# Instructor and Developer Perspectives on the Capability and Usability of Submission Tools for an Online Laboratory Course

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## Abstract

More science courses are being taught online, including those with labs. Resources and support vary widely across various institutions for creating functional online lab experiences. For this study, we conducted semi-structured interviews with faculty and Graduate Teaching Assistants (GTAs) about the desired capabilities for lab notebook platforms, as well as their experiences working with the two different lab platforms for a course that has an at-home lab kit and hands-on labs. The interview data includes faculty and GTA perspectives as they compare two different platforms for students to upload their lab data: a Word document and a custom web application. We coded and analyzed the data using an iterative phronetic approach with multiple rounds of coding. We analyzed the codes for repeated or frequent themes or forceful ideas that emerged related to our research questions. The results indicate that faculty and GTA preferences vary, each platform brought benefits and drawbacks, and each platform was relatively easy to use, but for different reasons. The findings presented here can help university instructional designers and media developers better understand faculty and GTAs' desired capabilities for these platforms. Additionally, the results highlight benefits and drawbacks for two types of lab platforms, which can inform faculty of various considerations as they weigh their available resources for developing online lab components.

## Introduction

The demand for online labs is growing (Jeschofnig, 2011; EDUCAUSE, 2023; Garrett & Simunich, 2023). While virtual labs have been created by private companies and publishers, these tools are generally expensive and are not widely adopted by many universities (Garrett & Simunich, 2023). Yet within the Canvas Learning Management System (LMS), the most dominant LMS on the market (Edutechnica, 2025) and the one used by Oregon State University (OSU), there is not an efficient way to directly submit the varied types of data and responses (such as images, graphs, descriptions, and numerical values) involved in a hands-on laboratory activity in one preformatted assignment.

As a land grant institution, OSU is committed to both access and affordability, meaning that all course materials, including lab platforms, must be high-quality, accessible, and affordable (or free) for students. Usability is a critical component of both quality and accessibility, and refers to how easy to use a tool is: how intuitive, how simple, how reliable, how pleasant (Jahnke et al., 2021; Nielsen & Loranger, 2006). For online learning design, it can be helpful to disaggregate "usability" into subcomponents: Technological Usability related to technological issues, Social Usability related to human presence and interaction, and Pedagogical Usability related to alignment of tasks and assessments with teaching or learning goals (Jahnke et al., 2020). Throughout this research, we will employ a social-technical-pedagogical (STP) usability framework to evaluate and discuss the usability of our online laboratory platforms (Jahnke et al., 2021).

A usual approach to submit lab data and responses in an online laboratory course is to require students to incorporate all of them into a single, templated Word document unique to each lab and upload that to the LMS. However, in our course, students reported that formatting their lab data and images into a Word template was time-consuming and frustrating, taking time and attention away from actual learning; formatting Word documents is not one of the course objectives. Furthermore, the way that Word handles image insertions tends to break the template; answer boxes and text descriptions get broken up and moved around the page, making it quite difficult (and time-consuming) for the instructors and GTAs to review and grade the submitted work.

Given that working within the existing LMS (Canvas) and office tools (Word) proved limiting and error-prone, we wanted an alternative

approach that would have higher usability for both faculty and students. Creating a custom lab platform designed specifically for student submission of lab data was appealing because the tool could be designed from a student- and faculty-centered perspective to be accessible, secure, private, free, and easy to use. At OSU, faculty developers of online courses generally have the assistance of not only instructional designers but also multimedia production, including a team of web developers who can create custom apps. Thus, from 2022-2023, the instructor (Mobley) and instructional designer (McBrien) worked with the OSU Ecampus media team on the development of an in-house lab submission tool designed specifically for the 10 labs within a science course.

The course is an online laboratory course in the environmental sciences discipline that fulfills a Scientific Inquiry and Analysis requirement of OSU's general education curriculum. The course has mid-sized enrollment (60-80 students per section per term), and is offered every term. Thus, improvements made in this course have direct benefit to the advancement and graduation success of over 500 Ecampus students per year. Reducing barriers to student success in this course would support the goals of OSU's recent general education reform as well as the university's goal of increasing Ecampus enrollments, as well as supporting the discipline-specific needs of students in the majors served by the course.

This white paper describes faculty, GTA, and developer perspectives on desired capabilities of an online lab platform, and compares the benefits and drawbacks observed with use of the traditional versus the custom tool. This analysis explored perspectives on whether developing a custom tool improved usability, primarily for faculty and GTAs compared to the traditional Word documents. We used the social, technical, and pedagogical (STP) usability framework of Jahnke et al. (2020) to identify aspects of usability that emerged as benefits or drawbacks of the tools.

The study addressed the following research questions:

> *$RQ_1$: From the perspective of instructors and GTAs, what are the desired capabilities of an online lab platform?*
>
> *$RQ_2$: According to instructors and GTAs, what are the benefits and drawbacks found in the traditional and custom tool?*
>
> *$RQ_3$: What improvements would developers, instructors, and GTAs like to see in the tools and in the process of developing the tools?*

Our goal is to provide information that will aid any faculty or developers who are considering such an effort in determining whether the benefits of developing an online lab platform balance the drawbacks.

## Research Design and Methods

### Study Design

Two 80-student sections of the course were taught in Spring 2024 term. Students in one section used the custom web tool to submit laboratory assignments, whereas those in the other section used Word documents to submit their laboratory assignments to Canvas LMS. Examples of the custom vs Word tools are shown in Appendix A. The design, content, learning activities, and instructor were identical for the two sections. Labs were graded in Canvas LMS regardless of how they were submitted. Student experiences and perspectives were surveyed and are described in another manuscript. Two GTAs were assigned to the course, and they alternated between the two sections week-to-week to have experience with both Custom and Word notebooks. The instructor of the Spring 2024 courses had prior experience with the Word notebook, while neither GTA had prior experience with either version of the notebook.

