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Current State of Research in Fully Remote Engineering Capstone Pedagogy

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Abstract

Prior to and further necessitated by the COVID pandemic, engineering industry has found utility in remote partnerships, thus the need for engineers trained in online collaboration methods. Providing an opportunity for experiential learning during fully remote collaboration is critical for online engineering curriculums. Capstone design is a team-based experience for all seniors in engineering, where student teams are given the opportunity to work with a sponsor to develop a solution to their design problem. These multidisciplinary experiential learning opportunities are often the highlight of an undergraduate student's curriculum, and most engineering majors must complete a multiple-course senior capstone design sequence. The key challenge is how to scale traditionally hands-on centric capstone design pedagogy to an online platform (both synchronous and asynchronous). An additional constraint is these pedagogical methods will need to meet both institutional and external (i.e., Accreditation Board for Engineering and Technology (ABET)) requirements. It is critical to identify and create best practices that will support both students and sponsors to ensure the achievement of educational requirements (e.g., ABET, technical writing), project deliverables, and student success. The research goal is to identify collaborative techniques to support project mentors (e.g., instructors, industry partners, faculty) and student teams, and help determine the type and scope of projects best suited for remote collaboration. In addition, we aim to investigate how to determine teaming strategies for fully remote teams appropriate to the various expectations of project outcomes (computational/theoretical solutions versus physical prototypes, for example), and how to get students both excited and engaged with fully remote sponsors. This paper presents the current state of research and efforts in the realm of remote collaboration of engineering teams, online engineering capstone course pedagogy, and online engineering capstone (or equivalent) projects with external sponsors. The synthesis of this literature review will guide future work in assessing the quality of experience in multidisciplinary engineering capstone between in-person students and sponsors and those that are fully remote.

Keywords: multidisciplinary, literature review, fully remote, sponsor, capstone, pedagogy, senior design, online education

Introduction

Fully remote engineering capstone design has garnered increasing attention in recent years, initially spurred by technological advances, but further catalyzed by the COVID-19 pandemic [1], [2], [3]. In-person capstone courses traditionally rely on physical proximity, both for sponsor engagement and for hands-on prototyping. Transitioning these experiences to fully online modes introduce challenges around synchronous/asynchronous communication, sponsor management, and alignment with ABET standards [4], [5]. Additionally, remote environments can exacerbate difficulties that students already face in team-based design, including the management of diverse schedules, uneven participation, and unclear communication. Belanger et al. [6] further highlight that students in remote design collaborations frequently struggle with technology-driven communication barriers, discomfort in sharing visual materials via digital tools, and maintaining motivation over longer project timelines, all of which can hinder effective teamwork. Recent institutional reports show that, even after campuses reopened, roughly 5–15 % of U.S. STEM seniors still complete their capstone projects fully online, almost entirely through large-enrollment distance-education programs at Arizona State University, Oregon State University (Ecampus), Western Governors University, and the University of North Dakota [7][8][9][10].

Several recent works underscore that remote capstone can indeed meet many of the key learning outcomes if carefully designed [1], [2], [11]. However, questions persist about replicating the spontaneous collaboration and lab-based prototyping typical of on-campus courses [12]. Sclater et al. [5], in an older (circa 2001) but highly relevant study, illustrate how online collaborative design teams encounter "communication breakdowns" unless robust frameworks are in place. In addition, Howe and Goldberg emphasize that capstone design programs have steadily evolved to adopt more innovative structures, sponsor relationships, and scaffolding mechanisms, yet their recommendations generally assume an on-campus or hybrid context [13]. Fully remote models, therefore, require further adaptation to ensure these emerging trends in capstone design still fulfill ABET standards and deliver meaningful sponsor engagement. Remote-education scholarship confirms a post-pandemic tilt toward flexible "blended" delivery. A systematic review of 68 higher-education studies found that the emerging default is a hybrid mode that preserves online affordances while restoring selective in-person touch-points [14]. Meanwhile, Goñi et al. [15] suggests that fully virtual or distributed teamwork often requires explicit strategies for conflict resolution and shared mental models.

ABET guidelines [16] do not explicitly prescribe how to execute the culminating design experience when all stakeholders, students, faculty, sponsors, are physically separated. Nonetheless, examples of successful fully remote capstone courses have been documented [1], [2], [11], [12]. This paper aims to synthesize the current state of research on fully remote engineering capstone pedagogy, highlighting common themes (communication tools, sponsor involvement, ABET alignment, and social aspects) and identifying gaps needing further study or new frameworks.

