Pull Requests From The Classroom: Co-Developing Curriculum And Code

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Abstract

Educational technologies often misalign with instructors' pedagogical goals, forcing adaptations that compromise teaching efficacy. In this paper, we present a case study on the co-development of curriculum and technology in the context of a university course on scientific writing. Specifically, we examine how a custom-built peer feedback system was iteratively developed alongside the course to support annotation, feedback exchange, and revision. Results show that while co-development fostered stronger alignment between software features and course goals, it also exposed usability limitations and infrastructure-related frustrations, emphasizing the need for closer coordination between teaching and technical teams.

CCS Concepts

• **Human-centered computing** → *HCI design and evaluation methods*; *Usability testing*; **Field studies**; **User studies**.

Keywords

Educational Technology, Higher Education, Peer Feedback

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1 Introduction

From assignment submissions to grading and communication, Learning Management Systems (LMS) such as Moodle or ILIAS have become a foundational infrastructure in higher education. These platforms are typically generic in design and functionality, offering a one-size-fits-all approach that often misaligns with the specific pedagogical goals of individual courses and educators [5, 13]. As a result, educators feel forced to adapt their teaching to fit predefined workflows, or to repurpose existing features to approximate what they actually want to do [9]. Consequently, teaching and technology often feel misaligned for students and educators [18], creating inefficiencies, increasing administrative overhead, and limiting the positive impact of educational technology [2].

To overcome these challenges, prior work called for closer integration of pedagogy and technology through tandem design of software and curriculum [1, 11]. The promise of this approach lies in the idea that as pedagogical goals and software infrastructure evolve together, they can support coherent workflows, reduce friction, and preserve educators' control over content delivery. However, we still lack insight into how such co-development plays out in practice, including the challenges and experiences of those involved.

In this paper, we explore what this process looks like in practice. We present a case study of a large university course on scientific writing integrating a custom peer feedback system. This system enables students and educators to annotate and review each other's submissions using structured tags and free-text comments. Each student reviewed two peers and received both peer and educator feedback, which they used to revise their submission. The platform was developed iteratively during the course, adapting to legal, pedagogical, and infrastructural needs as they emerged.

The contribution of this paper is two-fold: First, we show how pedagogical, technical, and organizational factors interact in the co-development of curriculum and educational software. Second, based on mixed-methods data, we analyze how course and platform co-evolved, revealing both the potential for better pedagogical alignment and tensions around feedback, usability, and AI integration.

2 Background and Related Work

Technology in Higher education. Implementation research [7] studies the extent to which software implementation efforts achieve the specified goals. Implementation research has a long history in EdTech; for example, in their analysis of 46 empirical research studies with focus on technology implementation issues, Chugh et al. [10] highlight significant challenges such as technology and stakeholder barriers [21] or the ability of students and educators to cope with new technology [10]. While previous studies explored stakeholder experiences with *existing* implementations or

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established courses [14, 19, 24], our study focuses on how software and curriculum are co-developed to meet pedagogical goals.

Peer Feedback and Learning. Peer feedback is essential in higher education, as it helps students critique peer work [25] and reflect on their own writing [8], and supports learning at scale when providing direct instructor feedback is not feasible [23]. Peer feedback is widely used both in university courses and in online education, and is an active research area in educational psychology [3]. To support peer feedback, digital tools like Juxtapeer [6] and PeerStudio [16] guide students through structured, rubric-based reviews. These systems are optimized for short-term, synchronous settings and support novel features such as comparing submissions side-by-side or routing them to active peers for quick turnaround. In contrast to these works, we explore a scenario of a semester-long university course with asynchronous participation, slower feedback cycles, and deeper curricular integration.

CARE. The **C**ollaborative **A**I-Assisted **R**eading **E**nvironment [26] was selected as the core platform for this course due to its unique capacity to support systematic data collection and workflow integration. Originally developed as a research tool, CARE's architecture enables fine-grained text annotation with pre-defined semantic and color-coded tagging (i.e., Highlight, Strength, Weakness, Other) derived from Kuznetsov et. al. [17], and interaction logging. To operationalize CARE within a live university course, the platform had to be significantly extended, as the original scope did not fully address the pedagogical, procedural, and legal requirements of curricular integration.

3 Course and software development

Goals, curriculum and stakeholders. Our study focuses on the Bachelor-level course "Introduction to Scientific Work" at the computer science department of a major European university, launched in Winter 2024. As part of the course, Students write a six-page exposé on a predefined computer science topic. Each student provides two anonymous peer reviews, receives feedback from peers and Educators, and revises the exposé accordingly. Developers are responsible for the development and deployment of the software. The Educators included one lecturer, two doctoral researchers, one postdoctoral researcher, and six teaching assistants. Developers were a team of five research assistants led by a doctoral researcher. In total, 193 bachelor Students enrolled in the course; 159 completed the course.

