

1909 Conference: Advancing Thought, Research, and Practice in Technology and Engineering Education

Title: Exploring Technology and Engineering Student Experiences with Digital Engineering Notebooks

Abstract

Engineering notebooks are essential in documenting problem-solving processes and design methods of students engaging with technology and engineering curricula. Commonly, engineering notebooks are paper-based, but the growing shift toward digital tools has created a need for a digital engineering notebook template option for teachers. This paper presents a qualitative descriptive study demonstrating an initial digital engineering notebook template that teachers can use to provide students with practical engineering discourse experiences applicable to their future academic and professional environments. The authors will share student perspectives and present examples of how a digital engineering notebook can be used in technology and engineering education to encourage student reflection and project documentation.

Participants include students from a large land-grant university in the southeastern United States, with data arriving through deidentified notebook submissions and anonymous reflections on students' documentation experiences. Analysis of data will report themes, including how digital engineering notebooks promote engineering discourse aligning with the Standards for Technological and Engineering Literacy, students' perceptions of successes and challenges, and considerations that teachers should take when integrating digital engineering notebooks. Anticipated outcomes of the paper and presentation include a demonstration of a digital engineering notebook template, a presentation of students' input with examples of project application, concluding with a discussion on future developments and evaluation of digital engineering notebooks in technology and engineering education environments.

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Introduction

Engineering notebooks are essential tools in technology and engineering education, supporting design thinking and problem-solving while serving as both learning and assessment instruments. Traditionally paper-based, these notebooks are now transitioning to digital formats as professional engineering practices adopt digital documentation. This shift highlights the need for structured, classroom-ready digital engineering notebooks that reflect authentic industry processes.

This study presents the design and classroom implementation of an open-access digital engineering notebook and examines its potential to enhance engineering discourse and design documentation. Specifically, this research addresses the following questions.

1. How do digital engineering notebooks support engineering discourse and reflect students' reported experiences with these tools?
2. What are students' perceptions of the successes and challenges of using digital engineering notebooks?
3. What key considerations should teachers take into account when implementing digital engineering notebooks, particularly in relation to student experiences and alignment with practices of the Standards for Technological and Engineering Literacy?

Literature Review

Historically, innovators such as Leonardo da Vinci, Marie Curie, and Thomas Edison used notebooks to record their design work and experimentation, demonstrating the value of systematic documentation and reflection in technological advancement (Kelley 2011). In education, notebooks have long encouraged reflection, organization, and assessment as early as the Enlightenment period, starting in the late 1600s and continuing to be common learning artifacts even today (Eddy 2018).

In technology and engineering education, notebooks serve as records of design work and as tools for engineering discourse, including written, visual, and verbal communication used to convey ideas, justify design decisions, and collaborate (Kelley, 2011; ITEEA, 2020). Practicing engineering discourse helps students develop technological and engineering literacy, strengthening communication and reasoning skills aligned with professional practice (Silvestri et al., 2021; ITEEA, 2020).

As engineering increasingly relies on digital tools for modeling and collaboration, classrooms must provide similar experiences (Silvestri et al., 2021). Yet many engineering education environments still depend on physical notebooks even while teaching the use of digital design tools (Purzer, 2014). Integrating digital notebooks bridges this gap and aligns education with professional expectations.

Regardless of format, notebooks support the Standards for Technological and Engineering Literacy (STEL), emphasizing creativity, collaboration, communication, and problem-solving (ITEEA, 2020). Structured documentation encourages reflection and deeper engagement with these competencies (Bergsman, 2018). Despite extensive research on physical notebooks, few open-access digital templates exist to support engineering discourse or guide teachers in using them effectively. This study addresses that gap through qualitative analysis of student experiences with structured digital documentation.

Method

This qualitative study examined student engagement with digital engineering notebooks in a Technology, Engineering, and Design Education course at a large land-grant university in the southeastern United States. The course emphasizes the engineering design process and includes a convenience sample of six undergraduate students. Before beginning the design challenge, students were taught the core stages of the engineering design process, including problem definition, brainstorming, planning, prototyping, testing, refining, and communicating outcomes (ITEEA, 2020). Students also reviewed the STEL framework to understand how documentation supports technological and engineering literacy.

