Case Study: Using Narrative Books to Deepen Conceptual Understanding and Reflection in Civil Engineering Education

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Abstract

Engineering courses often rely on technical textbooks and problem-solving exercises that emphasize analysis and computation. While these materials are essential to developing technical competence, they can leave limited room for students to explore the human, historical, and conceptual dimensions of engineering. This case study describes the use of narrative and non-technical books in an undergraduate civil engineering course to promote conceptual understanding, reflective thinking, and student engagement. The initiative was piloted in the Structural Analysis course, an upper-level course where theoretical understanding is critical but can sometimes feel disconnected from practice. Students were asked to read one chapter per week from a selected narrative book that explores engineering ideas through storytelling, history, or design philosophy rather than formulas. Readings were integrated with weekly course topics, allowing students to connect technical content (such as load paths, design decisions, and professionalism) to real-world applications and societal impact. Survey results indicated strong student agreement regarding relevance to professional practice. Therefore, this study contributes to ongoing discussions in engineering education about humanizing technical curricula, bridging the gap between theory and practice, and developing critical thinking and communication skills.

1 Introduction

Recent discourse in engineering education asserts that technical proficiency alone is insufficient for the modern practitioner; there is a critical mandate to help students bridge the gap between analytical content and professional identity [1, 2]. Specifically, Forte et al. [1] argue that "teaching humanity" is not a secondary concern but a fundamental requirement for developing engineers who can navigate complex, real-world sociotechnical systems. Similarly, the National Academy of Engineering [2] identifies that engineers must possess a "strong sense of ethics" and "social awareness" to meet the challenges of the globalized century. Within this context, narrative-based learning, incorporating storytelling, historical case studies, and reflective writing, is a high-impact strategy to meet these requirements. By engaging students at both the cognitive and affective levels, this approach seeks to humanize the curriculum, moving beyond the "numbers" to foster a deeper understanding of the engineer's role in society.

This study documents the implementation of a narrative reading and reflection activity in an upper-level Structural Analysis course. Structural Analysis is a foundational course in civil engineering curricula that requires students to synthesize mathematical methods, physical intuition, and engineering judgment. Usually, this course covers topics such as determinacy, internal force analysis, deflections, and structural behavior. Instruction in these topics typically relies on technical textbooks, lectures, and problem-solving exercises that emphasize analytical correctness and procedural fluency. While effective for developing calculation skills, research suggests that an over-reliance on "algorithmic" problem-solving can limit opportunities for students to reflect on why structures behave as they do or how design decisions are made in practice [3]. This pedagogical gap is particularly relevant given the ABET Student Outcomes, which require that engineering graduates demonstrate an ability to recognize ethical and professional responsibilities and understand the impact of engineering solutions in global, economic, environmental, and societal contexts [4].

Thus, a narrative reading and reflection activity was introduced as a supplementary component in the Structural Analysis course of the Department of Civil and Environmental Engineering at the Catholic University of America in the United States. This intervention was designed not to replace technical rigor, but to serve as a "conceptual anchor." By situating abstract formulas within the historical and narrative framework, the activity aims to foster situated cognition, the idea that knowledge is best acquired when linked to the social and physical contexts in which it is applied [5]. In summary, the objective of the reading and reflection activity is to enhance conceptual understanding and reflection without compromising analytical rigor.

2 Methodology

The pedagogical intervention in the Structural Analysis course was the integration of a non-technical, narrative-based book on structural engineering and the built environment. The book chosen was "Why Buildings Stand Up" by Mario Salvadori [6] because it emphasizes storytelling, historical examples, engineering successes and failures, and design philosophy rather than equations or formal derivations.

2.1 Narrative Reading Component

Each week, students were assigned a specific chapter intended to align thematically with the world of structural engineering or to serve as a review of fundamental concepts learned in previous courses (such as Statics or Mechanics of Materials).

