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Digital Engineering Notebooks for Supporting Engineering Discourse in Pre-College Engineering Education (Evaluation)

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Introduction

Engineering notebooks play a critical role in pre-college engineering education by supporting the documentation and reflection of problem-solving and design thinking while also serving as tools for assessment. Although such notebooks have traditionally been paper-based, professional engineering practice increasingly relies on digital documentation, highlighting a need for classroom-aligned digital alternatives. Structured digital engineering notebooks have the potential to support pre-college engineering discourse and reflective practice while promoting aligning educational experiences with contemporary engineering workflows.

This study examines student perspectives on an open-access digital engineering notebook and its potential to enhance design documentation and engineering discourse in pre-college contexts. While paper-based notebooks continue to support creativity and free-form ideation, their limitations in digitally mediated learning environments suggest a need for expanded documentation modalities. Preparing students for technology- and engineering-related careers requires providing authentic learning experiences that reflect professional practices, including digital documentation and communication. In response, a team of technology and engineering educators developed and implemented an open-access digital engineering notebook adaptable across projects and curricular contexts using readily available tools. Central to this work is the inclusion of student feedback, which informs both the refinement of the resource and its dissemination to pre-college engineering educators seeking to utilize digital notebook practices.

Literature Review

Throughout history, innovators such as Leonardo da Vinci, Marie Curie, and Thomas Edison have used notebooks to document experimentation and design thinking, underscoring the enduring role of systematic record keeping and reflection in technological innovation [1], [2]. In educational settings, notebooks have similarly served as tools for organization, reflection, and assessment for centuries, with documented use dating back to instructional practices of the Age of Enlightenment in the late seventeenth century and continuing as common learning artifacts today [1]. Beyond pre-college engineering education, undergraduate seniors in engineering are commonly expected to conduct a showcase project documenting a capstone problem-solving design project to display their applied cumulative knowledge for graduation [3].

Within pre-college engineering education, engineering notebooks function as records of problem-solving design, avenues of reflection, foundations of critical thinking, tools of creativity, and overall, as vehicles for engineering discourse [4], [5]. Engineering discourse encompasses the language, symbols, tools, and practices engineers use to communicate ideas, justify design decisions, and collaborate with others through written, visual, and verbal forms of communication [2], [4], [5], [6]. Engaging students in these discourse practices supports the development of technological and engineering literacy by strengthening communication, reflection, reasoning, and decision-making skills aligned with professional engineering practice [4], [6]. Prior research has shown that such discourse development is well-supported through collaborative design-based learning experiences that require students to document through multiple modalities and reflect on their thinking [4], [5].

Engineering notebooks also play a critical role in supporting reflective documentation, enabling students to monitor their learning, make sense of design iterations, and engage deeply with problem-solving processes [4], [5], [6], [7]. Purposefully structured documentation has been shown to encourage reflection and strengthen student learning outcomes related to creativity, collaboration, communication, and problem-solving, as emphasized in the Standards for Technological and Engineering Literacy (STEL) [6], [7]. Despite these benefits, educators and students often face challenges when implementing notebook practices in pre-college settings, including barriers to access to resources, self-efficacy when using new resources, and access to support for using tools in the classroom [2], [4], [7].

Previous research on the input of teachers and students in engineering notebooks presents information related to how students appreciate the utility of notebooks in the design process. Specifically, students in an underserved area reflected positively on notebooks providing the "utility in allowing them to record their thought processes and as a tool for brainstorming and reflection" [8]. Teachers in the same study state direct appreciation of engineering notebooks for their ability to facilitate formative and summative assessments of their students [8]. Gaining students' perspectives is essential, as such insights can inform practices that support the success of future students pursuing engineering degrees. As noted by Mettler, the documentation process in senior engineering design projects contributes to student success by serving as a critical form of professional communication and by demonstrating soft skills that are highly valued by employers in engineering and related fields [3].

As professional engineering practice increasingly relies on digital tools for modeling, analysis, and collaboration, engineering education environments are encouraged to provide comparable documentation experiences [4]. However, a number of pre-college engineering classrooms continue to depend on paper-based notebooks, even as students regularly engage with digital design tools [9]. While some digital notebook approaches exist, few open-access, accessible templates are designed specifically to support engineering discourse and reflective documentation in pre-college contexts.