Stakeholder touch points and integration. Each stakeholder group played a distinct role in integrating CARE into the course workflow. Students used CARE in two stages: first, to annotate and review the peers' exposés, summarizing their assessments in free-text form using previously introduced feedback principles and exposé-writing guidelines; then, to access feedback on their own work and revise accordingly. Educators handled both technical and pedagogical tasks: transferring exposés from Moodle, managing user credentials, assigning peers, and assessing and grading submissions using annotations and written feedback. Together with the Developers, they trained users and later extracted data for analysis. The Developers oversaw the development and deployment of CARE, integrated it with Moodle, ensured stable operation of the tool, provided support, and conducted the studies.

Mutual adaptation of course and software. The course design directly influenced key software features. Embedding informed consent into the UI stemmed from the need to ensure ethical clarity at the point of student interaction. The data collection process through CARE required an ethics approval process, which in turn provided a concrete and timely case study for teaching research ethics, anchoring ethical education in the Students' direct experience. The demand for open-ended feedback pushed the implementation of a free-form editor, while the requirement for structured annotations and PDF-based submissions led to a mandatory LaTeX template, aligning student output with software processing needs. Contractually agreed working hour variations of the Educators shaped flexible reviewer assignment strategies. Uncertainties in availability and workload led to fallback mechanisms for reassigning review duties and prompted a role management logic. Pedagogical structure also dictated timing: lectures on feedback and writing were placed before introducing CARE, and synchronized with credential distribution. Institutional workflows demanded an integration with the Moodle API, enabling seamless data access and minimizing friction for Students and Educators.

4 Methodology

To understand stakeholder experience with CARE and gather improvement suggestions, we distributed a questionnaire (Q1) to Students, followed by two focus groups [4]: one with teaching assistants from Educators group (Focus Group Educators, FE) and one with students (Focus Group Students, FS).

Questionnaire Q1 was distributed shortly after the peer feedback phase via Moodle. The survey assessed usability using the Usability Metric for User Experience (UMUX) scale [12]. It also included open-ended questions about user experiences and potential friction points when interacting with CARE.

Focus groups FE and FS were conducted after the end of the course. Each session followed a semi-structured format. After giving informed consent, participants completed a warm-up questionnaire (Q2) covering demographics and attitudes toward digital learning technologies.

After this, participants discussed their experiences with CARE, guided by open-ended questions and followed by a brainwriting exercise [22] to surface improvement ideas. Finally, participants prioritized these ideas using dot voting. FS took place on-site, while FE was conducted remotely using Zoom and a Miro Board. A researcher unaffiliated with the course moderated all focus group sessions.

We recruited participants via direct outreach and Moodle; participation was voluntary. Two teaching assistants (1 man, 1 woman) joined FE through their employment; three students (1 man, 1 woman, 1 undisclosed) joined FS and were compensated at minimum wage. We transcribed recordings with Whisper [20], anonymized and coded them in QualCoder.[1] Three researchers independently coded and iteratively refined themes.

[1]https://qualcoder.wordpress.com

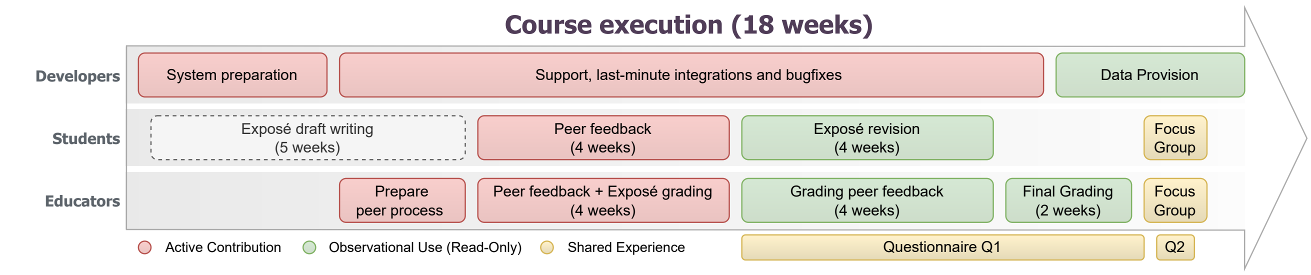
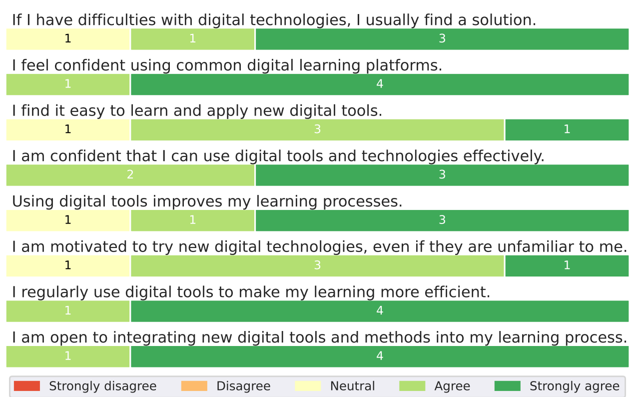
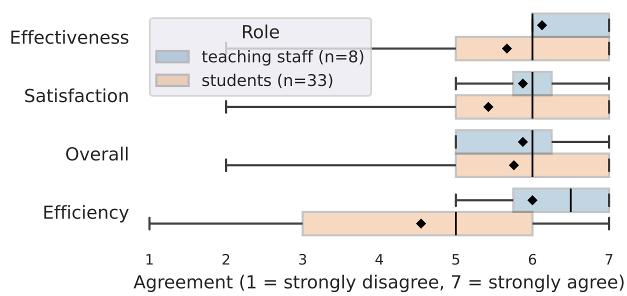