While the book contains 18 chapters, the instructor selected 10 specific chapters most relevant to the broader goals of a Structural Analysis course. These readings were framed as a conceptual complement to the technical material covered in lectures, providing a "real-world" lens through which to view analytical theories. Table 1 illustrates the mapping between the narrative readings and the corresponding course context or technical topic.

2.2 Reflection Activities

To encourage active engagement, students were assigned a weekly reflection after completing each reading. These reflections emphasized interpretation and articulation in the students' own words rather than mathematical precision. Students were given the flexibility to:

- Share personal insights or reflections on the chapter's narrative.

Salvadori Chapter	Course Focus / Technical Topic	Primary Objective
Ch. 1: Structures	Introduction to Structural Engineering	Establish the "Big Picture" of the Structural Engineering field.
Ch. 3: Loads	Types of Loads & Load Path	Direct Link: Learn different types of loads and identify them.
Ch. 4: Materials	Stress, Strain, & Material Properties	Review: Revisit fundamental concepts from mechanics of materials.
Ch. 5: Beams & Columns	Internal Forces (Shear & Moment)	Direct Link: Physical behavior of beams & columns.
Ch. 6: Houses	Residential Structures	Context: Apply analysis to common, small-scale structures. Learn different types of construction.
Ch. 7: Skyscrapers	Lateral Loads (Wind & Seismic)	Context: Understanding stiffness and drift in tall buildings, and lateral force-resisting systems.
Ch. 9: Bridges	Influence Lines, Moving Loads	Direct Link: Efficiency in span design and load positioning. Context: Different types of bridges.
Ch. 11: Form-Resistant Structures	Slabs, Curved Shapes, and Shells	Context: Learn different types of structures and shapes.
Ch. 17: Message of Structure	The Engineer's Role in Society	Judgment: Synthesizing ethics, aesthetics, and safety.
Afterword	Professional Identity & Future	Synthesis: Reflecting on the "So What?" of a structural career.

Table 1: Alignment of Narrative Chapters with Course Context and Topics

- Research and include information about real-world buildings or problems that align with the chapter's theme.
- Connect the author's stories to concepts learned in prior engineering courses.

The instructor explicitly required these assignments to be **handwritten** rather than typed. This was a deliberate choice to discourage the use of external summary tools (AI or online synopses) and to foster a more personal, deliberate connection to the material.

2.3 Assessment and Grading

The reflection assignments were graded solely on **completion**. The content of the student's reflection did not influence the grade, provided the student demonstrated a sincere attempt to engage with the chapter. This low-stakes grading structure was intentional, designed to create a "safe space" where students could express honest thoughts and explore their burgeoning professional identities without the pressure of technical correctness.

2.4 Student Feedback and Evidence of Engagement

At the end of the course, students were invited to share their thoughts through a survey, providing valuable insights into their feelings about the narrative reading and reflection activities and how these experiences influenced their learning journey. The survey focused on students' conceptual understanding of structural analysis topics, the relevance of the narrative format to real-world engineering practice, and their engagement and motivation in the course. Students were also asked to reflect on whether the readings provided perspectives not typically emphasized in traditional technical textbooks and whether the activity supported critical thinking about structural behavior and design decisions.

The survey items were designed to document student perceptions rather than measure learning outcomes, with the goal of evaluating the feasibility and perceived value of integrating narrative-based learning into a theory-intensive engineering course. Collectively, the responses provide descriptive insight into how this instructional approach may support conceptual engagement and reflection alongside traditional analytical instruction.

3 Results

The following section summarizes both qualitative student reflections and quantitative perception-based survey data collected at the end of the semester. These results capture student perceptions and are not intended as evidence of learning gains or causal effects.

3.1 Student Feedback

Students provided written feedback reflecting on their experience reading the narrative-based book alongside traditional course materials. Many students described the readings as engaging and helpful for contextualizing structural engineering concepts, particularly in connecting theoretical content to real-world practice.

