Reducing Digital Friction in K–12 Learning

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Abstract

This research proposal investigates how reducing digital friction can help close the intention–action gap in K–12 learning. At Oceanside High School, students often needed five to seven steps—sometimes multiple logins—to complete simple assignments on Chromebooks using Google Classroom and Drive. Building on cognitive load theory (Sweller, 1988) and the Fogg Behavior Model (2009), this study will test whether simplifying micro-flows through single sign-on and one-screen submission can improve student efficiency, completion, and perceived usability. A mixed-methods design will combine quantitative data (step counts, completion rates, usability and workload scores) with qualitative feedback from students and teachers to capture both measurable and experiential aspects of friction. Preliminary literature shows that platform overload, extraneous cognitive load, and inequitable access disproportionately hinder multilingual learners and students with executive-function challenges. The proposed research will evaluate whether streamlining workflows can reduce unnecessary cognitive effort, save instructional time, and promote equitable participation. Limitations include a small sample, localized context, and possible novelty effects, but the findings could inform future standards for K–12 user-experience design and digital equity initiatives. By integrating learning science, design, and ethics, this proposal aims to provide practical insights for making educational technology simpler, fairer, and more human-centered for all users.

Keywords: *digital friction, intention–action gap, cognitive load, usability, K–12 learning, single sign-on, mixed methods*

Reducing Digital Friction in K–12 Learning

The research focuses on digital friction–the avoidable effort within digital workflows that slows or interrupts task completion–and its connection to the intention–action gap in K–12 digital learning environments: authenticate → open → act → acknowledge feedback. At Oceanside High School, where I mentored students through AmeriCorps on Chromebooks with Google Classroom and Drive, a simple task often took five to seven steps (sometimes with extra logins). Students also forgot about available resources at the moment of need. These conditions add extraneous cognitive load and slow decision-making, resulting in missed starts, delayed submissions, and long feedback loops (Sweller, 1988; Proctor & Schneider, 2018). At scale, districts now expose learners to many different tools each year, which increases variability and inconsistency in common flows (Instructure, 2025). The problem is practical and actionable: reduce avoidable steps and re-authentications so students initiate work faster, complete more consistently, and receive feedback sooner (EDUCAUSE, 2024; National Institute of Standards and Technology, 2025).

History

Over the past decade, schools layered learning management systems (LMS) with cloud storage platforms (e.g. Google Drive), assessment applications (e.g., Kahoot!, Quizizz), and content tools (e.g., Nearpod, Edpuzzle), often adding rather than consolidating platforms (EDUCAUSE, 2024). Google Classroom's rise simplified some workflows, but in many districts it was added alongside an existing LMS, creating parallel patterns students had to learn. Single sign-on (SSO) emerged to tame multiple logins; however, its coverage and quality vary by district and by vendor integration. Federal digital identity guidance continues to evolve with explicit usability and equity considerations, underscoring the tradeoffs between security and ease

(NIST, 2025). Meanwhile, the number of ed-tech tools in use keeps climbing. A recent analysis showed increasing numbers of unique tools used per year by students and teachers, which compounds inconsistency in day-to-day tasks (Instructure, 2025). Cognitive load theory helps explain why this matters: unnecessary steps and split attention impose extraneous load that overwhelms learners' working memory and hinders the transfer of information into long-term memory (Sweller, 1988). Human-computer interaction (HCI) research adds that more choices and steps increase decision time and errors (Proctor & Schneider, 2018). Prior fixes often focused on digital literacy and workarounds rather than removing structural friction, so the underlying flows remained fragmented.

Current State

In my context, a common path is to open Google Classroom, follow a link, re-authenticate, find the activity, attach a file from Drive, and confirm. The path changes by class or tool. Notably, students with executive-function challenges, multilingual learners, and those with limited bandwidth are hit hardest by these inconsistencies. National indicators suggest why urgency is warranted: districts and learners now interact with a high volume of distinct tools annually, increasing the odds of inconsistent patterns and extra steps (Instructure, 2025). EDUCAUSE trend analyses also emphasize usability, integration, and learner support as near-term priorities for teaching and learning (EDUCAUSE, 2024). At the same time, security requirements (e.g., stronger authentication) can add steps that reduce ability at the exact moment a prompt to act arrives (Fogg, 2009; NIST, 2025). Consistent with learning-science evidence on productive struggle, we differentiate pedagogical difficulty that deepens learning from technical friction that merely taxes working memory (Kulesa et al., 2025)

Not all friction is negative, some is purposeful. For example, two-factor authentication or a confirm-before-submit step can prevent errors or protect data. The challenge is to distinguish necessary security safeguards from avoidable burdens and to design solutions that protect data while minimizing disruption to learning.