Method

This qualitative evaluation examines student use of an open-access, structured digital engineering notebook within a convenience sample of eight university undergraduate students enrolled in a technology, engineering, and design education course at a public land-grant university in the southeastern United States. Data was analyzed using qualitative methods guided by pre-established thematic categories to support systematic interpretation of student interactions and artifacts. Course content emphasizes learning to teach others about the associated standards, practices, and contexts of technological and engineering literacy and heavily involves the integration of technology through an applied engineering design process. The study investigates student use of an open-access structured digital notebook within a common pre-college engineering project, with attention to both documented examples and student perspectives on the tool. For this study, students who only used the structured digital notebook format were evaluated. Eleven of the 15 enrolled students submitted survey responses, and of those 12 submissions, eight were from students who utilized the structured notebook template.

The open-access structured digital engineering notebook template is informed by the structure and pedagogical intent of the VEX Robotics engineering notebook framework [10]. The template is designed to promote active student engagement with key phases of the Engineering Design Process, including problem definition, ideation, solution planning, prototyping and modeling, testing, data analysis, and iterative feedback. The use of multiple slide layouts supports structured yet flexible documentation, enabling students to represent their design thinking through written, visual, and interactive elements. Although the template includes predefined text fields and interactive components to scaffold student responses, all elements remain editable and unlocked, allowing instructors or students to adapt the notebook to specific instructional contexts or engineering challenges.

Data was collected through de-identified student submissions of engineering notebooks as well as student feedback intended to capture perceptions of challenges, successes, key resources, and engineering discourse associated with the notebook experience. The following research questions guide this study as the research team evaluates open-access resources intended to enhance pre-college engineering classroom practices and tools:

Research Questions

- What are the reported experiences of students using an open-access structured digital engineering notebook to document their engineering design process?
- How is engineering discourse represented in students' digital engineering notebook documentation produced during a hands-on engineering design project?

Data Collection

Prior to the design challenge, students received instruction on the steps of the engineering design process and on documenting each step using either a physical or digital notebook format. Instruction addressed defining the problem, generating and selecting solutions, planning, constructing and testing a model, using feedback to make improvements, and communicating the final solution. Following this instruction, students completed a hands-on project in which they were required to document their engineering design process using a notebook format of their choice while researching, modeling, and testing truss designs. Both physical and digital notebooks require identical content and design elements to ensure consistency across documentation approaches. Although students in previous course offerings were required to use physical notebooks, the introduction of a digital option through this study allowed participants to select their preferred documentation format. After completing the hands-on truss project, students were invited to provide feedback on their notebook use by responding to an optional survey described in Table 1 below.

Table 1. Survey Questions for Student Input on Engineering Notebook

What challenges do you face when using the notebook during the engineering design process? (Please specify during which step, if applicable.)
Which step of the process is easiest for you to document in your notebook? Which is most difficult? Why?
How do you use your notebook to record the different stages of the engineering design process (e.g., brainstorming, prototyping, testing, redesign)?
Share an example of how your notebook helped you solve a problem or refine an idea. Be specific.
How do you use your notebook to explain or communicate your ideas to others (peers, teachers, managers, etc…)?
How often did you look back at your previous entries, and what do you learn from doing so?
In what ways does the notebook help you collaborate with others or share responsibility in team projects?
How has the notebook influenced your ability to stay organized, manage time, or self-direct your learning?
How do you think the skills you practice through notebook use (like documenting, organizing, or reflecting) might help you outside of engineering projects—in school or in your future career?
Share a time when you felt proud of your notebook entry. What made it meaningful?

Data Analysis
The eight responses were subsequently analyzed using qualitative methods and deductive coding based on supporting research to examine students' perspectives on the use of their structured digital engineering notebooks within a problem-based learning context. Transcripts of student responses were analyzed using Taquette, a free, open-source qualitative data analysis software, enabling the research team to code and identify evidence related to pre-established thematic categories. The pre-established thematic categories, described in Table 2, arrive from previous literature that seek to identify the challenges, successes, key resources, and evidence of engineering discourse when using an engineering notebook.

Table 2. Definitions of Pre-Coded Themes for Qualitative Analysis of Student Responses

Challenges	Instances in which participants describe barriers, difficulties, limitations, or negative experiences directly associated with the use of the structured engineering notebook template.
Successes	Instances in which participants report positive outcomes, effective practices, or perceived benefits directly attributable to the use of the structured engineering notebook template.
Key Resources	References to tools, supports, or processes that facilitate or scaffold student engagement with and effective use of the structured engineering notebook template.
Evidence of Engineering Discourse	Occurrences of disciplinary communication practices, including the use of engineering-specific language, representations, symbols, tools, and conventions through which participants articulate ideas, justify design decisions, and engage in collaborative meaning-making via written, visual, or verbal modalities.

