illustrating how buy-in enables the SBL context to facilitate a cognitive ascent through Bloom’s Taxonomy, as students progress psychologically toward competence.

Table 3: Manifestations of the "Builder" and "Designer" Mindsets as Student Evidence Aligned with the Theoretical Framework

Psychological Stage	**Pedagogical Catalyst (Situated Cognition in "Burdell, Inc.")**	**Manifestation in Student Language & Action**	**Corresponding Bloom's Level & Cognitive Engagement**
Unconscious Incompetence (The "Builder")	Scenario is rejected; competition remains the dominant, "authentic" context.	"The House of Quality... literally did nothing. It was a lot of hoopla stuff." (P2)	**Apply** – Focus on executing steps to win.
Conscious Incompetence (The Trigger)	The scenario introduces authentic stakes, revealing the gap between "building" and "designing."	"I had to go off of what the stakeholders thought was important... I really needed the objective here." (P1)	**Understand /Analyze** – Recognizing the value and purpose of the process.
Conscious Competence (The "Designer")	Legitimate peripheral participation: Using design tools to meet explicit stakeholder demands and justify decisions.	"If we had chosen bridges... it would've been harder to justify." (P8)	**Evaluate** – Making judgments based on criteria from the scenario.
Towards Unconscious Competence (The Engineer)	Construction of a professional identity through authentic activity and argumentation.	"Our documents became argumentative... it's okay to argue with your boss... it's part of the job." (P9)	**Create** – Synthesizing a professional ethos and justified solution.

For students who bought in, the "Burdell, Inc." scenario functioned as a **pedagogical container**. We define this as a learning framework that manages (rather than eliminates) the tension between extrinsic motivators (like a competition) and intrinsic learning goals. It makes the "why" behind the process visible by providing an authentic, alternative context for action. Even the "Designers" felt the pull of the competition and voiced their frustration in the interviews, but the container gave them a professional framework to understand why they were doing more than just building to win. This tension was not abstract; it was felt acutely by students, even those who understood the pedagogical value. As Participant 7 summarized: *"I see the intention—helping us design in a way similar to Capstone. In terms of learning, it was helpful. But for the competition, it was a huge distraction... So, helpful for learning, hurtful for competing."* This quote captures the cognitive conflict at the heart of our intervention. The "Designers" were those who accepted this trade-off, valuing the learning despite the competitive distraction. The "Builders," in contrast, sought to minimize the distraction to focus solely on winning. The container's success, therefore, is not measured by the absence of this feeling, but by its ability to make the 'helpful for learning' outcome compelling enough to justify the friction.

8. Implications and Recommendations for Practice

This study complicates the findings of scholars such as Newstetter [1], who concluded that students in this very course were "unmotivated for scenario-based learning." Our results suggest they were not universally unmotivated; rather, motivation was bifurcated by competing forces. The "Builders" align with Newstetter's observation, but the "Designers" represent a cohort for whom the scenario was profoundly motivating and cognitively transformative. The difference lies in the intervening variable of buy-in. The variability of buy-in is not necessarily among the students but could also arise from the instructors taking a proactive role in simulating the scenario and bringing it to life. For example, providing feedback while roleplaying as a specific stakeholder during interactive lab/studio discussion sessions. Past research [2] [33] into utilizing avatars for communications' training also suggests that the scenarios based on avatars are more effective when instructors and TAs emulate the avatars while providing feedback on student deliverables/assignments. Furthermore, our findings provide empirical evidence for the theoretical claims in the literature regarding the importance of authenticity and "delight" [14]. The "hoopla" quote is the antithesis of delight—a clear signal of a failed buy-in—whereas the "argumentative nature" quote exemplifies a student who found professional meaning and engagement in the scenario.

Figure 4 Photo from the final competition showing an external invited judge roleplaying as the Design Supervisor (Jon).

Figure 5 Photo from the final competition showing a Teaching Assistant (in Yellow Polo shirt) roleplaying as the Intern Supervisor (Kim

The dichotomy between "Designers" and "Builders," mediated by psychological buy-in, moves beyond a theoretical diagnosis to offer concrete guidance for engineering educators. The core implication is that a competition cannot be left pedagogically uncontained. Its potent extrinsic motivation will inevitably dominate, often at the expense of more nuanced learning objectives. A robust SBL framework is not a decorative narrative add-on; it is the essential structure of a pedagogical container that manages this tension, making the systematic design process necessary and meaningful. The primary goal of implementation, therefore, must be to strategically engineer psychological buy-in. Based on our findings of what succeeded and what failed in the "Burdell, Inc." intervention, we propose the following actionable strategies for practitioners.