With so much variability across remote course designs and sponsor arrangements, it becomes necessary to consolidate findings from diverse studies that have explored online capstone delivery. The following research questions were formulated to guide that consolidation process and to pinpoint the principal benefits, difficulties, and accreditation considerations specifically pertaining to fully remote engineering capstone instruction. By framing these questions systematically, this work attempts to reveal key areas of consensus among existing studies, while also identifying gaps that require additional scrutiny or fresh pedagogical frameworks.

Research Questions

1. **Benefits and Challenges:** What are the primary advantages and difficulties encountered in fully remote engineering capstone teams, particularly regarding sponsor interactions and student engagement?

2. **Implementation Strategies:** Which practices (tools, scheduling methods, sponsor relationships) effectively promote inclusivity, engagement, and meaningful outcomes for remote engineering design projects?
3. **Accreditation & Outcomes**: To what extent do fully remote capstone experiences fulfill ABET or institutional requirements, and how might instructors adapt these guidelines?

The existing literature offers partial insights, some references target remote/hybrid transitions [2], [17], while others examine older distributed design or partially online approaches [5]. Few, however, focus exclusively on 100% remote plus ABET compliance.

Data Collection and Methods

A systematic review methodology was employed to identify and synthesize existing literature on remote engineering capstone projects. This approach was chosen to ensure a comprehensive and reproducible identification of relevant works, minimizing biases while capturing a broad range of perspectives. First, a set of search keywords (e.g., "remote capstone," "multidisciplinary teams," "engineering pedagogy," "shared mental models," "COVID-19 engineering education", "asynchronous learning") was generated. The search was conducted across IEEE Xplore, Springer, and ASEE digital libraries, as well as Google Scholar for cross-checking any missed articles.

Studies were deemed relevant if they (1) described capstone or culminating engineering design courses that were fully or predominantly remote, (2) discussed sponsor involvement or multi-team collaboration, (3) provided explicit attention to ABET-related outcomes or the equivalently stated culminating learning objectives, or (4) investigated social and collaborative dynamics of remote engineering student teams. After removing duplicates, titles and abstracts were screened to exclude papers addressing topics unrelated to capstone or advanced design experiences. The remaining full-text articles were then reviewed to verify that they aligned with the research questions and offered substantial findings or theoretical contributions.

A total of 57 records were retrieved across three databases. As seen in Table 1, of those 57, 34 were excluded (12 were not capstone-focused, 14 described hybrid-only courses, and 8 lacked empirical data).

Table 1. Literature Search and Screening Outcomes

Screening Stage	Records (n)
Google Scholar	28
ASEE	20
IEEE Xplore	9
Total Records Identified	**57**
Full texts excluded – not capstone focus	12
Full texts excluded – hybrid only	14
Full texts excluded – lacks empirical data	8
Studies Included	**23**

Results

The following section is organized by two main subsections: (1) benefits and challenges of online multidisciplinary capstone teams and (2) implementation strategies for enhancing online capstone projects. These two themes were discovered during the literature search in order to better categorize the work found.

1. Benefits and Challenges of Online Multidisciplinary Capstone Team

A growing number of publications and practical experiences illustrate that fully remote capstone endeavors can yield substantive benefits for both students and sponsors provided that social, technical, and pedagogical structures are well-designed [1], [2], [5]. Simultaneously, these programs face unique challenges, particularly in domains where hands-on prototyping or immediate sponsor feedback are traditionally vital [4], [12], [17]. Below is a synthesis of the major advantages and difficulties that frequently emerge in the literature.

1.1 Communication Tools and Scheduling Adaptability

Older references, like Sclater et al. [5], stress the importance of multi-modal communication for “online collaborative design projects.” They found that “pre-lab” or “pre-meeting” sessions can significantly reduce confusion in remote design planning. Building on that, Goñi et al. [15] underscores the changes in group conflict resolution patterns online. More recent experiences, such as fully remote capstone pilots [1], [11], show that integrating synchronous stand-ups with asynchronous platforms (Slack, Trello, GitHub) allow continuous iteration or “follow-the-sun” development, which can accelerate design tasks if the group’s communication readiness is high. This arrangement can be particularly beneficial for older or non-traditional students who might otherwise struggle with rigid on-campus meeting times [1], [5].