After collecting student responses and analyzing those using digital notebooks, the instructor then collected student notebooks for analysis of engineering discourse to support student responses. The open-access structured digital engineering notebook used for this study can be accessed through the link and QR code provided in Table 3.

Table 3. Open-Access Structured Digital Engineering Notebooks

https://go.ncsu.edu/engineering_design_notebook

Results

The following sections synthesize student responses within each of the analytic themes.

Challenges

Student responses included 14 mentions related to challenges, which were heavily centered on difficulty providing regular updates and knowing what kind of information to insert into the notebook, even with the prompts. Student statements included challenges of “iterating through steps”, “update the notebook regularly”, “figuring out how to actually answer the questions”, “understanding how to explain the content that I'm putting in it”, and “deciding what information to include”. Additional challenges faced by students include time management and being sure to go into their notebook and insert information as identified by such statements as “time constraints”, “update the notebook regularly”, “managing time”, “refine it over time”, and that notebook work “ can be hard to maintain it while working on a project”. One student even stated that a challenge was seeing how practicing such documentation and reflection benefited them as individuals. Two student responses were that the notebook “feels like another responsibility” and requires “attention.”

Successes

Student responses strongly suggest that the digital engineering notebook supported not only procedural documentation but also engagement with engineering discourse, practice, and reflection. Students perceived the notebook as a meaningful tool for structuring design work, supporting collaboration, and developing transferable skills aligned with authentic engineering practice. Of the 43 success-related references, 15 responses indicated that the notebook supported engagement across multiple phases of the engineering design process, including problem identification, planning, brainstorming, modeling, testing, and reflection. Students reported that the notebook helped them refine early problem identification and planning, “showcase each step of the process,” and recognize missing details, enabling iterative refinement of their design ideas. Additionally, students highlighted the notebook’s effectiveness for documenting processes and communicating empirical evidence through multiple representations, including, but not limited to, hand-drawings, data tables, graphs, graphical models, photographs, and screenshots. These affordances supported clearer interpretation of results and reflection on design outcomes, including accountability for failures and evidence-based reasoning.

Beyond design documentation, students described the digital notebook as a tool that supported organization, time management, and self-directed learning. Responses indicated that the structured format helped students keep information accessible, track progress, and use the notebook as a self-check for design processes. The digital format also facilitated communication with peers, teams, and non-technical audiences by enabling easy sharing of ideas, visuals, and explanations of engineering work. Students further emphasized the long-term value of reflective documentation skills, noting connections to professional engineering practices and future careers. Reflections on learning from mistakes, documenting tasks, and revisiting completed projects suggest that the notebook functioned as both a reflective learning artifact and a professional practice tool, reinforcing its role in supporting sustained engagement with engineering discourse.

Key Resources

As students reflected on their use of the notebooks, responses included references to tools, supports, or processes that supported their use of the structured engineering notebook template. The majority of the 13 key resources highlighted include seven references to using visuals to inform group members and viewers of the problem-solving process. Specific quotes include using “as many pictures as possible”, including “photos or links to videos of the actual test”, “pictures to showcase what is happening”, including “hand drawings”, and “pictures with captions”. Further key resources highlighted by students include being sure to “reflect on why issues occurred” and “be more detailed and in-depth” with content. Additional key resources mentioned by students include being sure to “break down each part” of the project or process, practice “organization”, the template itself, and clear section titles.

Engineering Discourse

Student responses included 43 instances that indicate that the digital engineering notebook supported multimodal engineering discourse by integrating visual, textual, and quantitative representations to communicate engineering thinking. Students described using the structured notebook not only to document problem-solving activities but also to articulate reasoning, justify decisions, and reflect on design processes in ways consistent with professional engineering practice. Visual representations emerged as a primary mode of communication, with students referencing features such as a “graphical modeling section,” opportunities to “draw, mind map, and come up with the initial ideas,” and the ability for them to include “as many pictures as possible,” including “hand drawings.” These multimodal affordances supported students in conveying design intent, processes, and solutions more clearly than text alone.

In addition to visual communication, students reported engaging in discipline-specific documentation and analytical practices through the notebook. Responses highlighted the inclusion of structured design elements such as “goals, materials, constraints, design matrix,” as well as clearly defined sections to “identify the problem,” support “planning,” and document “drafting” and decision-making processes. Students also emphasized the use of empirical evidence, noting that the notebook supported the inclusion of “data and test results” through “graphs and tables,” enabling them to justify design choices.