**Participants**

Instructors and GTAs of the course and OSU Ecampus media specialists experienced in development of online lab courses were identified as potential participants. We invited these participants for their multiple perspectives on what is desired in an online lab notebook, specifically, and the processes and challenges of developing and testing custom tools more generally. Recruitment via purposive sampling mainly happened in the spring and summer of 2024 and varied due to the differing nature of work for these individuals. Participants were invited to a semi-structured interview via an email including a link to a Qualtrics consent survey. For the instructors and GTAs involved in the course during spring term, we aimed to interview them after they had finished teaching the course and experienced the two different lab notebooks for the full term. Those interviews took place at the end of spring term or during the summer. Other instructors and Ecampus media specialists were scheduled for interviews according to their preference in spring or summer of 2024. Six participants consented and participated, including two instructors (one who taught with both versions of the tool, and one familiar only with the Word version), one instructional designer, one media manager, and two graduate teaching assistants (both familiar with both versions of tool). All participants received a $20 gift card to the university bookstore as an incentive.

**Data Collection**

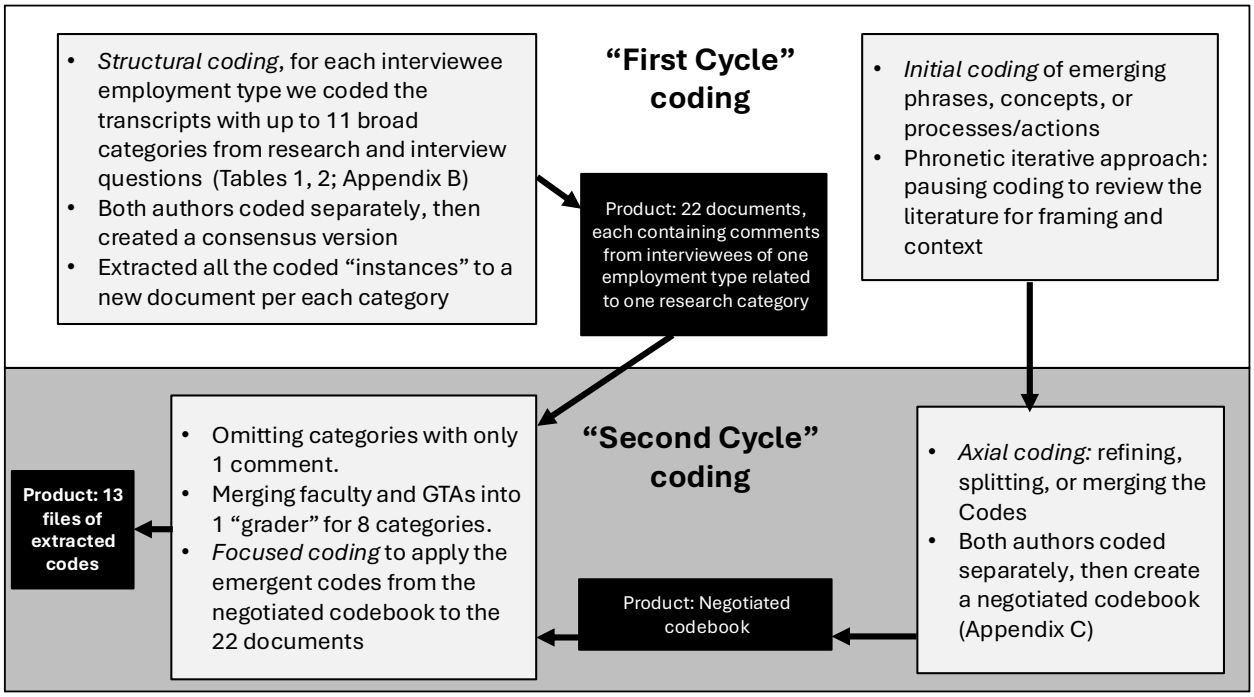
Once participants had consented in Qualtrics, we scheduled the interviews. Each semi-structured interview lasted approximately 30 minutes. Faculty and GTAs were asked 10 questions, and media specialists were asked seven questions (see Appendix B). Participants granted their permission to have the interview recorded in Zoom with automatic captions transcription turned on. After the interviews were conducted, we de-identified the data according to protocols approved by IRB, creating unique identifiers to substitute for names and storing those files in a secure Box folder. We corrected the auto-generated transcripts manually by re-watching the interviews and correcting any transcription errors. We cleaned the transcripts of extraneous information like frequent timestamps and unnecessary line breaks to prepare the transcript data for coding and analysis.

**Analysis**

We coded and analyzed the data using an iterative phronetic approach as synthesized by Tracy and others (Tracy, 2020). Transcripts were separated by employment type for analysis, as we noted that each group had quite different perspectives. This included Ecampus media specialist transcripts (n = 2), the instructor transcripts (n = 2), and the GTA transcripts (n = 2). The Ecampus media specialists were more development focused, and the instructors and graders were more pedagogy and implementation focused. Our goals were to: 1) gather knowledge that emerged from the interviews; 2) locate relevant literature on pedagogy or usability; 3) apply both knowledge gained from the interviews and from the literature to guide future decisions about the use of custom web tools for the course. We did this iteratively, allowing the literature search to inform revisions to the codebook even as the emergent codes directed the literature search.

Our approach to coding the interview data was a negotiated coding process with multiple rounds of coding. We employed two first-cycle coding methods followed by a second cycle of coding (Saldaña, 2021; see Figure 1).