Large-scale engagement research conducted prior to COVID-19 found that courses with a higher proportion of online delivery were associated with lower collaborative-learning and student–faculty interaction scores, even while they modestly increased quantitative-reasoning practice [18]. A post-pandemic meta-review of distance learning reports the same engagement risks in non-capstone courses, underscoring that remote capstone inherits rather than escapes general online-education trade-offs [19]. However, not all students or sponsors are equally adept at digital collaboration tools, and users often report “digital fatigue” if not carefully moderated [2], [5], [17]. If the team’s “communication readiness” is low, confusion and delays can ensue. Tools designed for in-person instruction may not seamlessly transition online, and ensuring consistent, reliable technology for all stakeholders can be a logistical burden [20].

1.2 Sponsor Engagement and Final Deliverables

Remote models enable sponsors, mentors, and students from diverse regions to collaborate, eliminating typical location-based constraints [1], [2]. This broader network can enrich design projects through varied cultural insights and specialized expertise. Davidson [4] notes that students gain exposure to real-world global engineering practices by working with geographically dispersed sponsors, mirroring modern industry norms.

In a fully remote capstone, sponsor relationships become more reliant on scheduled calls and thorough documentation. Al-Ahmari et al. [1] discuss how a practical remote capstone design course thrived by systematically hosting sponsor design reviews, ensuring that remote meeting times were well-defined. Another article by Joshi et al. [21], presents multi-institutional data stating that, while sponsors worried about fewer face-to-face interactions, frequent virtual check-ins effectively replaced in-person site visits, provided the deliverables (including partial or virtual prototypes) were well communicated.

A relevant demonstration of remote hardware design labs can be found in the work of Mohtar et al., who developed the Remote Microelectronics Fabrication Laboratory (MEFLab) for undergraduates to test micro-scale electronic devices without physically entering a cleanroom [22]. Their architecture integrated precise motor controls, video feedback, and a digital interface for instrumentation, affording students hands-on experience with wafer inspection and circuit validation. Although not strictly a capstone environment, MEFLab's emphasis on real-time manipulation, location independence, and specialized instrumentation parallels many needs in online capstone design, particularly when sponsor deliverables involve hardware prototypes.

Recent literature offers comparable discipline-specific exemplars of fully remote practice. In electrical and computer engineering, a Texas A&M senior-design program replaced on-campus benches with VPN-secured instruments, video-guided bench work, and mailed prototype kits; 94% of students later rated sponsor interaction as "comparable to in-person" [23]. A chemical-engineering plant-design course at Brazil's UNICAMP shifted entirely online, substituted open-source simulators for commercial software, and achieved face-to-face-equivalent grades and high student satisfaction [24]. More recently, a 2024 computer-engineering capstone in Singapore leveraged an Industry 4.0 tool-chain (remote analytics, secure IoT, and cloud pipelines) to let geographically dispersed teams code, test, and merge subsystems asynchronously [25]. Together these cases show that robust remote strategies extend beyond software-only domains and mirror the effectiveness of the Micro-electronics Laboratory model.

Joshi et al. [21] also notes that some teams overcame prototyping restrictions by simulating or partially building hardware at home if small kits were feasible. Meanwhile, Davidson [4] discusses how intangible designs or purely software-based solutions can fit remote course constraints with minimal friction, though some students lament the loss of hands-on experiences.

Despite the feasible shift to simulations or partial at-home kits, the inability to access campus labs regularly can compromise the authentic "build-test" cycle fundamental to many engineering capstones [2], [12]. Some instructors mitigate this by shipping hardware or restricting designs to intangible deliverables like software or system models [11]. This approach can satisfy project goals but may also reduce hands-on skill development that ABET highlights [16].

1.3 Relation to General Remote-Education Literature

Blended-learning meta-studies highlight three recurring benefits (temporal flexibility, rapid digital feedback, and widened access) as well as two persistent drawbacks: diminished social presence and assessment integrity challenges [14]. Our synthesis shows that remote capstone offerings inherit the first set of benefits almost unchanged, yet face amplified versions of the drawbacks because prototype work and sponsor reviews add collaboration overhead. Unlike general online courses, remote capstones must also negotiate sponsor availability and physical prototyping constraints, making hardware-access solutions (e.g., tele-labs, mailed kits) a uniquely critical design axis.

1.4 Teamwork, Motivation, and Well-Being

Transitioning to 100% remote can erode the spontaneity and camaraderie of typical face-to-face classes, intensifying the need for frequent check-ins [2], [5], [15]. Rupprecht et al. [11] found that remote students experienced varying impacts, with some reporting enhanced time flexibility while others felt increased isolation, highlighting a lack of uniform effects across participants. In a capstone environment, students require a sense of mutual accountability, often missing if they never physically meet. Davidson [4] suggests introducing remote social or "coffee break" sessions to replicate in-person bonding.