8.1. Make the Professional Narrative Inescapable through Structural Integration.
Merely setting a scenario is insufficient. To compel engagement from reluctant "Builders," the professional narrative must be structurally embedded into the course workflow.

Action: Implement graded "professional compliance audits." These are quick, targeted checks where students must explicitly link a design decision to a specific stakeholder need from the scenario, using a course tool (e.g., "Cite which stakeholder priority from the transcript justifies your choice of actuator in your morphological chart.").
Rationale: This forces the cognitive act of justification for all students, not just the willing "Designers." It makes the scenario a functional gatekeeper to progress, moving it from the periphery to the core of the student's workflow.

8.2. Induce "Conscious Incompetence" through Authentic Feedback.
Buy-in is catalyzed when students realize their current approach is inadequate for the professional context. Instructors must act as catalysts for this realization.

Action: Use the scenario to provide formative feedback in character. The "supervisor" (instructor/GTA) should challenge design proposals not on competition rules, but on engineering requirements derived from the scenario: "Your proposed design is fast acting, but your report does not justify its cost against the town's budget constraints. Please revise your decision matrix to reflect this."
Rationale: This directly creates the "Conscious Incompetence" that triggers the journey toward professional competence. It teaches students that in this course, "engineering" is not synonymous with "winning"; a design must also be "justifiable."

8.3. Radically Align Assessment with the Professional Narrative.
The decoupling of the final grade from competition performance was a critical first step.

Action: Make professional design deliverables the primary basis for the course grade. These should require students to curate their work (e.g., HOQ, prototyping logs, reports, engineering drawings) and explain how they synthesized stakeholder needs, constraints, and analysis to arrive at their final design.
Rationale: This directly assesses and values the cognitive processes of *evaluate* and *create*. It signals that the course is about documenting and defending an engineering logic, not just submitting a winning machine. The competition becomes a testbed for the design, not the objective of the course.

8.4. Foster Buy-In through a Meta-Discussion on Pedagogical Tension.
Instead of letting students grumble about the "hoopla" in isolation, address the pedagogical design head-on to legitimize the struggle.

Action: In the first week, explicitly state: "There is a deliberate tension in this course between the competition and the professional scenario. The competition is here for excitement, hands-on learning, and fun. The "Burdell, Inc." scenario is here to teach you how to think, justify, and communicate like a professional engineer. Your challenge is to learn to succeed at both."

Rationale: This transparency reduces resistance by framing the scenario not as arbitrary academic overhead, but as a deliberate simulation of professional practice. It validates the students' feeling of friction while channeling it toward a productive purpose, thereby preemptively building buy-in.

8.5 Looking Forward: Navigating the Line Between Containment and Confinement

Our findings demonstrate that an SBL framework can function as an effective pedagogical container, managing the tension between competition and learning. However, our data also reveals a critical design challenge: for a significant number of students, this "container" was perceived not as a guiding structure, but as a confining one. The very friction that catalyzed learning for the "Designers" generated frustration and resistance for the "Builders."

This frustration was most acute where the professional narrative of "Burdell, Inc." and the physical reality of the competition stage diverged. Despite our efforts to reskin all tasks and objectives to fit the Stormhaven narrative, students consistently struggled with any discrepancy. The fictional stakes of a coastal town could not perfectly map onto the literal, physical tasks of moving objects on a competition track. This points to a fundamental principle for future implementations: the most effective pedagogical container is a seamless one. The goal is to minimize arbitrary dissonance so that the cognitive effort is spent navigating authentic, professional tensions (e.g., budget vs. performance), not reconciling a flawed simulation. Therefore, we propose a strategic goal for curriculum design:

> **The ideal is to design the competition from the scenario, not the scenario onto the competition.**

In an ideal setting with ample resources, educators would first solidify a compelling, authentic professional scenario. The competition's rules, field, and objectives would then be derived directly from that scenario's core problems, ensuring a "one-to-one" mapping where winning feels synonymous with satisfying the client's needs.