**Figure 1**. Graphical representation of the coding process.




In a first cycle approach of structural coding, we coded parts of the transcripts according to their alignment with the 11 broad categories from our research and interview questions (Table 1). This allowed us to organize the transcript pieces according to category for the next round of focused coding (Saldaña, 2021).

Both authors conducted the first round of coding separately, then compared documents side by side to create a consensus version. We then ran a Word macro (Fredborg, 2013, Peach, n.d.) to extract all the coded "incidents" to new documents for each broad category. Not all categories occurred in all transcripts: at the end of this stage, we had 10 categories for faculty, nine categories for GTAs, and three categories for Ecampus media specialists, for a total of 22 categorical transcript subsets (see Table 2).

Another, first cycle approach of initial coding involved identifying emerging codes and themes, whether in vivo phrases, concepts, or processes/actions codes (Saldaña, 2021), reviewing the literature for framing and context for these ideas, then axial coding (Tracy, 2020) by refining, splitting, or merging the codes again. We began this process while correcting and cleaning the interview transcripts and then rereading the transcripts multiple times, underlining and making marginal notes, and writing analytic memos about the recurrent or forceful themes (Owen, 1984) that came up and how they related to our research questions and literature reviewed thus far.

Recurrent themes were concepts or ideas put forth multiple times in different transcripts, though often described by different people using different words (Owen, 1984). Forceful themes were those ideas in which one or more participants placed particular emphasis or description, sometimes even invoking emotional language (Owen, 1984). In line with the phronetic iterative approach, we toggled between coding and pausing to consult relevant literature to inform our analysis. In particular, our research questions and interview responses led us to explore literature and terminology related to social, technical, and pedagogical (STP) usability (Jahnke et al., 2020, 2021) and adopt STP heuristics from Jahnke et al. (2021) as a framework for sorting and merging our

**Table 1**. Eleven structural coding categories aligned to research and interview questions.

| Category | Aligns to Research Question | Description |
|---|---|---|
| **Desired Capabilities** | RQ1 | Desired Capabilities of Tool; Known desired technical capability of the tool |
| **Development Process** | RQ3 | Description of current/past Development Process, including goals and other tools/resources developed to meet those goals. |
| **Development Recommendations** | RQ3 | Recommendations for development process and testing; including "Doesn't know what the desired capability would be but would like to find out by creating modifications to the development process of these tools or collecting data from students." Includes capabilities that are not technical, like "supports the learning outcomes" |
| **Custom Benefits for Graders** | RQ2 | Benefits of new tool for Graders; things that made grading/providing feedback better or faster or clearer or more pleasant when using the new notebook |
| **Custom Benefits for Students** | RQ2 | Benefits of new tool for Students; things that made filling out, submitting, or reviewing feedback easier or faster or clearer or more pleasant for students when using the |
| **Custom Drawbacks for Graders** | RQ2 | Drawbacks of new tool for Graders; things that made grading/providing feedback harder or slower or more confusing or more frustrating when using the new notebook |
| **Custom Drawbacks for Students** | RQ2 | Drawbacks of new tool for Students; things that made filling out, submitting, or reviewing feedback harder or slower or more confusing or more frustrating for students when using the new notebook |
| **Word Benefits for Graders** | RQ2 | Benefits of old tool (Word) for Graders; things that made grading/providing feedback better or faster or clearer or more pleasant when using the previous Word docs |
| **Word Benefits for Students** | RQ2 | Benefits of old tool (Word) for Students; things that made filling out, submitting, or reviewing feedback easier or faster or clearer or more pleasant for students when using the previous Word docs |
| **Word Drawbacks for Graders** | RQ2 | Drawbacks of Word Docs for Graders; things that made grading/providing feedback harder or slower or more confusing or more frustrating when using the previous Word docs |
| **Word Drawbacks for Students** | RQ2 | Drawbacks of Word Docs for Students; things that made filling out, submitting, or reviewing feedback harder or slower or more confusing or more frustrating for students when using the previous Word docs |

**Table 2**. Number of instances of each research category (described in Table 1) coded during first cycle structural coding of six interview transcripts

| Category | Faculty (n=2, except where "*" indicates n=1) | GTAs (n=2) | Ecampus Media Specialists (n=2) |
|---|---|---|---|
| **Desired Capabilities** | 36 | 26 | 25 |
| **Development Process** | 2 | -- | 27 |
| **Development Recommendations** | -- | -- | 21 |
| **Custom Benefits for Graders** | 8* | 10 | -- |
| **Custom Benefits for Students** | 1* | 8 | -- |
| **Custom Drawbacks for Graders** | 15* | 31 | -- |
| **Custom Drawbacks for Students** | 7* | 23 | -- |
| **Word Benefits for Graders** | 2 | 7 | -- |
| **Word Benefits for Students** | 6 | 9 | -- |
| **Word Drawbacks for Graders** | 7 | 12 | -- |
| **Word Drawbacks for Students** | 9 | 6 | -- |

*Note: n refers to the number of unique participants in each employment type; "--" indicates topic was not mentioned in interviews*

initial codes. From our notes and memos, we each individually generated a preliminary codebook. Then we went into the literature again and reviewed the interview transcripts further before refining our individual lists of codes, and then discussing and creating a negotiated codebook in a meeting together.