Figure 1: Touch-points of developers, educators, and students with CARE along the course. Color-coded regions indicate the stakeholder engagement with the system: *red* areas denote active contributions, *green* areas represent read-only or observational use, *yellow* marks phases where stakeholders share their experience or feedback.



(a) Digital Tool Acceptance (n=5)



(b) Usability Metric for User Experience (UMUX)

Figure 2: Summary of user responses: (a) Tool acceptance and (b) UMUX score.

5 Results

We focus on usability, workflow integration, and satisfaction, and identify areas for improvement. We contextualize findings using participants' EdTech experience and tool expectations. As focus groups were held in German, we provide English translations.

5.1 User Experience and System Perception

No focus group participants had previously used dedicated peer feedback systems like CARE. Instead, they previously relied on general-purpose tools such as Adobe Acrobat Reader, Google Docs, or Overleaf to handle feedback tasks. Despite this unfamiliarity, overall responses were positive. In Q1, the UMUX (Figure 2b) showed high satisfaction (M = 75.2, SD = 17.76, N = 39); Educators rated the system higher (M = 82.81, SD = 15.18, N = 8) than students (M = 73.19, SD = 18.06, N = 31), indicating a difference in perceived usability between user groups. In focus groups, FE participants expressed a strong interest in contributing to the tool's improvement, while FS participants were primarily motivated by a desire to enhance the overall course experience. Open-ended responses revealed that CARE was broadly perceived as fast, intuitive, and well-structured. Users appreciated its clear visual design and structured annotation workflow (Q1), particularly the pedagogically motivated use of pre-defined color-coded feedback tags that "*helped to think more systematically about what I was reviewing*" (FS1). As reflected in Figure 2a, responses to tool acceptance items were predominantly positive, indicating a general willingness to engage with digital systems in the learning process. Yet, participants also reported challenges that affected efficiency and satisfaction, especially regarding CARE's structuring of the feedback process and workflow.

5.2 Effects on Workflow Efficiency

CARE's co-development with the course's peer feedback component aimed to align pedagogical goals with technological functionality. Yet, real-world usage revealed frictions where course design and software logic misaligned. Initially, CARE implemented a linear review workflow that guided users step-by-step through the process. This structure conflicted with the course design that required flexible transitions between stages, prompting an interface update to support bidirectional navigation between the annotation view and free-form editor. Though better aligned with course goals, it created practical challenges. Users "*ended up opening two browser tabs [...] because there was no way to use annotations while writing the review*" (FS2) and suggests that "*it would have helped to see annotations and write feedback side-by-side*" (FE1). In particular, Students struggled with the navigation: they switched between views significantly more often (M = 13.49, SD = 11.69, n = 107) than Educators (M = 7.51, SD = 6.29, n = 173), t(144.5) = 4.86, p

< .001 (Welch's t-test). This behavior suggests that the system's navigation still does not fully accommodate users' natural feedback workflows.

Workflow was further impacted by CARE's server-dependent architecture. While the system performed well under stable internet conditions, intermittent connectivity (e.g., during commute) led to synchronization failures, where participants "*lost parts of the review [...] when the connection dropped*" (FS2). "*On the train*", where "*the connection was bad*", inputs were still accepted, but the lack of immediate error signaling led to user frustration, as "*it was annoying not knowing if anything worked*" (FE1). These limitations led to the emergence of parallel user workflows, such as writing "*the feedback in a separate file to avoid losing data*" (FS2). The annotation system of CARE was praised for its tagging functionality and efficiency gains due to the reduction of manual input. However, practical issues such as missing filtering functionality, limited editing and imprecise text selection caused confusion and impaired workflow efficiency.