Implications for Learning Design

This problem highlights several learning needs and gaps. Students often intend to engage with their work but lose momentum during the authenticate → open → act → feedback loop. The gap is not primarily about content knowledge but about navigating systems. Learners need clear entry points, consistent patterns, and faster feedback loops so that students' attention remains on the learning task rather than on navigating the platform. While students with executive-function challenges and multilingual learners are particularly affected, all learners benefit from a more seamless digital process that reduces unnecessary cognitive effort and keeps attention on the learning task.

Instructional design can help address the problem by shaping both the learner experience and teacher practice. One approach is to develop standardized submission templates and one-screen workflows that minimize unnecessary steps. Professional development for teachers can emphasize designing assignments with consistent patterns, clear labels, and visible progress indicators. Training can also support teachers in integrating SSO-enabled tools and in giving timely, actionable feedback within the same environment where students complete work.

Different learner contexts matter. For example, high school students balancing multiple classes and limited home access benefit from frictionless flows that work equally well on Chromebooks, phones, or low-bandwidth connections. All learners benefit from clear visual cues, consistent design patterns, and default settings that reduce the likelihood of procedural errors and support sustained focus.

This issue can also be addressed through delivery and support systems. Curriculum design that incorporates friction audits–systematic reviews of each step in a digital learning task to identify unnecessary actions or usability barriers–can help surface and address hidden barriers that impede access, slow task completion, or hinder learning outcomes. Resource decisions at the district level, such as implementing pass-through SSO, can structurally reduce logins. Finally, support systems can embed nudges and reflection prompts to help students reinforce learning once the task is complete. In short, learning design that prioritizes clarity, consistency, and cognitive simplicity can mitigate digital friction and help close the intention–action gap.

Literature Review

Problem Statement

K–12 students increasingly navigate fragmented digital micro-flows to complete routine work: authenticate → open → act → acknowledge feedback. In my AmeriCorps mentoring at Oceanside High School (Chromebook + Google Classroom/Drive), common tasks took 5–7 steps and sometimes one or two extra logins. Each additional step adds extraneous cognitive load (Sweller, 1988) and slows decision-making (Proctor & Schneider, 2018), widening an intention–action gap where students intend to work but do not initiate or complete. Nationally, districts juggle many tools (EDUCAUSE, 2024; Instructure, 2025). Stronger authentication policies can also add steps unless designed for usability and equity (NIST, 2025). The students most affected include multilingual learners, those with executive-function needs, and learners with limited time/bandwidth, making this both a usability and equity problem.

Definition of Terms

- **Digital friction.** Avoidable effort in a digital workflow (e.g., re-logins, extra clicks, inconsistent UI) that slows or derails goal completion; in education, it diverts attention from learning to navigation (EDUCAUSE, 2024).
- **Cognitive load.** The total mental effort used in working memory; learning improves when extraneous load from nonessential steps/interface complexity is minimized (Sweller, 1988).
- **Intention–action gap.** The discrepancy between intending to act and actually acting; behavior occurs when motivation, ability (ease), and a prompt co-occur, so friction reduces ability at the moment of action (Fogg, 2009).
- **Single sign-on (SSO).** An identity approach allowing one authentication to access multiple integrated apps; reduces credential burden and supports equitable access when implemented with usability safeguards (NIST, 2025).
- **Usability (SUS).** Perceived ease-of-use of a system; the 10-item System Usability Scale (SUS) is a validated, low-cost measure suitable for quick comparisons of flows (Brooke, 2013).