Our final, second cycle round of coding involved focused coding (Tracy, 2020) to apply the emergent codes from the negotiated codebook (Appendix C) to the 22 categorical transcript subsets (Table 2). After coding each category, we ran the Word macro (Fredborg, 2013; Peach, n.d.) to extract the codes to another new file where we analyzed the results. For Desired Capabilities category, we analyzed Ecampus media specialists, Faculty, and GTAs separately (n = 2 interviews each group). For Development Process and Development Recommendations, we only had one comment from faculty and none from GTAs, and so we focused the analysis on Ecampus media specialists only (n = 2). For the eight Benefits and Drawbacks categories, we combined faculty and GTAs together as "graders." One faculty member hadn't used the new custom tool, hence there were n = 3 interviews for Benefits/Drawbacks of Custom, whereas n = 4 for Benefits/Drawbacks of Word. Ecampus media specialists were not asked about Benefits/Drawbacks of Tools. Thus, our analysis involved reviewing each of 13 files of extracted codes (Figure 1), looking for repeated or frequent themes or forceful ideas that came up and were related to our research questions.

## Results and Discussion

### Usability Framework

Many of the major themes and ideas coded from our six interviews were related to usability, aligning with six of the 14 social, technical, and pedagogical (STP) usability heuristics from Jahnke et al. (2021) (see Table 2). The STP usability heuristics emphasized by faculty, GTA, and

Ecampus media specialists in our interviews were related to Technological Usability -- *Easy to Use*, *Page Layout*, *Ecosystem*, *Functionality*—and to Pedagogical Usability–*Assessment* and *Teaching/Learning Goals*. Much of the discussion occurs within the space of technical-pedagogical usability (Jahnke et al., 2020), in that the ability of faculty and GTAs to accomplish pedagogical goals related to learning and assessment depend on the available technological tools and functions. Some of our codes were not related to usability as defined within the STP heuristics (for example, *emotions* that resulted from usability successes or challenges).

**Desired Capabilities**

***Faculty***

Instructors' desired capabilities for an online lab tool primarily fell into ease of use (including abilities of students to see instructor feedback), layout, grading functions, integration with the LMS, and ability to personalize the tool to the instructor's voice and preferences. These fall into the STP technological usability categories of easy to use, page layout, functionality, ecosystem, as well as the assessment aspect of pedagogical usability. In many cases, we found descriptions of ease of use were inseparable from and thus simultaneously coded with layout (i.e., the perception of whether something was simple or easy or obvious was often directly related to the format or layout). Similarly, grading functions (functionality) were often simultaneously coded with integration (ecosystem), as the availability and usefulness of tools for viewing and grading submissions often depend on the level of integration with the Canvas LMS.

Instructors' requested ease of use capabilities were related to making the tool simple to fill out (and hard to get lost) via a step-by-step layout or instructions and making it easy for students to manage images and show mathematical work. For example, faculty stated:

> *"some students really need hand holding" --Faculty*
>
> *"It would have to be a step by step, so easy for students to follow that they can't get lost or trip up in any way, shape or form" --Faculty*
>
> *"making it easy for students to upload images, to show their work on math-related problems, to be able to easily identify where they need to put their answers" --Faculty*

An emergent theme was a wish to make the grading easily understandable by the students. Faculty wanted to make it easy for students to view the instructor feedback in the same place as their answers and the points and for students to be able to make sense of that feedback.

Requested grading functions were those that would provide flexibility for different grading and feedback styles (rubric vs. annotation vs. a text box of grading comments), ease of use for graders in making the student work and rubric and commenting tools all available in the same window, and students ease of seeing and understanding the feedback (related to ease of use above). Most of the requested grading functions were related to integration with the LMS, which makes sense given that the courses are required to be delivered via the LMS and grades are required to be entered in the LMS; thus any new and improved capabilities must be easy to use with the LMS. For example, faculty stated:

> *"to be able to...[grade] question by question...rather than in text comments, column comments, and then a rubric. In other words, all these things are separate. If it could all be connected to the actual lab where students immediately saw, you know. Question 1, I got 3 points off, I've got 2 point, and then saw the comments attached to that." --Faculty*
>
> *"having it to be very integrated with Canvas, being able to use the use it within the*

*Speedgrader so that it's possible to use the rubric directly. Depending on how the lab notebook is put together, being able to add in line comments and annotations on the notebook, rather than having to do sort of general comments in the assignment itself." --Faculty*

*"so that you know you don't have to bounce back and forth between windows. I work on a 15 inch laptop. So that gets cumbersome, especially with some of the more involved labs that require lots of notes." --Faculty*

***GTAs***

GTAs' desired capabilities were largely similar to those of the faculty, particularly the emphasis on simple layout and ease of use for students (including showing work and managing photos), having a variety of grading tools (rubric, annotation, and comments) and on LMS integration (being able to access the student work, commenting tools, and rubric all in one window).

Different from the faculty, GTAs did not mention personalization of the tool to their voice or preference, but did heavily emphasize reliability (functionality) – that the tool facilitates efficient grading; that it does not break for students; that it works with multiple image file types and sizes; that it saves work reliably; and that it allows students to (p)review their work, etc. In particular, GTAs' comments illustrated how issues with reliability impacted the efficiency of their grading process - this probably belies the GTAs being constrained on time and on the "front lines" of encountering student complaints and frustrations when things break. For example, GTAs stated:

*"I think that the most important thing for an online notebook for grading is organization. So making sure that answers line up with questions, that things are formatted, so there's not big margins, or blank spaces, or empty fields that take up a bunch of room, things that format the medium nicely, so that grading can be efficient and done very, very easily." --GTA*

*"you would hope that an online notebook is fairly robust, so you don't have things, dramatic things happening that wreck student submissions." --GTA*

***Ecampus media specialists***

Ecampus media specialists mentioned both technological and pedagogical usability, emphasizing wanting to build tools that are easy to use and are reliable. In this context, reliability included ability to save student work, ability to work across multiple devices and/or device types, and learners' ability to view and interact with all the intended content and features. Ecampus media specialists wanted the tools to meet the faculty's pedagogical goals for learning and engagement. They also wanted the tools to integrate with Canvas, because that contributes to ease of use for both student and instructor. Finally, Ecampus media specialists wanted the ability to get feedback on how the tool is working and serving instructor and student needs, or when things go wrong.