Students then completed an open-ended human-centered design challenge documenting their process in either a digital or physical notebook, both requiring identical content. Of the 24 students, six chose a full digital mode of notebook, 11 opted for a physical mode, and seven selected a hybrid option. This represents a shift from previous course iterations that used only physical notebooks, allowing

students to select a format matching their technological comfort and learning preferences. For this study, the six fully digital structured engineering notebooks were analyzed.

Data Collection and Analysis

Following notebook submission, students completed an optional survey containing open-ended questions about usability, organization, and satisfaction with the digital notebook format. Questions were specifically:

- Did you use a Physical or Digital Engineering Notebook? Please explain briefly why you chose your notebook format.
- Describe how your notebook integrates practices identified in the Standards for Technological and Engineering Literacy.
- Describe briefly how using your chosen format of notebook influences your ability to express creativity and/or critical thinking in your designs.

De-identified responses were analyzed using Taquette, an open-source qualitative data analysis tool. Coding categories were based on the research questions and previous literature on engineering discourse and documentation.

Findings

Analysis identified four main themes: alignment with STEL practices, usability and accessibility, support for engineering discourse, and teacher considerations.

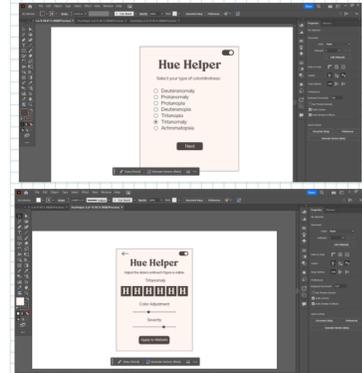
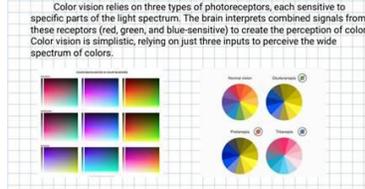
Alignment with STEL Practices

Digital notebooks supported communication, creativity, and critical thinking, as students documented iterative design processes, reflected on feedback, and used digital tools to communicate ideas, as shown in Table 1. Systems thinking and collaboration appeared but did so less frequently, likely due to the individual nature of the assignment. Future versions can integrate collaborative notebook features such as shared reflections, team planning spaces, and project management tools to address these competencies more fully.

Table 1: STEL Practices Identified From Student Responses and Supporting Evidence From Digital Structured Student Engineering Notebooks.

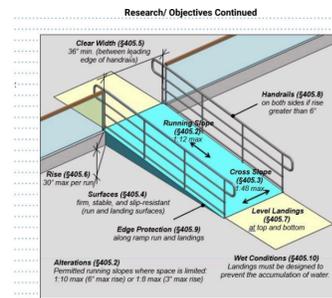
Communication

Digital notebooks facilitated communication through features like easy image inclusion, linking, and sharing for collaboration. Many images included in the digital notebooks are images that would not be as easily drawn in a physical notebook.



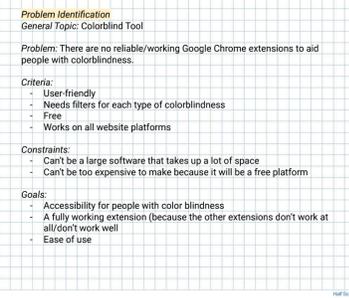
Critical Thinking

Students emphasized how notebooks helped organize their thoughts, iterate designs, and refine problem-solving approaches. Digital notebooks, in particular, were praised for enabling edits and reorganizations to support critical thinking.



U.S. Access Board. ADA Accessibility Standards. (n.d.). <https://www.access-board.gov/ada/>

Image helped the group visualize the project and create the foundations for what our ramp design could be like. As well as laying out the requirements and restrictions for creating an ada accessible ramp.