Preliminary Findings

A review of recent scholarship and professional reports highlights three recurring themes related to digital friction in K–12 learning. First, tool and platform overload creates inconsistent flows for students, as districts stack multiple systems with uneven integration. Second, cognitive load research and usability studies show how extra steps and fragmented workflows impose unnecessary mental effort, slowing decisions and reducing task completion. Third, equity analyses demonstrate that multilingual learners, students with disabilities, and those with limited bandwidth or devices are disproportionately burdened by friction. Together, these findings illustrate how technical design, human cognition, and systemic inequities intersect to impact students' ability to start, sustain, and complete digital tasks.

Theme 1: Tool/platform overload and inconsistent flows

K–12 systems layered LMS, Google Workspace, and many apps, increasing variability in routine tasks (EDUCAUSE, 2024). Districts frequently run **dual ecosystems** (e.g., Google Classroom alongside Canvas/Schoology), creating parallel patterns that students must learn and re-learn (Instructure, 2025). State-level briefs flag **access friction** and propose SSO to reduce repeated logins (Office of Superintendent of Public Instruction, 2023). Together, these sources indicate structural fragmentation that produces unnecessary steps and divergent submission experiences across classes. Recent market telemetry confirms this fragmentation; districts average thousands of distinct tools annually, and secondary students engage with dozens, producing inconsistent patterns students must repeatedly relearn (Instructure, 2025). Together, these sources indicate that the proliferation of tools without coherent workflow patterns reliably increases extraneous steps that impede student follow-through.

Theme 2: Cognitive load and usability barriers

Extraneous steps and scattered screens impose extraneous cognitive load, leaving less working memory for the task itself (Sweller, 1988). Choice complexity (more options/steps) slows decisions and raises error likelihood (Proctor & Schneider, 2018). Design best practices emphasize minimizing steps and adding progress indicators or just-in-time help to keep learners on track (Sherwin, 2014). Evidence frameworks in e-learning also tie system quality and usability to use and satisfaction (Al-Fraihat et al., 2020). Design choices aligned to Universal Design for Learning reduce extraneous barriers while retaining appropriate effortful tasks

(Almeqdad et al., 2023). Across studies, friction inflates extraneous cognitive load; reducing step increases ability and should raise usability and speed to action.

Theme 3: Equity and access gaps

Digital friction disproportionately affects multilingual learners and students with disabilities when interfaces, instructions, and support are not accessible (GAO, 2020). Even in 2022, national surveys show many teens still complete schoolwork primarily on smartphones and face intermittent connectivity, conditions that magnify multi-step, multi-app friction outside school (Pew Research Center, 2022). The homework gap persists: many teens still lack reliable computers or internet and resort to doing homework on phones, compounding friction from multi-app flows (Pew Research Center, 2022). Authentication policies that increase steps without usability accommodations can further reduce ability from the start (NIST, 2025). Equity-minded design implies multilingual supports, consistent patterns, offline-tolerant flows, and minimal authentications. Evidence suggests friction magnifies existing inequities, making workflow design a practical lever for access, not a mere convenience.

While reports and usability guidance describe friction and recommend remedies, few K-12 empirical studies experimentally test whether reducing workflow steps measurably improve time-to-first action, completions, and perceived usability in authentic coursework. This study addresses that gap.

Research Design

The purpose of this study is to examine whether reducing the number of steps and authentications in routine digital workflows improves time-to-first-action, assignment completion rates, and perceived usability for high school students using Chromebooks in a Google Classroom ecosystem. This study addresses the intention–action gap in K-12 learning by testing a friction-minimal design (one-screen submission, single sign-on) against the current multi-step flow. By focusing on common micro-flows such as assignment submission, the research seeks to generate actionable insights for instructional design, system integration, and equitable access in digital learning environments.

Participants

The participants will be approximately 50–60 high school students (ages 14–18) enrolled in two classes at a public school where Chromebooks and Google Classroom are standard. These students are daily users of the systems under study and reflect diverse needs, including multilingual learners and students with executive function challenges. The decision to select this population is based on both access and relevance: high school students are frequent users of these digital workflows, and friction in their learning processes has immediate academic consequences. Teachers in the selected classes will also contribute observational notes, enriching the qualitative data.

Research Questions

These research questions flow directly from the purpose, examining both structural elements (step count, logins) and perceptual elements (usability, satisfaction) of digital friction.