**Development Description and Recommendations**

***Faculty***

To develop a custom web application as part of a formal OSU Ecampus course development project, a faculty course developer works with Ecampus media specialists, including web developers, to create a custom web application. In this case, the faculty course developer is one of the authors of the study (Mobley). Hence, the faculty interviewed for this study were not involved in the development phase of the custom online lab notebook, and only one had experience with the custom notebook in a class. Therefore, all faculty comments about this online notebook referred to the platform in use and not the development phase. The only faculty comments related to development were that the first term of use by

students revealed technical problems that hadn't been found during user testing by Ecampus media specialists.

### *Ecampus*

Ecampus media specialists' description of past development of custom tools emphasized prioritizing accessibility, inclusivity, ease of use, and the specific pedagogical goals of the course. Challenges mentioned with developing custom media include capturing and storing data from student submissions and integration with Canvas.

> *"The most challenging part is capturing the data and storing the data. Because you can build, you know, the application, you can build the framework for it, the text boxes, the buttons, and all of that, but it seems like the hardest part when it comes to a lab is capturing the data and making sure it's being stored correctly, and making sure that each user is able to access their own data."*
> *--Ecampus media specialist*

Ecampus media specialists wanted more feedback to come to the media team for future tool development. They expressed that the media team doesn't hear back often enough from students and faculty about how custom tools are working or about problems that arise. Related to this, Ecampus media specialists also wanted to see more user testing during the development process and to expand the population of testers to include those who are *not* involved in development and are representative of the range of technological proficiencies and device types that occur among student and faculty/GTA populations (i.e., not just Ecampus media specialists or student workers).

The request for additional user testing is particularly notable given that many of the challenges we encountered with the custom tool in its initial run were related to this – the user testing hadn't revealed problems that became apparent when students with a variety of device types and technological proficiencies used the tool. Once those were revealed, the media team fixed the issues and addressed any additional issues that came up. This ongoing support of continuous improvement is one benefit of working directly with a media team to develop a custom platform.

In addition to wanting to know about glitches and problems, media specialists also wanted to know about the student and faculty experience when everything was working: 1) are students enjoying the tool?; 2) Is it easy and reliable?; 3) Can they use it on any/all of their devices?; 4) Are faculty finding that it supports their pedagogical goals?

## Benefits and Drawbacks of Two Lab Submission Platforms

Faculty and GTAs had many comments on benefits and drawbacks of the old and new platforms, both what they directly experienced as graders and what they perceived to be the benefits and drawbacks for students. We acknowledge that a student-centered design process requires considering the experience of the online students themselves in their courses. To that end, a separate study and manuscript focuses on the perceptions of and outcomes for students using the old and new lab notebooks. What is described below is a synthesis of the perspectives of one faculty and two GTAs who experienced both notebook versions in the Spring 2023 courses, and one faculty who was familiar with the Word versions from previous terms' teaching.

### *Benefits of Word*

While two instructor participants found the Word document to be neutral in terms of benefits and drawbacks, the two others identified specific benefits and drawbacks. The benefits of Word for grading feedback included that instructors or GTAs could leave comments on the document itself via annotations, and that there was only one computer window needed to be open at a time because the Word submission could be viewed in Canvas Speedgrader next to the rubric (so that there was no window-switching required while

grading). Both of these seemed to provide improved efficiency of the grading process. Both of these benefits of Word documents can be attributed to Word's ubiquity as a word processor allowing for the integration with the LMS. This ability to provide feedback in the document rather than the comments section of the gradebook was cited by one grader as the major reason they preferred the Word document over the custom notebook.

> *"I think one of the biggest benefits of the Word document are the way that the instructors and the graders can leave comments on the document itself." --GTA*

Other benefits identified included a perception that Word was familiar to most students, providing ease of use for students in working within Word, saving their work, and using Word's equation editor to show mathematical work.

***Drawbacks of Word***

The major drawback identified for the Word notebook, and indeed one of the motivations for the developing the custom version, is that users of the Word document could easily "break" the formatting, which then made assignments difficult to grade and reduced grading efficiency. This includes accidentally deleting questions, inserting a photo larger than the pre-formatted placeholder, and shifting questions onto different pages, typing answers in the same line and style as the question so that the two are not easily distinguishable, etc. These formatting problems required the grader to spend extra time closely examining the document to figure out where the students' answers are, and/or lead to graders marking answers missing when they are actually present. One GTA complained of the extra time it took to grade when there were formatting issues, such as with photos embedded upside down or too large/small to view, or when photos create extremely large Word files that take extra time to load in Canvas Speedgrader. When GTAs are juggling large numbers of assignments to be graded with both intrinsic and instructor pressure to provide quality feedback on each assignment, efficiency matters. Efficiency of grading process maps to the Assessment heuristic for pedagogical usability in the STP framework. One GTA stated,

> *" I think that's just the biggest drawback...is an efficiency issue. And due to formatting. Sometimes it's impossible to find the answers. Sometimes the photos are too tiny. Sometimes students make the Word document...far too giant, and it doesn't render. It's a huge, huge document so I think ease at grading is the biggest downside for the Word document." --GTA*

***Benefits of Custom Notebook***

A number of benefits were reported for grading in the custom notebook. Most commonly, it was clear where students were to submit their data and where graders were to find their answers. That clarity cut down on the time graders spent trying to find student answers, thus improving grading efficiency. One grader strongly preferred the online notebook over the Word document because it was easier to read through and faster for grading work.