Project TDE331 Final - Hue Helper

Gantt Chart

	10/29	10/31	11/5	11/7	11/12	11/14	11/19	11/21	11/26	12/3	
Introduction/Planning	[Bar]										
Engineering Notebook	[Bar]										
Research	[Bar]										
Sketches	[Bar]										
Modeling	[Bar]										
Testing	[Bar]										
Redesign	[Bar]										
PowerPoint Presentation	[Bar]										

Decision Matrix

	Efficiency	Complexity	Time	Total
Chrome Extension	1	2	1	4
Website	2	3	3	8
Physical Lenses	3	3	3	9

Sources for Research

- Reviews on the Chrome web store for other colorblind apps (Colorblindly)
- Types of colorblindness via the National Eye Institute
- Web Content Accessibility Guidelines via W3C
- "What is colorblindness accessibility" via Bureau of Internet Accessibility
- Colorblind Classmate

Evidence:

Colorblind - Dalton for Google Chrome

Extension Accessibility: 6,000 users

This extension may soon no longer be supported because it doesn't follow best practices for Chrome extensions.

Peter Hukins ★☆☆☆☆ Jul 21, 2023
Extension is broken. As of very recently (this week), it blanks out every page that I look at. Chrome of MacOS, Version 110.0.5790.58 (Official Build) (arm64). Developer links are

Used to LOVE this utility, as it allowed me to see the subtleties in graphs and data representations that were not made for colorblind people.

8 out of 9 found this helpful

Colorblindly

Featured 3.4 ★ (47 ratings)

Extension Education 10,000 users

Neither of the extensions appears to function properly, and the one that might be working is scheduled to be removed from Chrome soon.

Our design is inspired by a combination of these extensions, along with some original ideas to enhance and refine the concept.

Rachel ★☆☆☆☆ Sep 26, 2024
It doesn't work anymore. This was a great extension when it did work.

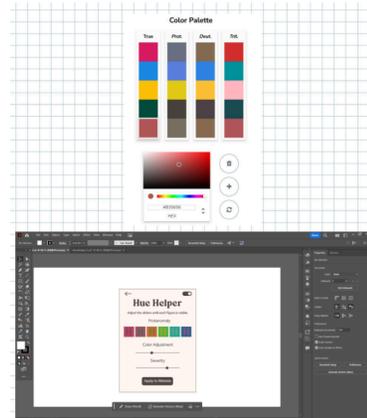
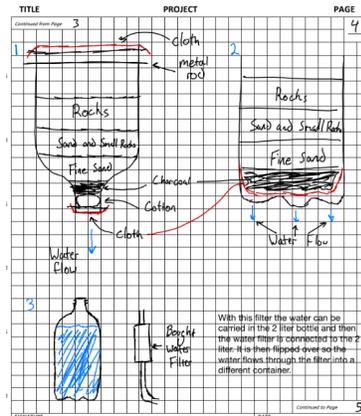
3 out of 3 found this helpful

Dave Campbell ★☆☆☆☆ Sep 8, 2024
very broken.

2 out of 2 found this helpful

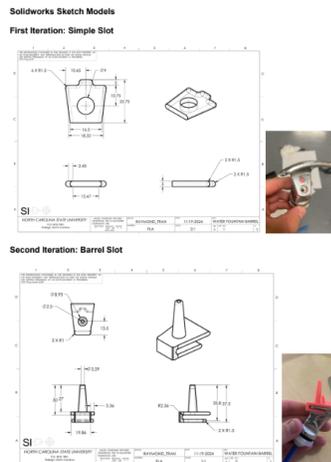
Creativity

Many students discussed how digital notebooks influenced their creative process. They highlighted features like sketching, spontaneous idea generation, multimedia incorporation, and free-form brainstorming.



Making and Doing

Responses frequently mentioned how digital notebooks offered tools for experimenting with and iterating on designs through CAD drawings. Additional student feedback highlighted how students were able to incorporate a chronological display of constructing and testing their model.



Collaboration

Student responses highlight how digital notebooks enable collaboration through shareability and simultaneous editing. Physical notebooks were viewed as more personal but less suited for collaborative environments due to only having one copy and one individual working in it at a time. Furthermore, digital tools afford an opportunity for tracking changes and monitoring student collaboration efforts.