RQ1: How do step count and repeated logins affect time-to-first-action and completion of routine assignments in a Google Classroom ecosystem?

RQ2: To what extent does a friction-minimal workflow (e.g., one-screen submission with pass-through Single Sign-On) improve students' perceived usability and task completion compared with the current flow?

Design Overview

This study employs a mixed-methods design. Quantitative measures (step counts, time logs, completion rates, usability survey scores) provide objective data on workflow efficiency, while qualitative measures (student reflections, teacher observations) capture subjective experiences of friction. A mixed-methods approach is most appropriate because it connects measurable outcomes with lived experience, ensuring that findings are both rigorous and grounded in the perspectives of actual learners (Creswell & Creswell, 2018).

This quasi-experimental mixed-methods study compares two intact high-school classes completing the same assignment sequence over two weeks. Control uses the current multi-step Google Classroom workflow; Treatment uses a friction-minimal prototype (single sign-on, one-screen submission). Assignment prompts, rubrics, and due dates are identical. Students receive a 5-minute orientation to their workflow to reduce novelty effects. Data include (a) system logs (step counts; repeated authentications; time-to-first-action from assignment release), (b) completion records, (c) SUS (usability) and NASA-TLX (workload), and (d) two open-ended prompts plus brief teacher observational notes focused on observed blockers and ease cues.

Variables. Independent variable: workflow type (standard vs friction-minimal). Mediators of interest: steps; repeated authentications. Dependent variables: time-to-first-action (seconds), completion (submitted/not), SUS score (0-100), NASA-TLX (overall effort/mental demand).

Data Collection and Analysis

To answer the research questions, this study will combine quantitative and qualitative measures in alignment with a mixed-methods design (Creswell & Creswell, 2018). Data collection will capture both efficiency and perception. Efficiency will be measured using system logs and assignment records, while perception will be assessed through validated usability and workload instruments. Perceived workload will be assessed using the NASA Task Load Index, which asks students to rate dimensions like mental demand (Hart & Staveland, 1988). Using SUS provides a validated usability benchmark that is comparable across interface variants; paired with NASA-TLX we capture perceived workload linked to cognitive load (Hart & Staveland, 1988). Surveys will be administered digitally using Google Forms, the school's standard platform for classroom feedback. Short, open-ended survey items (e.g., "What frustrated you most about this process?") and teacher observational notes will complement the quantitative data by revealing lived experiences of friction (Al-Fraihat et al., 2020). A mixed-methods design is warranted because quantitative deltas (steps, completion, SUS, NASA-TLX) establish whether a friction-minimal flow improves outcomes, while qualitative reflections and teacher notes explain why specific steps felt easier or harder (Hart & Staveland, 1988).

Quantitative Data

- **Step counts and time-to-first-action:** Tracked through system log data, a standard efficiency metric (Nielsen, 1993).
- **Completion rates:** Recorded automatically within Google Classroom.
- **System Usability Scale (SUS):** 10-item validated instrument for perceived usability (Brooke, 2013).
- **NASA Task Load Index (NASA-TLX):** Adapted for student workload perception (Hart & Staveland, 1988), tied to cognitive load theory (Sweller, 1988).
- Both SUS and NASA-TLX are widely used, validated instruments, lending reliability for the data collected.

Qualitative Data

- **Student surveys:** Short open-ended prompts such as What frustrated you most about this submission process? and What made it easier to complete your work?
- **Teacher notes:** Observations of where students hesitated, asked for help, or bypassed steps.
- All participating students (approximately 50–60) will complete SUS and NASA-TLX surveys, while two classroom teachers will contribute observational notes.