> *"Benefits: Not having to hunt and peck for things... it being very clear, there being a lot of space in between the areas where they need to have their responses, makes it so... the person grading doesn't have to spend the time trying to find what the student's trying to say." --Faculty*

> *"The notebook does do a fairly good job at keeping stuff contained and organized, and additionally it makes it very, very easy to find the answers that you need to grade. Which can be an issue...with mediums that aren't like this online notebook...so that was the benefit with grading this notebook. Every week I kind of knew what it was going to look*

*like, and it was really easy to find the answers, which made grading more quick." --GTA*

Faculty and GTAs familiar with the custom notebook described perceived benefits for students as well. Note that these are the instructional team's perceptions of benefits for students, not the recorded perceptions of the students themselves. Interviewees stated that it was clear and easy for students to find where they needed to put their information, that it kept the information organized and contained, and that students did not have to download anything and just had to click a button to upload their images and type in their data (instead of inserting it all into Word and then uploading the Word doc). These ease-of-use benefits for students, in turn, may have helped students to include all information they were required to provide, thus making grading easier and more efficient for the GTA, and improving student scores on the assignments. One instructor stated,

> *"I think that you could say the same thing about the web notebook version, where it's trying to streamline that process down even further. So someone doesn't have to download something. They can just click a button to upload stuff. It's more of a...drag and drop sort of feature. You don't have to have Word. You know there's a lot of students that that are running computers that they don't have Office installed, or they don't want to...so there's a huge benefit to that for those folk." --Faculty*

***Drawbacks of Custom Notebook***

GTAs and faculty also identified drawbacks to the custom notebook, largely related to grading functions and to reliability. For grading, some thought the online notebook was difficult to grade because they had to have two windows open while grading, one to view the student's submitted notebook and one to view the rubric in Canvas Speedgrader, an efficiency challenge if one is working only on a single monitor. Experience with this varied depending on browser preference (Mozilla Firefox and Apple Safari display the notebook inside Speedgrader, Google Chrome and Microsoft Edge do not), as well as monitor size. The instructors explained,

> *"It's not integrated in next to the grading rubric. So then you kind of have to have two screens and you're looking back and forth, which slows stuff down compared to the normal submission next to the rubric, in one, one window." --GTA*

> *"So to me, the drawback, and I've thought about this a lot. It almost comes down to just personal style. For someone like myself who prefers to work in the Speedgrader, leave in-line notes, you know, work from a rubric, it's challenging. Especially on a, I don't want to say a small laptop screen, but a 15-inch screen is not huge. Whereas if you are sitting in an office with dual 27-inch monitors, something like that, and you don't mind writing...longer comments that are more general, that's fine...I think a lot of it is personal preference."*
> *--Faculty*

Because the custom notebook is not integrated with Canvas, there was no way to annotate on the students' notebook submissions and leave a comment for students adjacent to the relevant question; feedback could only be delivered in the Canvas rubric or in the general Speedgrader comments. Other drawbacks noted were that there were occasional technical issues. Students were frustrated when their work was not saved, for example, or if their images could not be uploaded. The instructors stated,

> *"Another downside was just technical difficulties. When it seemed like there were some issues with photo uploads, things not uploading and rendering, and then the other*

*big issue was for a couple weeks or a couple labs there was an issue with student submissions getting erased after submitting. And that was difficult because it caused…student frustration…it adds extra time for the TA trying to remedy and grade…And so…that was really the only the only biggest downside I had." --GTA*

*"I think that, having only worked with it the one term, there were a good amount of kinks that, in my opinion, are due to it being new…in a class." --Faculty*

As this comment suggests, even though the Ecampus media team tests all new platforms to reveal and fix critical errors before anything new goes live, there is a risk that technical difficulties will be discovered as students use a newly built platform. Technical difficulties can also arise even after the first term from server errors, underlying software updates, etc. With a custom tool not able to be supported or monitored at the same level as a major LMS or productivity tool like Canvas or Microsoft Word, it can take longer to identify, report, and fix these problems and communicate the solutions back to students. One recommendation that could be gleaned from this work is to minimize risk by expanding the depth and breadth of the testing phase before a custom platform goes live, and at regular intervals after launch to catch new problems that arise with browser updates, etc. Faculty considering a custom tool must consider their own comfort with and capacity for managing these kinds of challenges.

## Comparing Desired Capabilities to Available Options

### *Grading Efficiency and Feedback Literacy*

Overall, reviews of both tools and views on the benefits and drawbacks of each were mixed. Instructional team preferences for one tool or the other seemed to be informed by their own experiences of efficiency or inefficiency of grading with the tool, as well as their perceptions of students' experiences with technical difficulties and students' ability to locate and make sense of feedback. The two GTAs came to opposite conclusions of which tool was more efficient and better for grading, as illustrated by these quotes,

*"…the online notebook is 100%, in my opinion, the right idea…That's how it should be done for the graders…it's night and day." --GTA1*

*"I was dreading grading the web, the online version. It's because I had to have 3 screens open, and I couldn't directly comment on changes. --GTA2*

Grading efficiency matters to both teaching and to learning. On the instructor productivity side, a more efficient grading process allows the grader to reallocate time from hunting for answers and checking work to leaving higher quality, more personalized feedback and/or returning that feedback to students more quickly. On the student learning side, prompt and personalized feedback are both critical to students being able to use that feedback to improve their learning process and mastery of content. Studies of student perspectives on feedback indicate that prompt, actionable, personalized feedback is critical to building students' confidence as learners and to develop their feedback literacy – their ability to receive, interpret, and make use of feedback for learning and improving (Ferguson, 2011; Sutton, 2012). So, while some graders may be most focused on efficiency for its benefit of getting them through the grading faster, a more important pedagogical benefit may be that an efficient grading process allows for higher quality and/or more prompt feedback that is more beneficial to student learning.