However, we recognize this is often pedagogically ideal but logistically impractical. Like many institutions, our course relies on complicated and expensive competition stages that cannot be redesigned from scratch each year. For practitioners in this common situation, the imperative shifts from achieving a perfect map to strategically managing the mismatch. This involves:

1. **Anticipating Dissonance:** Proactively identifying where the scenario and competition rules will conflict (e.g., a stakeholder's nuanced priority vs. a game's simple point structure).
2. **Addressing it in the Meta-Discussion:** Explicitly discussing these known discrepancies with students as examples of real-world design constraints. Frame them not as failures of the simulation, but as analogous to the inevitable compromises engineers make between ideal client solutions and practical and regulatory limitations or as the often-needed scoping of a prototype from a full-scale device.

By openly acknowledging and reframing these friction points, educators can transform a logistical constraint into a teachable moment about professional practice, thereby strengthening the pedagogical container even when it cannot be made perfectly seamless.

8.6 Reflections from Fall 2025 Integrations

Summer 2025 informed the creation of Fall 2025's scenario. Typically, the course uses a popular culture text to theme the competition, such as *Lord of the Rings* and *Star Wars*. In Fall 2025, *How to Train Your Dragon* was chosen. The goal of the Summer 2025 implementation of ME 2110 which included an authentic scenario-based problem framing was to allow students to evaluate design requirements based on plausible customer needs. The thematic framing historically serves to build student engagement and enthusiasm for the competition but does not meaningfully inform student design decisions other than through arbitrary points assigned to each task. With the goal of adding a relatable customer within the context of a pop culture thematic framing, this led to the development in Fall 2025 of a simple story based around *How to Train Your Dragon*, where the students are competing to become "chief engineers of Berk," the island where the movies take place. Each task was developed with a specific audience in mind, being the different artisans or dragons on the island, so that when generating design tools, the students can directly connect everything their robot does to serving a specific purpose for the island.

Though no direct data was gathered, anecdotally, the design tools such as the house of quality were much better understood by the students, because they had explicit audiences to insert as customers. In previous semesters, the students had to essentially make up customers for their robot themselves, as there was no reason for the robot to be built besides getting a grade for the course. With the tasks being specifically designed for a customer, the students were able to readily integrate them into their design choices.

While Summer 2025 students were reluctant to role-play within the scenario, Fall 2025 semester (with a pop-culture-based scenario) students seemed to be more willing to role-play, as their suspension of disbelief was much easier to achieve. When students are pretending to be fictional Vikings that ride dragons, a "sillier" scenario as depicted in Figure 6, they are much more likely to ignore any irregularities in the scenario. For example, during the summer implementation, the students questioned the scale of the competition stage, and the budget for the robot, because if they are role-playing as real engineers for a real city government, it didn't make sense. In the Fall scenario, questions like these were incredibly uncommon, even though the technology used to build robots wouldn't be possible in the Viking setting.

Figure 6 Photo from the final competition of the Fall 2025 semester class.

9. Conclusion

This study began with a problem familiar to many engineering educators: the student who dismisses systematic design as "a lot of hoopla stuff" in the single-minded pursuit of getting their hands on tools and acquiring competition points. We argued that this represents more than just a preference for building over documenting; it signifies a fundamental cognitive gap between the lower-order thinking of *application* and the higher-order processes of *creation* and *evaluation* essential to learning how to be a professional engineer. Our investigation into the "Burdell, Inc." Scenario-Based Learning intervention demonstrates that this gap is not inevitable, but its bridging is not guaranteed by the scenario alone.

The stark dichotomy between "Designers" and "Builders" reveals that the pivotal factor is psychological buy-in. Buy-in is the crucial catalyst that transforms an SBL framework from a decorative narrative into a powerful pedagogical container. This container does not eliminate the energy of the competition but can successfully manage its tension, creating a context where the tools of the trade become necessary instruments for logical justification rather than academic exercises. For students who bought in, the scenario induced a state of conscious incompetence, compelling them to "humble themselves" to stakeholder needs and catalyzing a cognitive journey toward conscious competence in systematic design. They learned to argue, justify, and synthesize—to design, not just build. This exploratory study is limited by its small, voluntary sample and reliance on self-reported metacognitive reflection. Future work should incorporate artifact analysis and longitudinal measures to triangulate these findings and complicate use of Bloom's Taxonomy with broader understandings of design cognition.