Figure 1

Friction Funnel Mapping the Chromebook/Google Classroom Workflow

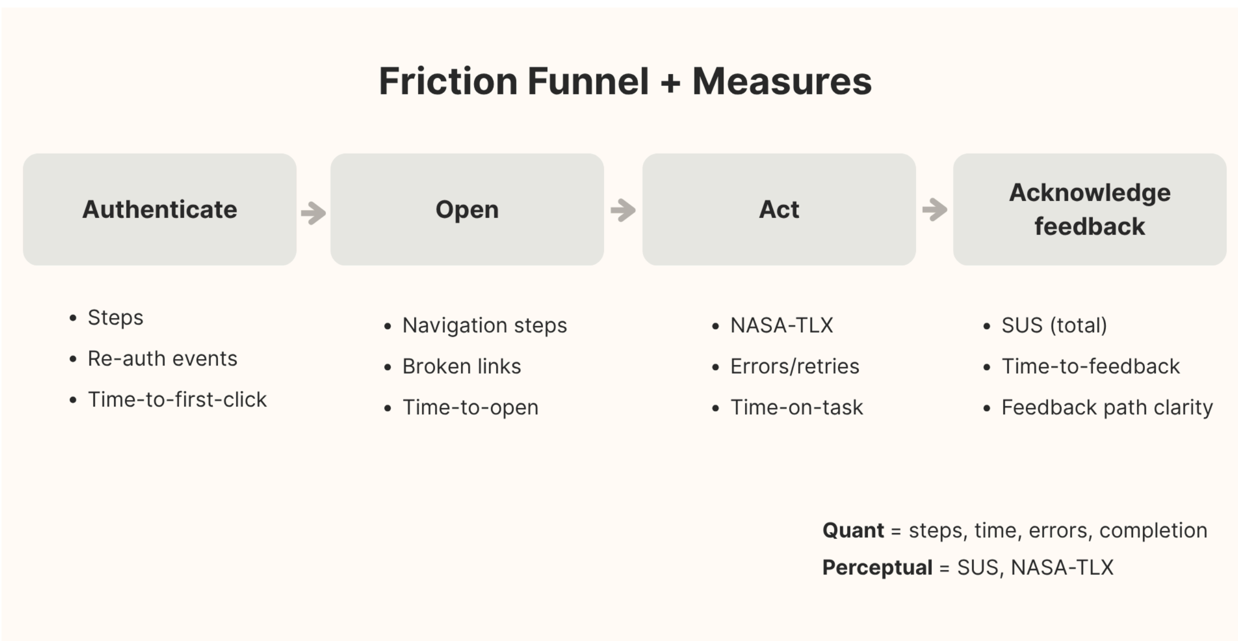

Figure 1. Friction funnel mapping the Chromebook/Google Classroom workflow (authenticate → open → act → acknowledge feedback) to planned quantitative and perceptual measures (steps/time/errors; SUS; NASA-TLX).

Note. This figure illustrates the data collection framework for the study, mapping each phase of the Chromebook/Google Classroom workflow—Authenticate, Open, Act, and Acknowledge Feedback—to its corresponding quantitative (steps, time, errors) and perceptual (SUS, NASA-TLX) measures.

Analysis

Quantitative data (steps, time, completion rates, SUS scores, workload ratings) will be analyzed using descriptive statistics, t-tests, and chi-square tests to compare outcomes across groups. Qualitative responses will be coded thematically, and teacher notes will be analyzed for recurring patterns. The integration of results will allow triangulation of data, providing both measurable outcomes and contextual understanding of student experiences.

Table 1

Aligning the Purpose Statement, Research Questions, Data Collection, and Analysis Methods

Purpose Statement: Examine whether reducing steps/authentications improves student efficiency, completion, and usability.		
Research Questions	Data Collection	Data Analysis
1. RQ1: How do step count and repeated logins affect time-to-first-action and completion of routine assignments?	Step counts, time logs, assignment completion rates	Descriptive stats, t-tests, chi-square
2. RQ2: To what extent does a friction-minimal workflow improve perceived usability and task completion?	SUS survey, cognitive load rating, student reflections, teacher observations	Mean SUS scores, workload ratings, thematic coding of qualitative responses

Conclusion

This study proposed a research plan to investigate how reducing digital friction can help close the intention–action gap in K–12 learning workflows. In conclusion, the major themes from the literature highlight platform overload, cognitive load, and equity issues, all of which inform the study's design. Key ethical considerations (participant consent, privacy) and limitations (small, single-school sample, researcher bias) frame the study's interpretive scope. Finally, this process has prompted critical reflections on bridging theory and practice in learning design.