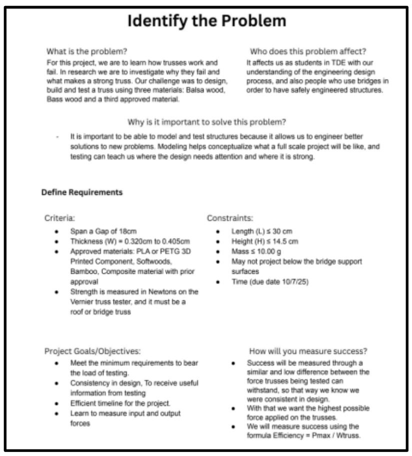
Reflective and collaborative discourse was further evident in responses referencing “reflection,” “stream of thoughts,” and descriptions of documenting “how I imagined solutions and took action to do so." Students also highlighted the notebook's role in communication and collaboration, noting that it allowed them to "easily share and communicate my thoughts, ideas, and solutions to individuals or a team," particularly when presenting processes "from start to finish." Collectively, these findings suggest that the digital engineering notebook functioned as a shared artifact that supported reflective, evidence-based, and collaborative engineering discourse throughout the design process.

Examples of Engineering Discourse

Analysis of students' engineering notebooks, summarized in Table 4, presents representations illustrating key aspects of engineering discourse.

Table 4. Engineering Discourse Evidence from Student Engineering Notebooks

Engineering Language and Terminology



Identify the Problem

What is the problem?
For this project, we are to learn how trusses work and fail. In research we are to investigate why they fail and what makes a strong truss. Our challenge was to design, build and test a truss using three materials: Balsa wood, Bass wood and a third approved material.

Who does this problem affect?
It affects us as students in TDE with our understanding of the engineering design process, and also people who use bridges in order to have safely engineered structures.

Why is it important to solve this problem?
- It is important to be able to model and test structures because it allows us to engineer better solutions to new problems. Modeling helps conceptualize what a full scale project will be like, and testing can teach us where the design needs attention and where it is strong.

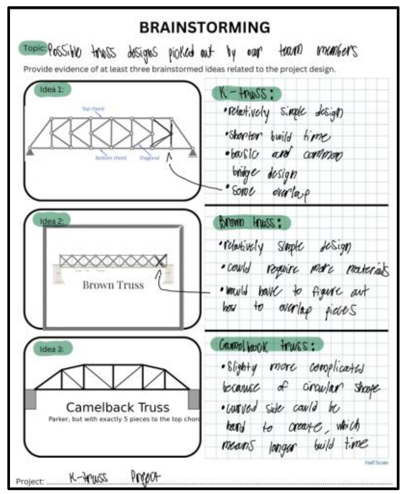
Define Requirements

Criteria:
- Span a Gap of 18cm
- Thickness (W) = 0.320cm to 0.405cm
- Approved materials: PLA or PETG 3D Printed Component, Softwoods, Bamboo, Composite material with prior approval
- Strength is measured in Newtons on the Vernier truss tester, and it must be a roof or bridge truss

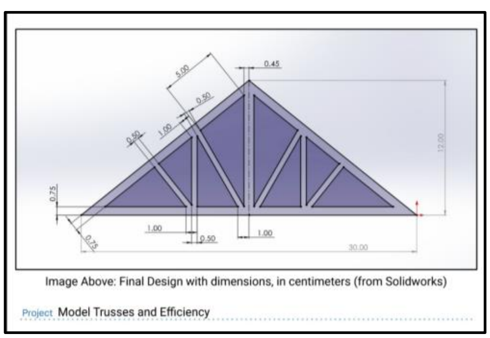
Constraints:
- Length (L) ≤ 30 cm
- Height (H) ≤ 14.5 cm
- Mass ≤ 10.00 g
- May not project below the bridge support surfaces
- Time (due date 10/7/25)

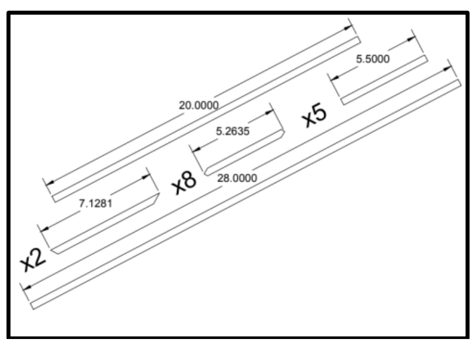
Project Goals/Objectives:
- Meet the minimum requirements to bear the load of testing.
- Consistency in design, To receive useful information from testing
- Efficient timeline for the project.
- Learn to measure input and output forces

How will you measure success?
- Success will be measured through a similar and low difference between the force trusses being tested can withstand, so that way we know we were consistent in design.
- With that we want the highest possible force applied on the trusses.
- We will measure success using the formula Efficiency = Pmax / Wtruss.