This leads us to consider the role of the instructional technology in supporting or obstructing students feedback literacy (Carless & Boud, 2018; Molloy et al., 2020). Several

comments by graders noted their concern that students wouldn't be able to find or make sense of feedback due to the custom tool not integrating with Canvas, and thus not having the ability to be directly annotated upon, examples of technological usability challenges. This created uncertainty for the grader about whether the students would be able to relate their feedback back to their answers and to the assignment criteria, examples of pedagogical usability challenges (Jahnke et al., 2021). Completing the feedback cycle in this way is a critical aspect of students' ability to make sense of the feedback and use it for continued improvement (Carless & Boud, 2018; Molloy et al., 2020). Inability to do this due to the technological limitations is a major technical-pedagogical usability issue that we did not foresee when designing the custom tool. The GTA's explained,

> *And I feel that there's a dissociation between the two because at least from what I can see students can't just see what they submitted in the web version and have the rubric right next to it. They would have to have 2 screens open, looking at one and then looking at the other. --GTA*

> *And I just...had no idea whether what I was commenting in the rubric correlated in the student's mind. It's harder for me to know whether they're interacting with the material or not or with my comments, I guess. I think it's harder to miss comments in the Word version because when you open Canvas and you click on your grade, you can see where the comments are or on the assignment, you can, the document populates, and you can see the comments." --GTA*

***Reliability and Technical Support***

Whenever a new web application is developed, there is always a risk of bugs in the first run of the tool, even when there is a testing phase before the platform is launched. However, at OSU the media team provides ongoing support to fix errors and provide improvements, thereby leading to a more robust and continuously customized lab platform over time. In contrast, in Word there are few "bugs" or errors because it is a widely used and corporately supported application, but also no opportunity for continuous custom improvements to the functionality of the Word document or how it integrates with Canvas. Therefore, when starting the term with a Word document as lab notebook, there are no bugs, but other problems (i.e., image sizing issues or disorganization of the data uploaded) are not able to be resolved until Canvas or Microsoft makes a change.

From a design justice perspective (Costanza-Chock, 2020), it is also important to consider who the "bugs" are affecting and what are the consequences. One of the goals of the custom notebook was to reduce the formatting errors that negatively affected the efficiency of the grading process. This was largely an inconvenience to the grader, though it could sometimes negatively affect student grades if the grader couldn't find or decipher the student answers and certainly affected quality of feedback and time to feedback as described above. That problem was largely resolved with the robust layout of the custom notebook. However, the custom notebook introduced new technical problems that had potentially larger impact on students, but lesser impact on faculty. When the custom notebook failed to save student work, it had a much bigger effect on the students than on the graders, although the empathetic grader communicated the stress in the interview:

> *That produces...a really big hit to student morale, an extra kind of contingency to deal with outside of the actual grading. --GTA*

The at-home labs in this course can take several hours to complete. Online students with full lives may not have the time to repeat the lab if their initial work is lost to a technical glitch. Furthermore, and as the powerful quote above

indicates, students who are still building their confidence as learners may have both confidence and motivation undermined by such a setback, which can easily cause them to give up on the course. Faculty and GTAs are limited in their ability to encourage and re-motivate students after such an incident, not least because their time is now occupied with troubleshooting, determining the extent of the problem, and communicating with the media team about repairs and possible data recovery.

While problems of this severity were limited to the first terms after the launching of the tool, they provide supporting evidence for Ecampus media specialists, faculty, and GTA requests for more extensive user testing before product launch, as well as a need for a faculty members or units developing such a tool to be prepared for high technological support needs and student communication burdens in the first terms of using the tool.

***Custom vs Personalized***

Faculty expressed a desire to be able to edit and personalize a lab notebook platform themselves without submitting a support ticket to the media team to make the adjustment. One faculty stated,

> *"Something that [colleagues] and I discussed year ago...was being able to freely update things in all the different versions of [the course] to better reflect our own personal styles and personal, the way that we speak, the way that we might write, you know, all working from a common central template. But be able to add little spins here and there to better reflect ourselves. So having something like that possible in a web notebook, being able to say, 'Okay, here's the master version, but then here's kind of our teaching version that we can change a word or two here or there, would be lovely."*
> *--Faculty*

In this case, our custom tool was only directly editable by the media team. In order to make updates, whether minor wording changes or substantial reorganization, faculty have to submit the request to the team and wait for the fix to be completed according to the media team's workflow. Although the notebook was customized to the learning goals and assignments of the course and able to be updated at regular intervals, unlike a completely "canned" publisher-provided platform, it was less personalizable than the Word document alternative for an individual faculty member or a particular academic term.

## Conclusion

In conclusion, there were benefits and drawbacks to both of the lab submission platforms (Word notebook and custom online notebook) that were the focus of this study. Several themes arose from interview participants:

- Faculty, GTAs, and Ecampus media specialists wanted to see better integration of tools with Canvas LMS, whether it was stated as a desired capability or as a drawback of the platforms used.
- Media specialists, faculty, and GTAs acknowledge limitations of current user testing for detecting issues before they arise in a class.
- Faculty and GTAs reported ease of use for most students on both lab notebook types for different reasons of familiarity for Word and robust, clear layout for the notebook.
- Faculty and GTAs reported that some students had technical challenges with both platforms related to technological usability in the area of functionality (e.g., uploading photos).
- GTA opinions are split as to which platform has higher pedagogical usability for assessment of student learning, due to different GTA experiences of grading efficiency with the two platforms.