TASK TITLE	TASK OWNER	START DATE	DUE DATE	DURATION	PCT OF TASK COMPLETION	Progress Tracking											
						10/29	10/31	11/5	11/12	11/14	11/18	11/21	11/24	12/3			
Iteration Phase																	
Diversity and Design	Ah	10/28/24	10/29/24	0	100%												
Identify Problems	Ah	10/29/24	10/31/24	2	100%												
Gantt Chart	Ah	10/29/24	11/5/24	6	100%												
Research Specifications (e.g. dimension, etc)	Tyler	11/5/24	11/5/24	0													
Ideate Design Choices	Ah	11/5/24	11/5/24	0													
Simulation Design	Lucas	11/5/24	11/5/24	0													
Theme	Ah	11/5/24	11/5/24	0													
Generate Concept Drawings	Ah	11/5/24	11/5/24	0													
Generating Solutions																	
Create a Final Sketch	Ah	11/5/24	11/21/24	7													
Construct a Digital Model	Ah	11/19/24	11/19/24	7													
3D Print Model	Ah	11/19/24	11/21/24	2													
Testing																	
Fit Test Using Trainer	Ah	11/26/24	11/26/24	5													
Presentation																	
Create a Presentation	Lucas	11/19/24	12/3/24	13													
Present to Class	Ah	12/3/24	12/3/24	0													

Usability and Accessibility

Students reporting using the digital format found that the mode of notebook was easier to organize and revise. Features such as typing, handwriting using a stylus, hyperlinking, and image insertion supported flexible documentation, and the ability to access files across devices improved convenience. However, some, at times, faced technical issues such as poor internet connectivity or limited platform familiarity, emphasizing the need for reliable infrastructure and user training.

Support for Engineering Discourse

Evidence of applying practices from STEL supports that digital notebooks provide an opportunity for engineering discourse involving the communication of design ideas through text, graphics, sketches, models, and other forms of multimedia integration. Student responses show that these features made design reasoning more explicit, and notebooks mirrored professional practices found in a variety of current industries. Some participants also appreciated easier collaboration and feedback exchange via online digital tools. Others preferred handwritten notebooks, citing greater creative flow, suggesting that hybrid approaches may best accommodate different learning styles.

Teacher Considerations

Implementing digital notebooks requires careful attention to platform selection, accessibility, and training. Teachers should ensure that digital tools are intuitive and compatible with existing classroom technologies. Structured templates and rubrics help guide students to focus not just on results but on reasoning and reflection—core elements of engineering discourse.

Educators may also need professional development to effectively use and assess digital notebooks. Providing open-access templates aligned with design stages and STEL standards can streamline adoption and promote consistency. Integrating digital documentation further aligns classroom practice with professional engineering environments, giving students early exposure to authentic tools and workflows.

Implications for Practice

Findings suggest that digital engineering notebooks can strengthen technological and engineering literacy by promoting authentic documentation, reflection, and communication. For successful implementation, educators should introduce notebooks alongside instruction on engineering discourse and design documentation to clarify purpose and expectations. Teachers should also use STEL-aligned templates to connect documentation with learning standards if they have an established comfort level with such tools. With this in mind, it may also be beneficial for teachers to practice flexibility in providing documentation tools between digital and physical formats based on access and learning preferences.

In technology and engineering education, engineering notebooks have long documented the design process. As digital tools become central to professional practice, introducing digital documentation helps prepare students for authentic engineering experiences. To support this, the research team is developing an open-access structured digital engineering notebook template for both learning and

assessment. While standardized physical notebook templates are common, few classroom-tested interactive structured digital versions exist.

The project also includes the development of professional development resources to help teachers integrate digital notebooks and related industry practices. Rather than promoting one format over another, this approach expands educators' options and encourages flexibility in student documentation. The Version 1 digital notebook template linked in Figure 1 is openly available under a Creative Commons Attribution 4.0 International License (CC BY 4.0), allowing educators to freely share, adapt, and apply it with appropriate attribution.

Figure 1: QR Codes for Open Access Engineering Notebook Template



https://go.ncsu.edu/engineering_design_notebook

Conclusion

Engineering notebooks remain vital for teaching the design process, reflection, and communication skills central to technological and engineering literacy. As education continues to integrate digital tools, open-access digital engineering notebooks offer opportunities to make learning more authentic, accessible, and aligned with modern engineering practice.

This study demonstrates that digital engineering notebooks effectively support engineering discourse and key STEL practices, though successful adoption requires addressing implementation challenges related to equitable access and adequate user training. Future research will refine these tools and explore their impact on collaboration, systems thinking, and long-term learning outcomes in technology and engineering education.

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