Symbolic and Mathematical Representations





Visual Representations

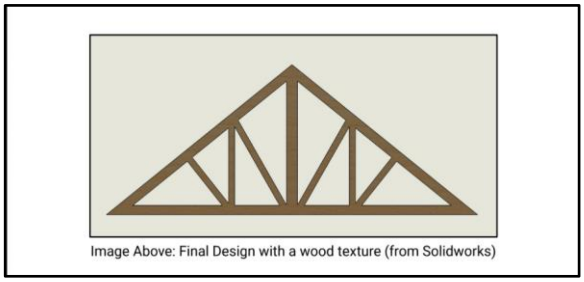
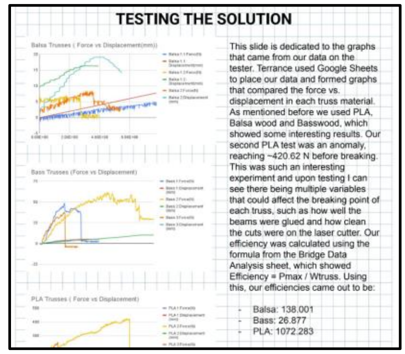
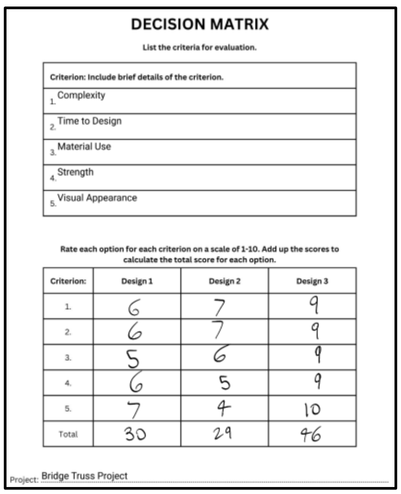


Image Above: Final Design with a wood texture (from Solidworks)



Justification of Design Decisions



DECISION MATRIX

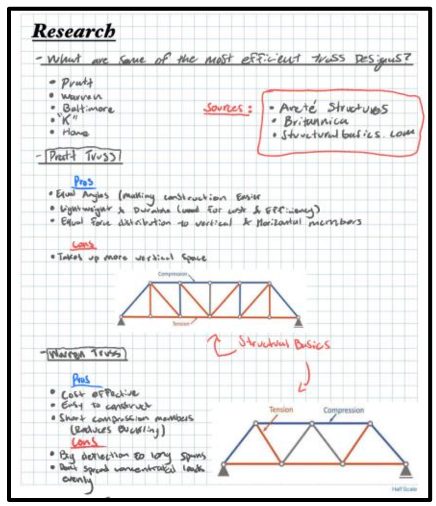
List the criteria for evaluation.

Criterion: Include brief details of the criterion.
1. Complexity
2. Time to Design
3. Material Use
4. Strength
5. Visual Appearance

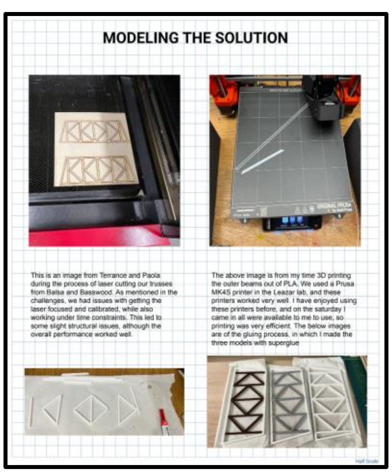
Rate each option for each criterion on a scale of 1-10. Add up the scores to calculate the total score for each option.