Given the current research, we conclude that the primary challenge in using competitions is not their existence, but their containment. The key to mitigating their pedagogical drawbacks lies in deliberately engineering SBL experiences that foster the psychological buy-in required for this cognitive shift. By making the professional narrative inescapable, aligning assessment with process, and transparently embracing the inherent tension, educators can construct robust pedagogical containers. These containers ensure that competitions serve as engaging testbeds for learning, rather than reductive endpoints that subvert it. Moving students "beyond hoopla" is not about stripping away the fun of competition but about enriching it with the deeper purpose and professional identity of an engineer. This is how we bridge the pervasive gap between student perception and the practice of developing professional engineering logic.

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Appendix 1 – Thematic Call for Proposals introducing the Fictional Design Scenario

In this example, the competition is situated within the context of an authentic need through the framing device of a Call for Proposals from the fictional town of Stormhaven, Coralina.

CITY OF STORMHAVEN

CALL FOR PROPOSALS

To : **Engineering Firms**

From : **City of Stormhaven, Coralina**

Date : **May, 15 2025**

Subject : **Call for Proposals: Autonomous Machine for Disaster Relief and Recovery**

Background
The City of Stormhaven, Coralina is highly vulnerable to hurricanes and flooding due to its coastal location. Environmental scientists have predicted an increased likelihood of severe weather events in the near future, necessitating proactive measures to ensure the safety and resilience of our community.

We are seeking solutions from engineering firms to design and develop an autonomous machine capable of assisting in disaster relief and recovery efforts for an identified location we expect to be unreachable to emergency responders. This machine will play a critical role in mitigating the impact of hurricanes and flooding, ensuring the safety of our residents in high risk areas, and supporting the rapid recovery of our infrastructure and economy.

Project Objectives
The autonomous machine must be designed to perform the following tasks in a disaster-affected area:

1. **Navigate Flooded Zones:** Safely traverse areas with standing water and debris.
2. **Clear Debris:** Remove or relocate obstacles to restore access to critical areas.
3. **Rescue Pets:** Safely retrieve animals in areas trapped by flooding.
4. **Deliver Relief Supplies:** Transport essential items (e.g., food, water, medical supplies) to designated drop-off points.
5. **Restore Power:** Deliver and install power components to restore electricity in affected areas.

The machine must be autonomous or semi-autonomous, with the ability to operate in challenging and dynamic environments.

Stakeholder Requirements
The design must address the needs and constraints of the following stakeholders:

6. **Emergency Response Teams:**
   - Priority: Speed, reliability, and safety.
   - Tasks: Clearing debris, restoring power, and ensuring access to affected areas.
7. **City Planners:**
   - Priority: Cost-effectiveness, scalability, and integration with existing infrastructure.
   - Tasks: Ensuring the machine can be deployed across multiple disaster zones.
8. **Environmental Engineers:**
   - Priority: Eco-friendliness and minimal environmental impact.
   - Tasks: Using sustainable materials and avoiding harm to natural ecosystems.
9. **Community Leaders:**
   - Priority: Cultural sensitivity, accessibility, and community safety.
   - Tasks: Ensuring the machine is easy to use and respects local customs.
10. **Local Business Owners:**
    - Priority: Timely delivery of goods and minimal disruption to business operations.
    - Tasks: Delivering relief packages and rescuing pets to ensure business continuity.

page 1 of 3

Jon did not include page two of the CFP because it has information not needed by the intern team.

APPENDIX

Figure 1: An AI rendering of the area after being hit by a Category 4 hurricane. Image point of view is from the perspective in which the needed machine would be placed. The machine needs to be able to clear debris to reach the hill and restore power and rescue residents.

Appendix 2 – Scenario-Based Learning Framing using Audience Avatars

Design deliverables were presented to students using framing devices such as email from the Scenario-Based supervisory stakeholders.

Team – Sprint 1 Stand-Up

Kim Jones,
Intern Supervisor
Burdell Inc.

Kim oversees day-to-day project progress across multiple intern teams at Burdell Inc., ensuring that engineering communication remains clear, professional, and decision-oriented. In this role, she expects teams to operate with autonomy, strategically delegate tasks, and communicate project status with both precision and foresight. Kim reviews stand-up presentations and accompanying handouts to ensure that teams are identifying meaningful next steps, justifying design directions, and making appropriate requests for support or resources.