Summary of Findings

Across the literature, three recurring themes emerged: platform overload and inconsistent flows, cognitive load and usability barriers, and equity and access gaps. Research shows that K–12 students are now expected to navigate multiple learning management systems and apps, often requiring several authentications and clicks to complete basic tasks (EDUCAUSE, 2024; Instructure, 2025). Each additional step introduces confusion, delay, or dropout, creating structural friction that reduces engagement and completion rates.

Cognitive load theory (Sweller, 1988) helps explain why: unnecessary interface complexity imposes extraneous mental effort, diverting attention from learning. Human–computer interaction research further confirms that more choices and steps increase decision time and error likelihood (Proctor & Schneider, 2018). Finally, evidence from the GAO (2020) and Pew Research Center (2022) shows that these barriers do not impact all students equally—multilingual learners, students with disabilities, and those lacking reliable devices or internet experience the highest levels of digital friction.

Together, these findings indicate that friction in learning technologies is not merely an inconvenience but a design and equity issue. The proposed study seeks to test whether a one-screen submission flow and single sign-on can measurably improve efficiency, usability, and completion—providing empirical evidence to guide future learning design and policy decisions.

Ethical Considerations and Limitations

This research involves human participants—specifically, high-school students—so ethical care is essential. Informed consent and assent will be obtained from both students and their parents or guardians, and participation will be entirely voluntary. Surveys will be anonymous to protect privacy, and all data will be stored on password-protected systems following district and FERPA guidelines. As a mentor-researcher, I must remain conscious of potential power dynamics; students should never feel that their participation or performance affects their standing in class.

Equity and inclusion principles guide the design of the study. Surveys will be offered in accessible, simplified language with translation support when needed. Students with learning differences or executive-function challenges will be provided with extra guidance and time. The study's focus on usability inherently requires sensitivity to participant well-being—reducing frustration, not adding it.

Key limitations include the relatively small sample (~50–60 students) a single-school context, which may limit generalizability. Thus, findings will be viewed as exploratory for this context. The researcher's prior mentoring role also introduces potential bias, mitigated through standardized instruments (System Usability Scale, NASA-TLX) and objective completion metrics. Lastly, novelty effects may influence behavior; students might perform differently simply because the interface is new or more visually engaging.

Reflections

Conducting this research proposal illuminated how deeply user experience, cognitive science, and equity are intertwined in digital education. I learned that engagement issues often stem not from student motivation but from the invisible friction built into the systems they must navigate. The literature revealed how even small usability improvements—fewer clicks, clearer feedback, unified logins—can produce meaningful gains in access and follow-through.

Designing this proposal reinforced the importance of objectivity and reflection in educational research. My mentoring experience raised awareness of these barriers, and grounding those observations in empirical evidence helped me distinguish systemic issues from anecdotal ones. Moving forward, I hope to translate this work into pilot studies that partner with schools to conduct friction audits and prototype one-screen learning flows.

The potential impact of this research extends beyond one classroom. Streamlining digital workflows can save instructional time, reduce frustration for teachers and students alike, and promote greater equity by ensuring that effort is spent on learning—not on navigating technology. This process has strengthened my professional identity as a learning designer who bridges theory, design, and practice to make education more efficient, inclusive, and humane.

References Al-Fraihat, D., Joy, M., Masa'deh, R., & Sinclair, J. (2020). Evaluating e-learning systems success: An empirical study. *Computers in Human Behavior, 102*, 67–86. https://doi.org/10.1016/j.chb.2019.08.004

Almeqdad, Q. I., Alodat, A. M., Alquraan, M. F., Mohaidat, M. A., & Al-Makhzoomy, A. K. (2023). The effectiveness of universal design for learning: A systematic review of the literature and meta-analysis. *Cogent Education, 10*(1), 2218191. https://doi.org/10.1080/2331186X.2023.2218191

Brooke, J. (2013). SUS: A retrospective. *Journal of Usability Studies, 8*(2), 29–40. https://uxpajournal.org/sus-a-retrospective/

Brooke explains the reliability and enduring relevance of the System Usability Scale (SUS) as a quick, standardized measure of perceived usability. I use this source to justify SUS as a practical instrument for comparing student experiences across current and streamlined workflows.