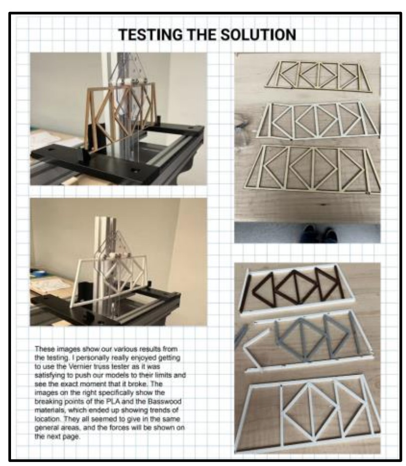
Criterion:	Design 1	Design 2	Design 3
1.	6	7	9
2.	6	7	9
3.	5	6	9
4.	6	5	9
5.	7	4	10
Total	30	29	46

Project: Bridge Truss Project

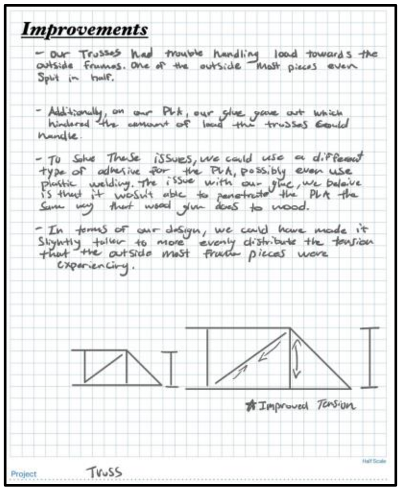


Use of Engineering Tools and Artifacts





Reflective Communication



Improvements

- Our Trusses had trouble handling load towards the outside frames. One of the outside most pieces even Split in half.

- Additionally, on our PLA, our glue gave out which hindered the amount of load the trusses could handle.

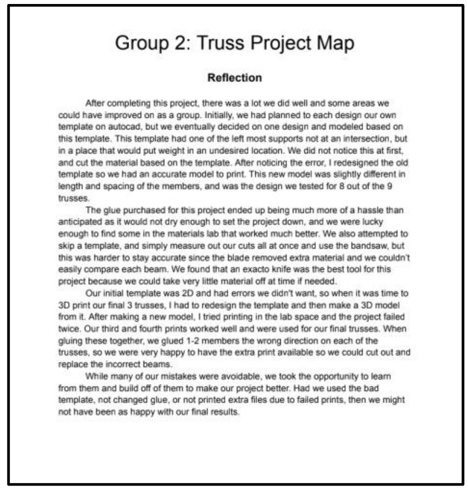
- To Solve These issues, we could use a different type of adhesive for the PLA, possibly even use plastic welding. The issue with our glue, we beleive is that it wasn't able to penetrate the PLA the same way that wood glue does to wood.

- In terms of our design, we could have made it Slightly taller to more evenly distribute the tension that the outside most frame pieces were experiencing.

☆Improved Tension

Half Scale

Project Truss



Group 2: Truss Project Map

Reflection

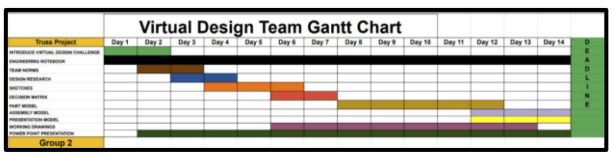
After completing this project, there was a lot we did well and some areas we could have improved on as a group. Initially, we had planned to each design our own template on autocad, but we eventually decided on one design and modeled based on this template. This template had one of the left most supports not at an intersection, but in a place that would put weight in an undesired location. We did not notice this at first, and cut the material based on the template. After noticing the error, I redesigned the old template so we had an accurate model to print. This new model was slightly different in length and spacing of the members, and was the design we tested for 8 out of the 9 trusses.

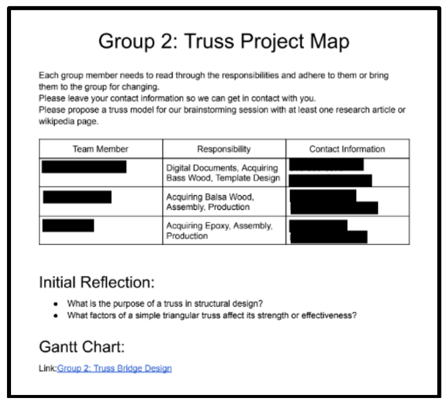
The glue purchased for this project ended up being much more of a hassle than anticipated as it would not dry enough to set the project down, and we were lucky enough to find some in the materials lab that worked much better. We also attempted to skip a template, and simply measure out our cuts all at once and use the bandsaw, but this was harder to stay accurate since the blade removed extra material and we couldn't easily compare each beam. We found that an exacto knife was the best tool for this project because we could take very little material off at time if needed.

Our initial template was 2D and had errors we didn't want, so when it was time to 3D print our final 3 trusses, I had to redesign the template and then make a 3D model from it. After making a new model, I tried printing in the lab space and the project failed twice. Our third and fourth prints worked well and were used for our final trusses. When gluing these together, we glued 1-2 members the wrong direction on each of the trusses, so we were very happy to have the extra print available so we could cut out and replace the incorrect beams.