Several students emphasized that the narrative format supported conceptual understanding by offering perspectives beyond equations and problem-solving. One student noted that the readings were *"a nice change of pace from the typical reading of a textbook"* and were '*'helpful for making connections between the class and real-world implications of what we're learning."* Another student highlighted that the activity encouraged deeper reflection, stating that it *"made me think about why we do engineering and not just how."*

Students also frequently mentioned that the book helped situate course concepts within broader professional and historical contexts. For example, one student reflected that *"it was great to read in a book the principles we were learning about,"* while another noted that the readings provided *"real-world examples of the different things we learn in class"* and supported awareness of engineering decisions during design.

At the same time, student experiences were not uniformly positive. A small number of students expressed concerns related to workload and alignment with course assessments. One student described the activity as *"fun but tedious, as it adds to the total work to be done,"* while another commented that *"it is not obvious how it ties into the course overall."* These responses highlight the importance of clearly integrating narrative-based activities within the structure and expectations of a theory-intensive course.

These reflection responses illustrate that, while student experiences varied, the narrative reading component was generally perceived as a meaningful supplement to traditional instruction, particularly in supporting conceptual understanding and professional context.

3.2 Quantitative Perception-Based Survey

At the conclusion of the semester, students (n = 22) were asked to evaluate the narrative reading component across five key metrics. The survey utilized a five-point Likert scale (1 = Strongly Disagree to 5 = Strongly Agree). The specific questions posed to students were:

- **Q1 (Conceptual Understanding):** The readings helped me understand structural analysis concepts more deeply.
- **Q2 (Professional Relevance):** The narrative style felt relevant and connected to engineering practice.
- **Q3 (Engagement):** The readings increased my engagement and motivation in the course.
- **Q4 (Critical Thinking):** The readings helped me think more critically about what I was learning.
- **Q5 (Novelty):** The book provided perspectives that traditional technical textbooks do not offer.

The results, summarized in Table 2, provide a quantitative measure of the narrative component's impact.

Survey Item	**Mean (μ)**	**Std. Dev (σ)**	**Median**	**Range**	**% Agree/SA**
Q1: Deepened conceptual understanding	4.05	0.84	4	3–5	68.20%
Q2: Relevant to real-world practice	4.59	0.50	5	4–5	100%
Q3: Increased engagement	3.95	1.00	4	1–5	72.70%
Q4: Prompted critical thinking	4.14	0.83	4	2–5	81.80%
Q5: Provided novel perspectives	4.55	0.67	5	3–5	90.90%

Table 2: Student Perception Survey Results (1=Strongly Disagree, 5=Strongly Agree)

Students indicated that the narrative readings helped them understand structural analysis concepts more deeply ($\mu = 4.05$) and think more critically about what they were learning ($\mu = 4.14$). The strongest consensus was found in the perceived relevance of the narrative style to real engineering practice ($\mu = 4.59$, $\sigma = 0.50$) and the extent to which the book provided perspectives not typically emphasized in traditional textbooks ($\mu = 4.55$, $\sigma = 0.67$). Notably, 100% of the students agreed or strongly agreed that the narrative style connected the course material to real-world practice (scores of 4 or 5).

Perceived engagement and motivation also received positive ratings ($\mu = 3.95$), though this category showed the greatest variability in responses, with a standard deviation of 1.00 and a full range of scores (1 to 5). While the majority of students found the readings motivating, the higher variance in the engagement domain (Q3) suggests that the additional workload was perceived differently across the cohort. This aligns with qualitative feedback, in which some students found the additional reading "tedious" despite acknowledging its educational value.

4 Discussion

The results of this case study suggest that integrating narrative literature into a high-intensity technical course provides a critical bridge between theoretical analysis and professional intuition. While the technical curriculum successfully builds procedural fluency, the quantitative data suggest that students perceive a gap in traditional textbooks regarding the human and historical context of engineering.