5.3 Reflections on AI Integration

Throughout both focus groups, one recurring topic was the potential role of AI within CARE. While not a core focus of our implementation, the use of AI in feedback sparked an active discussion. Educators favored AI assistance, including automated quality control, consistency checks, feedback generation and grading assistance. Students expressed more caution. While open to the use of AI for superficial tasks like grammar and style correction, or as a help with initial annotations, Student participants emphasized that "*the whole points is [...] to learn how to write feedback*" (FS3) as a central learning experience which should not be fully automated as this would undermine a key pedagogical goal. The idea of AI-supported grading was particularly controversial. While both groups saw value in using AI for provisional suggestions, they emphasized that final grading decisions should remain with human instructors and "*the final call should always come from a real person*" (FE1). Privacy also emerged as a key issue, with a clear preference for locally running models, as they "*don't want the data going who-knows-where*" (FS2). Notably, despite the interest in AI, Students consistently expressed a different priority: "*Before adding smart features, just make the system more stable.*" (FS3), meaning, resolving workflow frictions was more urgent than introducing new, intelligent tools.

6 Discussion and Key Takeaways

Software and curriculum co-evolve under constraints. CARE had to align with institutional standards and the course's pedagogical flow. Legal, technical, and scheduling constraints shaped features like access control and Moodle integration. In turn, these features influenced lecture sequencing and grading. The findings show that EdTech integration is not merely about fitting a tool into an existing curriculum but about co-developing technical and instructional frameworks under real-world constraints. Successful implementations depend on tightly coupling software architecture with educational priorities, while remaining flexible to evolving institutional demands.

Software design should align to pedagogical practice. Students and Educators valued CARE's annotation features, especially the semantic tags that supported structured, theory-driven feedback with minimal manual effort. These design elements aligned well with pedagogical goals and contributed to a more focused review process. In contrast, the system's initial step-by-step workflow posed challenges. Although intended to guide users through a structured review sequence, it conflicted with how students naturally approached the task. This points to a broader tension between formal instructional structures and the informal, often fluid nature of actual student behavior [15]. While the design reflected pedagogical reasoning, it underestimated the cognitive overhead and disruption caused by rigid sequencing. The results highlight that successful software integration depends not only on pedagogical alignment but also on sensitivity to user workflows.

Software reliability is central to workflow efficiency. Users consistently described CARE as fast and responsive during regular use, which contributed to smooth task execution and a generally positive user experience. The system's performance under stable conditions supported focused engagement, particularly during the annotation phase. However, when connectivity issues occurred, even minor disruptions quickly impacted user engagement. Students and Educators often resorted to ad hoc parallel workflows using external tools, which complicated later reintegration and broke the intended workflow. These workarounds point to a broader need for technical resilience in educational systems. Ensuring reliability through features like autosave, local caching, or offline access is essential to maintain workflow continuity, especially in real-world educational environments with variable access conditions.

A multiple-perspective approach is needed. CARE's integration into peer review workflows revealed contrasting stakeholder expectations regarding feedback processes and automation. Educators prioritized efficiency and standardization, welcoming AI-driven support to streamline grading and feedback generation. Students, in contrast, valued peer review as a learning opportunity. They saw potential in AI as an assistive tool but resisted full automation, concerned about authenticity and skill development. Close coordination between Educators and Developers is essential: Developers ensure system functionality, while Educators identify emerging issues early, through their direct contact with students and translate them into practical adjustments. These divergent perspectives highlight the importance of designing EdTech systems that accommodate multiple user expectations and roles.

7 Conclusion

Rather than treating technology as a fixed solution, our case illustrates how curriculum and software can mutually shape each other. This co-development requires close collaboration between developers and educators, rapid iteration, and ongoing responsiveness to user experience. Our study has natural **limitations**, as our findings stem from a single University course with a limited number of focus group participants, with a focus on a particular peer feedback tool. Thus, one productive **future research** direction is to apply our proposed methodology to other courses, tools and environments, with particular attention given to refining navigation, improving feedback workflows, and minimizing friction during critical teaching phases. Another promising research direction is to explore the long-term impact of co-developed tools across diverse course formats and disciplines. Finally, there is room to examine how AI can assist without undermining key learning objectives, especially in feedback-intensive scenarios.

Implications. At a broader level, our findings call for a shift in how educational technology is conceived and deployed. Instead of adopting generic tools and adapting pedagogy around them, educators should embrace co-development practices that treat software as an evolving component of curriculum design. This requires institutional structures that support iterative development, cross-functional teams, and space for experimentation. Beyond higher education, this approach holds promise for any learning environment where feedback, transparency, and workflow alignment matter.

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