Stand-Up Meeting Preparation – Automated Disaster Relief System

Zoom

Stand-Up Meeting Preparation – Automated Disaster Relief System

From: kim.jones@burdell.com
To: interns@list.burdell.com

Please prepare an **6-minute** presentation, including visuals, for our meeting with Jon and other stakeholders on the 24th of June. Expect 6 minutes or so of Q&A and feedback after your presentation. This presentation will highlight your unique concept development, documentation, and systematic evaluation of concepts. The goal of this presentation is to identify the best ideas to invest time into for further prototyping.

Please cover the following areas:

1. **Concept Development:** Make an argument for the effectiveness of your design solutions, using design tools as evidence. Explain your process and rationale, emphasizing how these tools sparked creativity while addressing the project's Problem Statement.
2. **Concept Evaluation Tools:** Describe how you ranked concepts using a Pugh Matrix or another systematic evaluation tool. Be sure to connect criteria from the House of Quality and Specifications Sheet, defending your weighting and consensus-building process.
3. **Prototyping Results:** Analyze the results of your prototyping and formal testing (as recorded in your Prototyping Log).
4. The output of this analysis should be a **Prototyping Plan** which prioritizes the effort of your build efforts between now and Sprint 2.
5. **Budget Enhancement:** Make a clear case for any enhancements required to implement your plan. Ideas that are creative and communicated credibly can receive up to 50% additional allocation in materials budget.

Ensure your content is clear, professional, and evidence-based, referencing design inputs.

1/3

Zoom

Stand-Up Meeting Preparation – Automated Disaster Relief System

When you're asked to present at a stand-up, your role is to give a concise, strategic overview that allows others—especially stakeholders like Jon—to quickly understand where your project stands, what decisions you've made, and what support you may need.

Think of the presentation as a focused update on your progress, priorities, and rationale, not a full report. To support this, please also prepare a **1-page handout** that clearly summarizes key project milestones, current status, next steps, and any projected resource needs. This handout should be easy to scan and serve as a takeaway Jon and others can reference when making decisions about project direction or budget allocation.

Since each team has a different strategic focus, ensure that your team's unique strengths are emphasized, while appropriately acknowledging any potential risks or difficulties inherent to your strategic direction.

Consider the following outline for your handout:

Project Handout Template: Stand-Up Meeting Summary

Team Name:
Project Title:
Date:

Sprint Phase: (e.g., Sprint 1 – Concept Development)

1. Current Focus
Brief sentence or two on your strategic direction and main problem your design addresses.
Example: Our team is developing a modular, ground-deployed relief unit focused on rapid water delivery and structural adaptability.

2. Key Activities Completed
Use a bulleted list to note specific tools/milestones completed.

3. Key Findings / Insights
What did you learn that is shaping your next steps?

4. Next Steps / Prototyping Plan
What is your team doing next, and why?

Zoom

Stand-Up Meeting Preparation – Automated Disaster Relief System

5. Requests / Resource Needs
List any requests for materials, budget increases, or support (optional).

- Request up to 50% increase to prototyping materials to build full-scale base
- Seeking advice on compatibility between control board and updated actuator

Thank you for your hard work. We look forward to your insights!

Best regards,
Kim

Appendix 3 – Stakeholder Interview Transcripts

Students were given the opportunity to ask questions of fictional stakeholders. The transcripts below were provided as Voice of the Customer artifacts to inform student problem definition activities.

CLIENT DISCOVERY: STORMHAVEN STAKEHOLDER TRANSCRIPTS

INTERVIEWER
JON FOX

PROJECT
STORMHAVEN AUTONOMOUS DISASTER RELIEF MACHINE

STAKEHOLDERS
- MARCUS TAYLOR, FIELD LEAD, METRO EMERGENCY RESPONSE TEAM
- KAREN LIU, DIRECTOR OF CITY PLANNING, STORMHAVEN
- DR. ALEJANDRA MORALES, ENVIRONMENTAL ENGINEER, SOUTHEAST REGIONAL WATERSHED COUNCIL
- TONY CALDERON, OWNER OF CALDERON'S NEIGHBORHOOD MARKET

BURDELL, INC.
DESIGN DIVISION

Stakeholder Interview Transcript #1 – First Responder

Name: Marcus Taylor
Role: Field Lead, Stormhaven Metro Emergency Response Team

Jon: Thanks for taking the time to speak with us today, Marcus. We know your input is critical for understanding how the Automated Disaster Relief System might be deployed in the field. Can you start by describing a typical scenario where you'd envision using this kind of system?
Marcus: Sure. So, imagine a hurricane response—trees down, power lines snapping, floodwaters rising. We've got about 10 minutes to assess a neighborhood and decide whether to stay, evacuate, or split our team. Right now, it's all boots on the ground. We need a system that could deploy quickly.