While many of our mistakes were avoidable, we took the opportunity to learn from them and build off of them to make our project better. Had we used the bad template, not changed glue, or not printed extra files due to failed prints, then we might not have been as happy with our final results.

Collaborative Communication





Group 2: Truss Project Map

Each group member needs to read through the responsibilities and adhere to them or bring them to the group for changing.
Please leave your contact information so we can get in contact with you.
Please propose a truss model for our brainstorming session with at least one research article or wikipedia page.

Team Member	Responsibility	Contact Information
[redacted]	Digital Documents, Acquiring Bass Wood, Template Design	[redacted]
[redacted]	Acquiring Balsa Wood, Assembly, Production	[redacted]
[redacted]	Acquiring Epoxy, Assembly, Production	[redacted]

Initial Reflection:

- What is the purpose of a truss in structural design?
- What factors of a simple triangular truss affect its strength or effectiveness?

Gantt Chart:

Link:Group 2: Truss Bridge Design

Discussion

Findings from this study reinforce prior research on the role of engineering notebooks as essential artifacts for documenting problem-solving processes, reflective practices, and as assessments for engineering discourse. This study extends prior research by providing student input on an open-access structured digital engineering notebook that teachers can use to facilitate engineering discourse in a pre-college engineering environment. Student responses indicate that the structured digital engineering notebook served not only as a record-keeping tool but also as a mechanism for supporting communication, reasoning, and iterative problem-solving, which previous research identifies as key engineering practices.

The challenges identified by students, particularly those related to maintaining regular updates, determining appropriate levels of detail, and managing time, align with previously documented barriers to effective notebook implementation in pre-college engineering classrooms. Prior studies have noted that without explicit scaffolding and instructional support, students may struggle to internalize reflective documentation practices or perceive their long-term value [7]. It is also important to note that it is vital that teachers are also familiar with the notebook format to support students where questions may arise. Such evidence directs to the need to have professional development resources ready to support teachers who may choose to integrate an open-access structured digital engineering notebook.

Some students in this study viewed the notebook as an added responsibility rather than an integrated component of the design process, suggesting that sustained modeling and alignment with instructional goals may be necessary to support student buy-in. This means that pre-college engineering educators integrating a digital notebook resource, and the developers of the notebook, must be clear on the advantages for students learning to utilize a structured notebook and also highlight how professional settings use similar tools.

Despite these challenges, the predominance of success-related responses suggests that the structured digital format meaningfully supported engagement with engineering practices. Students reported improved organization, clearer progression through the engineering design process, and enhanced ability to document data, test results, and design iterations. These findings are consistent with prior research indicating that purposefully structured documentation can strengthen learning outcomes related to problem-solving, communication, and reflection [4, 5]. The ability to incorporate multimodal representations such as hand-drawings, photographs, screenshots, graphs, and tables is a key affordance of the digital notebook, addressing limitations commonly associated with paper-based formats [9].

Evidence of engineering discourse was strongly represented across student responses and work examples. Students demonstrated use of discipline-specific language, visual and symbolic representations, data-driven justification, and reflective explanation, all of which are hallmarks of authentic engineering communication [2, 6]. The notebook functioned as a space where students could externalize thinking through sketches, design matrices, and graphical models, while also supporting reflection on failures and decision-making processes. These practices align closely with the Standards for Technological and Engineering Literacy (STEL), which emphasize competencies of iterative design, evidence-based reasoning, and communication [6].

Furthermore, students' descriptions of sharing notebooks with peers, teams, and non-technical audiences highlight the role of the digital notebook as a collaborative tool. Such a finding supports existing literature suggesting that engineering discourse is socially situated and strengthened through shared artifacts that mediate collaboration and explanation [4]. The digital notebook's accessibility and ease of sharing appeared to support coordination among group members working at different paces, as well as communication beyond the classroom context.

It was not without resources that students were able to practice applying such vital elements of engineering discourse. Students identified that to effectively communicate, they had to include a variety of graphics and images, ranging from brainstorming ideas to modeling concepts and visualizing data for feedback. These visuals function as a key resource in students practicing their engineering discourse and as an important resource for student reflection, which student responses highlight. Such statements show that not only do students have to actually input notes and responses, but they have to go back and review them for effective comprehension of their process. Such a key resource of reflection shows that novice users of engineering notebooks benefit from a structure that includes reflective questions.
Together, the findings of this study suggest that an open-access structured digital engineering notebook can effectively support engineering discourse and reflective documentation in pre-college engineering education. While implementation challenges remain, particularly related to self-efficacy of using the tool, time management, and instructional integration, results indicate that thoughtfully designed digital templates have potential to align pre-college engineering environment practices closely with professional engineering norms.