4.1 Bridging the Affective and Cognitive Domains

The primary evidence this study offers is a shift in student reflection. Rather than focusing solely on mathematical correctness, the handwritten reflections evidenced a deeper engagement with engineering judgment. This corresponds to a shift from the Cognitive Domain (calculation) to the Affective Domain (valuing professional impact).

The Structural Analysis course often requires students to move rapidly from theory to computation, leaving limited space for reflection. The narrative format appeared to encourage students to contextualize and engage more deeply with the underlying meaning of structural behavior and design decisions. The instructor observed that students frequently referenced ideas from the readings, particularly regarding structural failures and design trade-offs, during standard technical lectures. While these references did not directly translate into measurable performance changes, they suggested increased conceptual engagement. This also suggests that the narrative format helped students achieve higher-order cognitive levels of Bloom's Taxonomy [7], specifically moving students from application (computation) to analysis and evaluation.

It's important to note that by choosing chapters that emphasize failure and aesthetics rather than purely physics, the curriculum deliberately shifts its focus from objects to people, thereby fulfilling the requirement to deepen conceptual understanding and humanize the technical syllabus.

4.2 The "Workload vs. Value" Paradox

A key finding of this study is the tension between student engagement and perceived workload. While Q3 (Engagement) had a positive mean (μ = 3.95), it also had the highest variance (σ = 1.00). This statistical spread matches the instructor's observation that while many students found the readings *"a nice change of pace,"* a small cohort perceived them as an "extra" burden.

This indicates that while the pedagogical value is high, the integration must be highly intentional. The instructor noted that some students struggled to see the immediate tie-in to the course overall, validating the need to move from "supplementary reading" to "embedded learning." Future iterations will focus on explicit "mapping" between a chapter's story and a week's formula to reduce the "tedious" perception reported by some students.

4.3 Narrative as a Conceptual Anchor

Ultimately, the 100% agreement rate on relevance to practice (Q2) demonstrates that students are seeking the "Why" behind the "How." The instructor noted that the narrative format appeared to foster a more integrated understanding of structural behavior, as students began to view equations not as isolated mathematical hurdles, but as descriptions of physical realities.

This approach does not distract from technical rigor; instead, it reinforces it by providing a "real-world anchor" for abstract mathematical concepts. By humanizing the curriculum, the course supports the development of ABET-aligned professional competencies, such as understanding the impact of engineering solutions in global, economic, environmental, and societal contexts, which technical textbooks often overlook.

5 Conclusion

This case study documents the integration of narrative-based readings and reflective activities into an undergraduate Structural Analysis course. Student perceptions and instructor reflections suggest that this approach can complement traditional analytical instruction by fostering conceptual understanding, contextual awareness, and reflective engagement.

Although this case study does not include a formal assessment of learning outcomes, the combination of student reflections, perception-based survey results, and instructor observations suggests that narrative-based readings can support forms of engagement not typically emphasized in theory-heavy engineering courses.

Conceptually, the reflection activities encouraged the students to analyze engineering decisions, evaluate historical examples, and articulate broader implications in their own words. In this sense, the activity aligns with higher-order cognitive processes often described in Bloom's Taxonomy, such as analysis and evaluation.

By integrating narrative, this study demonstrates that it is possible to humanize a high-intensity technical course, effectively bridging the gap between analytical correctness and the professional identity required of the modern practitioner, addressing the ABET-required professional competencies that technical textbooks often overlook.

Finally, instructors considering a similar approach may find the following considerations useful:

- Narrative readings should be as closely connected to course topics and learning objectives as possible.
- Reflection prompts should emphasize interpretation and conceptual understanding rather than technical correctness.

- Workload expectations should be clearly communicated to students.
- Instructor reflection is essential to refine integration over time.
- This approach may be particularly effective in upper-level engineering courses where conceptual understanding and professional context are critical.

Future work will focus on expanding data collection through systematic analysis of student reflections, structured surveys, and potential correlations with course performance. Additional implementations across courses or semesters may further clarify the role of narrative-based learning in engineering education.

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