Sclater et al. [5] and Znidi et al. [12] both note that remote structures can reduce some physical or logistical barriers. For instance, students with mobility challenges or those living far from campus might fully participate, contributing to broader team diversity. While not a perfect solution, such inclusion often spurs creativity and varied problem-solving approaches, aligning with ABET's emphasis on preparing students for collaborative, diverse work contexts [16].

Shared mental models remain critical in design. Litster et al. [17] highlight that remote teams must actively measure and nurture group understanding; letting each student proceed in a silo can hamper the integrated nature of design. Tools for design reviews or "all-hands calls" can unify the group around sponsor feedback [2], [5].

While scheduling flexibility is beneficial, it can also lead to disconnection or "Zoom fatigue" [2], [5], [20]. Rupprecht et al. [11] show that online students sometimes feel isolated from peers, lacking the spontaneous synergy typically found in on-campus design studios. Without physical presence, quiet members may not voice concerns, and conflict resolution can be slower [15].

2. Implementation Strategies for Enhancing Online Capstone Projects

2.1 Establish a Structured Communication Framework

A structured communication framework can significantly improve team cohesion and design outcomes in a remote setting. Sclater et al. [5] report that online collaborative design teams perform best when they rely on both synchronous and asynchronous modes in a carefully defined manner. In a traditional face-to-face capstone, students converse spontaneously and share updates in the lab or hallway. Online courses, by contrast, risk fragmentation if participants do not follow consistent routines for both daily or weekly standups and frequent documentation updates. Aguilera et al. [2] add that each collaboration tool, ranging from Slack or Teams to

OneDrive or Google Drive, should have a clearly specified role so that students and sponsors do not become overwhelmed. Rupprecht et al. [11] observe that teams who adopt a predictable schedule for synchronous calls, plus asynchronous shared documents for ongoing design notes, replicate much of the synergy of an in-person course. Goñi, et.al. states that maintaining a "cameras-on" habit or having open communication periods in chat can further bridge the gap created by physical distance [15]. Litster et al. [17] likewise underscore that without these explicit communication guidelines, remote teams might develop inconsistent shared mental models, thereby slowing design progress and fueling misunderstandings.

2.2 Integrating Sponsors and Defining Flexible Scopes

Sponsor engagement is another essential pillar in online capstone courses. Al-Ahmari et al. [1] demonstrate that regularly scheduled video reviews enable sponsors to maintain robust oversight and feedback loops, similar to in-person visits. Rather than letting sponsors passively wait for final demos, remote instructors encourage them to attend milestone-based design reviews or join mid-sprint evaluations. Davidson [4] notes that clarifying sponsor expectations early on helps refine which deliverables are truly essential and which can be adapted to the remote context, for example, substituting a physical prototype with a series of advanced simulations. Znidi et al. [12] highlight that intangible or software-oriented design solutions are typically easier to execute fully online. However, if hardware prototyping is deemed necessary, educators can orchestrate partial or distributed building arrangements, some teams, for instance, have used home-based 3D printing or safe makerspaces with strict scheduling. In all scenarios, ensuring that sponsors and students have explicit agreements about timeline, constraints, and accessible tools remains crucial [21].

2.3 Aligning Assessment with ABET Criteria

ABET guidelines [16] emphasize comprehensive design experiences and teamwork, yet do not prescribe how to handle these aspects when an entire cohort is remote. Several authors note that remote capstones may require rethinking the weighting of certain assignments or rubrics. Because face-to-face lab observation is absent, instructors can gather alternative evidence of iterative design processes, such as archived version-control logs, sponsor sign-offs, or video-recorded design critiques [1], [12]. Sclater et al. [5] mention that centralized shared artifacts reduce confusion about accountability and serve as a record for accreditation purposes. Znidi et al. [12] and Aguilera et al. [2] add that final presentations, crucial to evaluating communication competencies, can be staged online via synchronous video conferencing, potentially with breakout sessions for sponsor Q&A. By systematically structuring these remote deliverables, weekly design logs, sponsor check-ins, final project expos, capstone courses can demonstrate the same thoroughness expected in on-campus formats.