Creswell, J. W., & Creswell, J. D. (2018). *Research design: Qualitative, quantitative, and mixed methods approaches* (5th ed.). Sage.

EDUCAUSE. (2024). *2024 EDUCAUSE Horizon Report: Teaching and learning edition.* EDUCAUSE. https://library.educause.edu/resources/2024/5/2024-educause-horizon-report-teaching-and-learning-edition

This annual report identifies usability, integration, and learner support as leading challenges for educators adopting new technologies. It positions my study within a national context emphasizing workflow simplification as a critical factor for equitable and effective digital learning.

Fogg, B. J. (2009). A behavior model for persuasive design. *Proceedings of the 4th International Conference on Persuasive Technology,* 40. https://doi.org/10.1145/1541948.1541999

Fogg's model shows that action occurs when motivation, ability, and a prompt align. My research builds on the "ability" component by testing whether simplifying student workflows increases ease of action and therefore raises task initiation and completion rates.

Hart, S. G., & Staveland, L. E. (1988). Development of NASA-TLX (Task Load Index): Results of empirical and theoretical research. In P. A. Hancock & N. Meshkati (Eds.), *Human mental workload* (pp. 139–183). North-Holland Press.

Hart and Staveland describe the six-dimension NASA-TLX scale that quantifies perceived workload and mental effort. This framework supports my inclusion of TLX ratings to measure how much cognitive demand students experience in complex versus simplified digital processes.

Instructure. (2025, June 30). *New LearnPlatform by Instructure report shows K-12 districts are more selective about the tools they use* [Press release]. Instructure. https://www.instructure.com/press-release/new-learnplatform-instructure-report-shows-k-12-districts-are-more-selective-about

The Instructure report compiles national telemetry showing that districts still rely on hundreds of separate digital tools each year. While not peer-reviewed, it offers credible descriptive data supporting my argument that fragmented ecosystems create inconsistent and inefficient student workflows.

Kulesa, A. C., Mission, M., Croft, M., & Wells, M. K. (2025). *Productive struggle: How artificial intelligence is changing learning, effort, and youth development in education*. Bellwether Education Partners. https://bellwether.org/publications/productive-struggle/

Nielsen, J. (1993). *Usability engineering*. Academic Press.

National Institute of Standards and Technology. (2025). *Digital identity guidelines: Authentication and authenticator management* (SP 800-63B-4, 4th rev.). NIST. https://csrc.nist.gov/pubs/sp/800/63/b/4/final

NIST's most recent digital identity guidelines balance security assurance with usability and accessibility. This source underpins my argument that implementing single sign-on aligns with national standards that value both secure authentication and frictionless user experiences.

Office of Superintendent of Public Instruction. (2023). Creating efficiencies through single sign-on. https://ospi.k12.wa.us/sites/default/files/2023-08/pl-single-sign.pdf

Pew Research Center. (2022). *How teens navigate school during COVID-19*. https://www.pewresearch.org/internet/2022/06/02/how-teens-navigate-school-during-covid-19/

Proctor, R. W., & Schneider, D. W. (2018). Hick's law for choice reaction time: A review. *Quarterly Journal of Experimental Psychology, 71*(6), 1281–1299. https://doi.org/10.1080/17470218.2017.1322622

Sherwin, K. (2014). *Progress indicators make a slow system less insufferable*. Nielsen Norman Group. https://www.nngroup.com/articles/progress-indicators/

Sweller, J. (1988). Cognitive load during problem solving: Effects on learning. *Cognitive Science, 12*(2), 257–285. https://doi.org/10.1207/s15516709cog1202_4

Sweller's experiments demonstrated that when learners must navigate unnecessary steps, their limited working memory becomes overloaded, hindering long-term learning. This study grounds my argument that excessive clicks or fragmented workflows create extraneous cognitive load that slows student performance in digital classrooms.

U.S. Government Accountability Office. (2020). Distance learning: Challenges providing services to K–12 English learners and students with disabilities during COVID-19 (GAO-21-43). https://www.gao.gov/assets/gao-21-43.pdf

This federal report highlights how English learners and students with disabilities encountered significant digital access barriers during remote learning. It strengthens my claim that reducing technical friction is an essential equity measure, not merely a convenience.