Jon: What would be most important in terms of how that system works?
Marcus: Simplicity. It needs to be autonomous. I don't have time to monitor a robot while I'm pulling people out of a building. If it takes more than one person to get it moving or if we have to babysit it, it's not useful. Ideally, I'd deploy it, turn it on, and go back to triage. It should run itself.

Jon: Got it. Are there particular features or functions you'd prioritize?
Marcus: Movement's a big one. It has to navigate debris—curbs, mud, even stairs if possible. And it shouldn't tip over if it hits a branch or uneven pavement. Also, noise is something to think about. Too loud and it creates panic. Especially at night, when survivors are already disoriented. Something quiet and low-profile is better.

Jon: That's helpful. And what about durability or environmental concerns?
Marcus: It's going to get knocked around. I don't need it to last forever, but it should survive a couple of hits and maybe a few deployments without falling apart. And don't give me something that needs special tools to fix in the field.

Jon: Understood. Any deal-breakers?
Marcus: Yeah, complexity. If you build something brilliant but fragile, it'll just end up unused.

Jon: I'd like to ask about task prioritization. In your experience, are there certain responsibilities that should be addressed first over others when the ADRS is deployed?
Marcus: Absolutely. Life safety comes first, always. If your system can help locate people trapped or unconscious, that's priority number one. Even just flagging movement in an area we haven't searched yet—that's huge. After that, things like delivering medical supplies or helping establish communication links move up the list.

Jon: So search and rescue first, followed by supply and coordination?
Marcus: Exactly. Time is everything in the first few hours. A person with a crushed leg might survive if we reach them within an hour—but not if we're focused on food drops. That stuff matters too, but it comes second to locating survivors. Even just accelerating the sweep process would be a game-changer.

Jon: That's really helpful. One more area I wanted to ask about—pets. Are there any special considerations we should be aware of for how animals should be handled?
Marcus: Oh, yeah. You'd be surprised how often people risk their lives for their pets. If they see a drone or robot coming down the street and it can't—or won't—help their dog or cat, they'll ignore the robot and try to handle things themselves. That's how we end up with second rescues.

Jon: So the system should be pet-aware?
Marcus: At the very least, don't spook them. Quiet movement, no sudden loud noises or flashing lights. Ideally, you'd have a compartment where small animals could be placed—something secure but ventilated. And label it clearly so responders know it's safe for animals. It doesn't have to carry them far, but just getting them out of a flooded building buys us time and cooperation.

Jon: That's a great point. Anything else we might overlook?
Marcus: Just don't underestimate how emotionally charged these scenes are. If your system can handle one or two emotional pain points—like helping someone's injured pet or bringing a bottle of water to a kid stuck in a car—it'll earn trust fast. That trust can make the whole response go smoother.

Stakeholder Interview Transcript #2 – City Planner, Procurement & Logistics

Name: Karen Liu
Role: Director of City Planning, Stormhaven

Jon: Thanks for speaking with me, Karen. I know you've been working closely on city logistics for years. When you think about a system like the ADRS, what are your first concerns from a city planning perspective?
Karen: Honestly? Storage, maintenance, and lifecycle cost. We're not just buying a one-off tool. If we're investing public funds, we need to know this thing can sit in a warehouse for six months, deploy with short notice, and come back in good enough shape that we can use it again. And if we need more of them to cover different districts, unit cost really matters.

Jon: So initial price point and maintenance costs?
Karen: Exactly. I'm not just thinking about what it costs to buy—I'm thinking about how much it'll cost us to store, repair, and operate over five years. Batteries, sensors, moving parts—they all need upkeep. And we're short on technical personnel. If it needs specialized calibration or software updates every two weeks, that's a problem.

Jon: That's helpful context. Are there size or handling limitations we should be aware of?
Karen: Definitely. These devices will be stored alongside other emergency gear—generators, water tanks, medical supplies. Space is tight; any device proposals beyond our listed constrains will not be considered.

Jon: What about setup or deployment?
Karen: If it's battery-powered, give me real numbers. "Up to 8 hours" isn't helpful if we only get four in field conditions.