One promising technique for assessing multidisciplinary knowledge in remote capstone is concept mapping, as illustrated by Borrego et al. [26]. Their work in green engineering education highlights how mapping allows students to depict complex interconnections among distinct disciplines, capturing deeper learning beyond standard quizzes or exams. Although their focus was an on-campus setting, the approach holds strong potential in remote contexts where instructors need evidence of integrative thinking without direct observation of studio-style collaboration. Concept map scoring rubrics, similar to those tested in Borrego et al.'s study, can help faculty systematically measure individual students' progress toward culminating design outcomes, particularly in multidisciplinary settings where knowledge integration is crucial. By tailoring these rubrics to emphasize remote design considerations and sponsor constraints, instructors could better satisfy ABET's requirement for robust assessment of outcomes like teamwork, communication, and multidisciplinary solution strategies.

2.4 Supporting Student Motivation and Well-Being

Though remote courses offer scheduling freedom, they also risk isolation and decreased engagement if students rarely see each other beyond official project calls [2], [11]. Chou et al. [17] suggest that instructors can mitigate this by crafting purposeful social touchpoints, whether brief "coffee chats" or online workshops that replicate the hallway conversations typical in a face-to-face environment. Goñi et al. [15] find that distributed engineering teams often need additional time to resolve conflicts or address miscommunications, so instructors should consider more frequent feedback loops and personal check-ins with each group member. Davidson [4] similarly observes that well-being improves when students feel they have ready access to the instructor, for instance through prompt Slack or email responses. While these measures may add to faculty workload, they can significantly enhance student morale, reduce the sense of social detachment, and maintain momentum on design tasks. The net effect, as described by Al-Ahmari et al. [1], is that remote capstone teams remain far more engaged, producing higher-quality design deliverables that match sponsor and ABET expectations.

Published evidence since 2021 shows that fully remote formats persist across multiple engineering disciplines. Biomedical-engineering cohorts completed at-home medical-device development [27]; chemical-engineering teams executed an entire plant-design sequence online with outcomes matching historical norms [24]; and computer-engineering students delivered cloud-based wearable-tech projects using an Industry 4.0 stack [25]. These examples illustrate that post-COVID adoption is no longer confined to software capstones and continues when project scope and sponsor geography favor a remote model.

2.5 Post-COVID U.S. Participation Patterns

Most engineering colleges reverted to on-campus capstone delivery by Spring 2023, yet institutional census data reveal a persistent remote cohort. Publicly reported enrollments indicate approximately 9,000-12,000 U.S. under-graduate STEM students now undertake fully remote capstones each year, represented by the distance-education segments of four flagship programs (Table 2).

Documenting these numbers proves the demand of fully remote engineering degrees and thus capstone programs in the post-COVID era. Quantifying participation is also prerequisite to any longitudinal dashboard the community might build.

Table 2. Main U.S. Programs Offering Remote Capstone

Institution & degree	Capstone Mode	Capstone required or optional	Fall 2023 online enrollment
Arizona State U. – B.S. Electrical & Software Eng. (ASU Online) [7]	Fully Remote	Required	8,242 students
Oregon State U. – Post-Bacc B.S. Computer Science (Ecampus) [8]	Fully Remote	Required	4,565 students
Western Governors U. – B.S. IT & Computer Science [9]	Fully Remote	Required	169,379 total enrollment (> 10 k in STEM)
Univ. of North Dakota – B.S. Mechanical, Civil, Chem, Elec Eng. (Distance) [10]	Fully remote with occasional lab intensives	Required	"Dozens per discipline" (exact data not published)

3. Results Summary

In summary, various references show that instructors can elevate the quality of fully remote capstone courses by establishing consistent communication practices, thoroughly integrating sponsors, adapting assessment rubrics to reflect ABET's culminating design outcomes, and addressing motivation challenges. Sclater et al. [5] demonstrated that online collaborative designs is feasible if instructors pay special attention to tool readiness and social dynamics receive focused attention, while Al-Ahmari et al. [1] and Aguilera et Al. [2] emphasize that sponsors remain highly engaged when they are involved through frequent checkpoints. Although remote teams may struggle with prototyping, Znidi et al. [12] and Davidson [4] illustrates how partial or simulated alternatives can deliver meaningful design experiences.

Once sponsors acclimate to structured remote practices, including well-defined milestones, transparent communication logs, and consistent meeting schedules, many adapt well to the online modality [11], [15]. The intangible nature of certain deliverables (e.g., design simulations, software prototypes) is often acceptable or even preferable for software-centric projects, as remote teams easily share version-controlled code or modeling tools [2], [21]. While some sponsors remain cautious, the cumulative evidence points to a growing industry acceptance of remote collaboration, aligning with broader corporate trends toward distributed teams. Capstone programs that proactively educate sponsors on digital collaboration norms and clarify mutual expectations tend to see sponsor satisfaction remain high, reinforcing the feasibility of a robust academic-industry partnership even in a completely online environment.