Limitations and Future

As this study provides positive insight into student perspectives on using an open-access structured engineering design notebook, there are existing limitations. This study utilizes a sample of undergraduate technology, engineering, and design education students that are just beyond the pre-college engineering education level. With this in mind, middle and high school students may possess different perspectives, experiences, and priorities than the undergraduate students used for this evaluation. An additional limitation is the need to be able to access the digital tools required for using the open-access structured engineering notebook, such as the need for a computer, internet, and software access. A final limitation that is identified in this paper is that both students and teachers will need familiarization and a level of self-efficacy in using tools related to digital engineering notebooks, which require time and access to resources.

Future research should examine how instructional strategies, duration of use, and teacher support influence student perceptions and long-term adoption of engineering documentation practices. As teachers incorporate an open-access structured digital engineering notebook, it will benefit the pre-college engineering education community to gain teachers perspectives related to challenges, successes, key resources, and the incorporation of engineering discourse.

Conclusion

As technology within a pre-college engineering environment evolves, so do the resources available to educators. Engineering notebooks continue to play a pertinent role in the documentation and reflection practices of students and as an assessment tool for educators.

While such notebooks have traditionally been paper-based, this study provides student-centered evidence of an open-access structured digital engineering notebook that teachers can use as an option in their pre-college engineering education environment to support the development of engineering discourse. While students identified challenges related to time management, maintaining regular updates, and determining appropriate levels of detail, these barriers are consistent with those documented in prior studies of notebook implementation. Such challenges underscore the importance of instructional scaffolding, teacher familiarity with the tool, and targeted professional development to support effective integration.

Student input and examples of work support existing literature that structured digital notebooks can facilitate communication, reasoning, reflection, and iterative design practices aligned with developing a technological and engineering literacy. Student responses indicate that the digital notebook functioned not merely as a record-keeping tool but as an integrated mechanism for engaging in authentic engineering practices, including data-driven decision-making, multimodal representation, and reflective evaluation of design outcomes. Structured digital notebooks provide students with opportunities to practice authentic engineering discourse, collaborate effectively, and document iterative design work, cultivating the competencies necessary to contribute meaningfully to future engineering fields.

References

[1] M. D. Eddy, "The nature of notebooks: How Enlightenment schoolchildren transformed the tabula rasa," *Journal of British Studies*, vol. 57, no. 2, pp. 275–307, 2018.

[2] T. R. Kelley, "Engineer's notebook—A design assessment tool," *Technology and Engineering Teacher*, vol. 70, no. 7, p. 30, 2011.

[3] C. Mettler, Engineering Design. Cham, Switzerland: Springer, 2023.

[4] K. N. Silvestri, M. E. Jordan, P. Paugh, M. B. McVee, and D. L. Schallert, "Intersecting engineering and literacies: A review of the literature on communicative literacies in K-12 engineering education," *Journal of Pre-College Engineering Education Research.*, vol. 11, no. 1, p. 1, 2021.

[5] P. Fernandez-Velasco, J. Nijman, and R. Casati, "The cognitive advantages of the notebook," *Cognitive Semiotics.*, vol. 16, no. 1, pp. 3–21, 2023.

[6] International Technology and Engineering Educators Association (ITEEA), *Standards for Technological and Engineering Literacy: The Role of Technology and Engineering in STEM Education*, Reston, VA: ITEEA, 2020.

[7] K. C. Bergsman, "The 'Structured' engineering design notebook: A new tool for design thinking within a studio design course," in *Proceedings of the 2018 ASEE Annual Conference & Exposition*, June 2018.

[8] M. Dunham, J. Deboer, D. B. Radhakrishnan, and N. Bhide, "Teacher and student perception of engineering design notebook utility," in *Proceedings of the 2023 ASEE Annual Conference & Exposition*, June 2023.

[9] Ş. Purzer, J. Strobel, and M. E. Cardella, Eds., *Engineering in Pre-College Settings: Synthesizing Research, Policy, and Practices*. West Lafayette, IN, USA: Purdue University Press, 2014.

[10] "VEX Digital Notebook Templates," *RECF Library*, Robotics Education & Competition Foundation, 2025. [Online]. Available: https://kb.roboticseducation.org/hc/en-us/articles/8369508470935-VEX-Digital-Notebook-Templates. Accessed: Jan. 18, 2026.