Jon: Any environmental or reliability factors?
Karen: I want to know how many times we can expect it to work without major repair. If it fails in the field once or twice, fine—but if failure is a 1-in-3 chance, we'll stop deploying it. And it can't be brittle in extreme temperatures. This has to survive freezing winters and Gulf Coast summers.

Jon: Understood. Is there anything other stakeholders don't always think about that matters to you?
Karen: Resupply and standardization. If one sensor type fails, can I order a replacement off the shelf, or is it proprietary? I don't want to stock 20 spare parts kits for one device. Keep it simple and interchangeable where you can. That kind of foresight builds trust with planners like me.

Stakeholder Interview Transcript #3 – Environmental Engineer

Name: Dr. Alejandra Morales
Role: Environmental Engineer, Southeast Regional Watershed Council

Jon: Thanks for meeting today, Dr. Morales. We're gathering input to make sure the ADRS doesn't just work—but works responsibly. From your environmental perspective, what do you want us to be thinking about?
Dr. Morales: Well first, thank you for including someone with an environmental lens early on—that's not always the case. When it comes to disaster response, one of our biggest challenges is that short-term urgency often overrides long-term damage. I'd love to see a system that doesn't just do less harm but actively considers its environmental footprint.

Jon: Can you give an example of what that might look like?
Dr. Morales: Sure. Power sourcing is a good place to start. Are you designing this to run on disposable batteries? If so, you've created a logistical waste problem during a crisis. Something rechargeable, with solar-assist or crank-charging options—even if only partial—would be more sustainable and practical in prolonged disasters. Fuel-based systems are almost always a no from us unless they're absolutely unavoidable.

Jon: Got it. And what about materials or components?
Dr. Morales: Use durable materials, but avoid exotic composites or plastics that can't be recycled. And minimize electronics that require rare earths unless you've really justified their inclusion. Devices like this tend to break or be abandoned in the field. You don't want to be responsible for introducing e-waste to sensitive ecological zones.

Jon: Is there a need for the device to interact with the environment in specific ways?
Dr. Morales: Not necessarily interact—but definitely avoid disruption. A lot of post-disaster areas are environmentally fragile. The device shouldn't be dumping heat, oil, or sensor waste. And noise pollution is a real concern. If it's running near wildlife zones or water systems, volume levels matter.

Jon: Last question: any tension you see between environmental priorities and response goals?
Dr. Morales: Always. For example, while I know the city and first responders need help with debris removal, it would be bad environmentally for the machine to create accidental trenches that could trap fish and create mosquito breeding grounds.

Stakeholder Interview Transcript #4 – Local Business Owner (Grocer)

Name: Tony Calderon
Role: Owner of Calderon's Neighborhood Market, Stormhaven's Disaster Relief Goods Partner

Jon: Thanks for making time, Mr. Calderon. I understand your store is part of the city's disaster relief pilot, and you've agreed to help distribute supplies using the new ADRS units?
Tony: That's right. We've got a partnership with the city and the Red Cross. During the last flood, we had people lining up in the parking lot with no way to get perishables more than a few blocks out. We're hoping this system can fill in some of that last-mile gap—especially for folks who can't leave their homes.

Jon: That's helpful. From your perspective, what would make this system most usable?
Tony: It has to be gentle. Most of what we're sending out is food—milk, eggs, medicine, even some dry goods. If it rattles or jostles too much, it's going to arrive broken or ruined. I don't need it to go fast—I need it to go smooth. Think of it like a delivery van for someone with a broken sidewalk and no front porch.

Jon: Got it. Are there other requirements around packaging or setup?
Tony: It should be easy for someone like me—or my cashier—to box and send for deployment. If it needs special crates or tie-downs, that's a barrier. Ideally, we'd just slide in a bin, press "send," and off it goes.

Jon: What about the environment it needs to operate in?
Tony: It's going to leave from paved areas but may end up at houses where the sidewalks are uneven, if they exist at all. Rain, dirt, low visibility—you name it. And we may be sending multiple deliveries back-to-back. If the system needs a long reset or recharge time, that limits how helpful it'll be.

Jon: Last thing—what's your biggest concern?
Tony: Honestly? Community trust. People already worry about fairness—who gets supplies, how much, when. If the system distributes the resources unevenly, some products could spoil that neighbors desperately need.