Conclusion

This literature review set out to explore three core questions: (1) What are the primary benefits and challenges of fully remote engineering capstone teams?; (2) Which practices (e.g., tools, scheduling methods, sponsor relationships) effectively promote inclusivity, engagement, and meaningful outcomes for remote engineering design projects?; and (3) To what extent do fully remote capstone experiences fulfill ABET or institutional requirements, and how might instructors adapt these guidelines?

In addressing Research Question 1, the studies reviewed consistently highlight both the advantages (e.g., flexible scheduling, broadened sponsor participation, opportunities for diverse student involvement) and the challenges (e.g., limited access to hands-on-prototyping, digital fatigue, potential isolation) of fully remote capstone courses. They reinforce the importance of intentional social engagement, clear communication, and robust conflict-resolution strategies for successful remote teamwork.

Pertaining to Research Question 2, much of the existing literature converges around effective implementation strategies that include establishing structured communication frameworks (both synchronous and asynchronous), integrating sponsors through routine milestone reviews and transparent documentation, and tailoring the scope of capstone projects to ensure they remain feasible in a remote format. Critical to these efforts is the adoption of cloud-based collaboration tools (e.g., Slack, Trello, GitHub) and carefully planned procedures for sponsor feedback, all of which help maintain team momentum and foster inclusivity.

Finally, for Research Question 3, the review suggests that fully remote capstone experiences can indeed meet ABET requirements on teamwork, communication, and design rigor, provided instructors adapt assessment protocols to capture the iterative process digitally. Some programs incorporate sponsor sign-offs, archived version-control logs, and video-based critiques to demonstrate compliance with accreditation standards. However, most sources call for additional long-term, multi-institutional data on student outcomes and well-being to document robust ABET alignment across diverse remote settings.

Overall, while this body of research affirms that fully remote engineering capstone courses can successfully replicate or even exceed certain aspects of on-campus experiences, it also exposes significant gaps, mainly around consistent frameworks for demonstrating comprehensive ABET compliance and sustaining student engagement with intensive hardware or lab-based projects.

Future Work

First, although many studies have examined distributing small hardware "kits" to students (e.g., Rupprecht et al. [11], Znidi et al. [12], Joshi et al. [21]), future work could expand these ideas by introducing an adaptable, budget-based approach: for instance, partnering with a specific vendor or curated marketplace where each remote team has a set allowance to purchase components that best fit their project scope. This strategy would preserve authentic design freedom while limiting logistical complexity. Such a model might also include a virtual "inventory" or item reservation system, which students can access as part of the course management platform. By more explicitly scaffolding hardware acquisition in this way, remote capstone projects could remain hands-on without requiring a fully equipped lab on every student's desk.

Second, in many existing remote capstones, sponsor participation remains limited to periodic check-ins or milestone reviews [1], [2], [21]. Future work can go beyond these traditional formats by embedding sponsors as active collaborators in a shared workspace, contributing design constraints, modifying preliminary schematics, or commenting on daily logs in real time. Researchers could then investigate how this ongoing sponsor-student "co-creation" impacts motivation, design quality, and industry relevance over multiple semesters, offering valuable insights for improving sponsor satisfaction and student engagement.

Third, several authors note the risk of student isolation and "digital fatigue" in fully remote settings [2], [5], [17]. Building on these observations, future research can develop purpose-built tools for student well-being. For example, automated Slack "coffee break" invitations, scheduled reflection prompts to destress, or online games for remote team building. By systematically assessing how such interventions affect engagement, conflict resolution, and final project outcomes, scholars can identify best practices for mitigating the social and cognitive strains of remote capstone experiences.

Finally, the field still lacks longitudinal evidence about student demand for fully remote capstones in the post-pandemic era. A multi-institution census-modelled on the blended-learning surveys reported by Balta and colleagues [14] could track annual enrollments, project modalities, and graduate outcomes over five or more years. Establishing a shared dashboard for such data is therefore a high-priority step toward evidence-based remote-capstone policy. Through these expanded or novel approaches, the field can continue to refine and optimize fully remote engineering capstone experiences, ultimately ensuring that course delivery, sponsor collaboration, and ABET-aligned learning outcomes evolve in tandem with modern industry demands.

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