- Faculty want to be able to personalize the platform immediately, without requesting a support ticket to edit.
- Media specialists would like more feedback from users (faculty, GTAs, and students) on how the web applications are functioning as they are being used.

Graders noted ease of use, as well as lack thereof, in both platforms for different reasons. For Word documents, it is the familiarity of Microsoft Word and its integration with Canvas Speedgrader that provides ease of use; for the online platform, it is the built-in simplified structure that provides ease of use. Conversely, the ease-of-use challenge for Word was that the document format could be altered, whereas the major challenge for the custom notebook was the lack of integration with the LMS. As faculty weigh the risks and benefits of developing a custom online lab platform, keeping desired capabilities, limitations, and available time and support resources in mind can help faculty choose the best platform for their needs.

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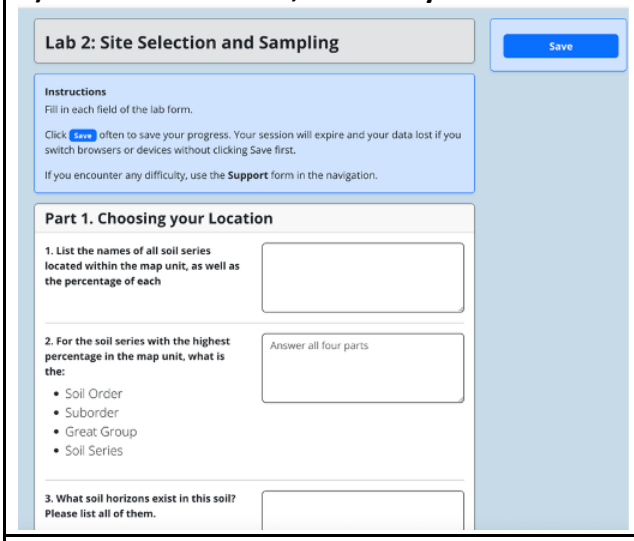
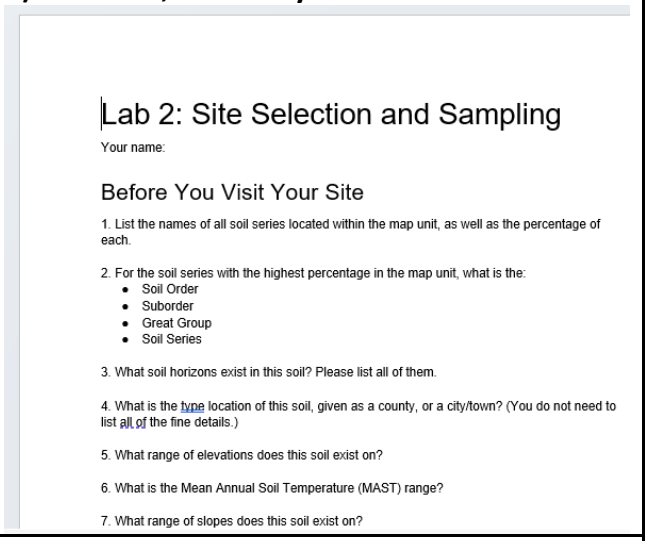
# Appendix A. Visual Comparison of Custom Online Notebook and Word Notebook

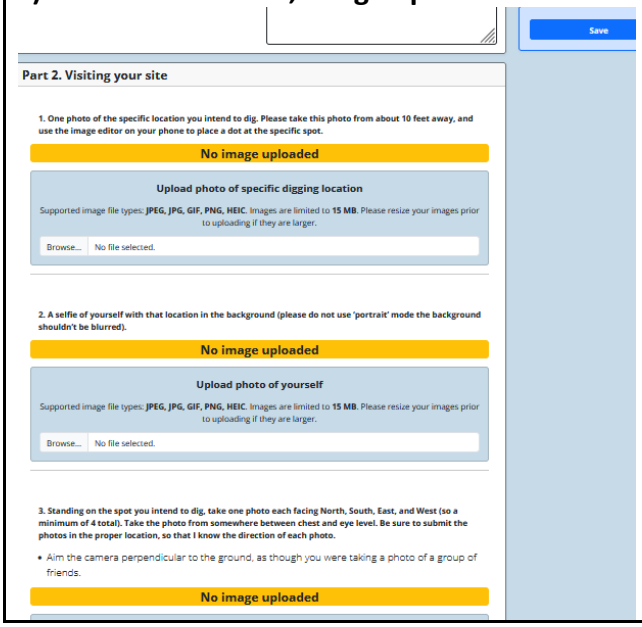
**a) Custom online lab, text entry:**




**b) Word lab, text entry:**




**c) Custom online lab, image upload:**




**d) Word lab, image upload:**

## Appendix B. Interview Questions

In all interview questions, "Lab Notebook" refers to a form/worksheet/template for recording and submitting lab assignments.

### Questions for Ecampus Media Specialists

*If a question does not apply to your role, please reply with "not applicable".*

1. Describe your role in creating custom web apps for online education.
2. What capabilities do you prioritize in creating a new custom web tool?
3. Describe your experiences in creating a new Lab Notebook.
    - What went well?
    - What was challenging?
4. What improvements do you think are needed in the *process of developing* new custom tools?
5. What improvements do you think are needed in the *process of testing* new custom tools?
6. What would you like to know about how students use these kinds of tools?
7. Is there anything else you'd like to share?

### Question for Instructors and GTAs

*If a question does not apply to your role, please reply with "not applicable".*

1. Describe your role in connection to [*course name/number redacted*]
2. What capabilities would you like to see in an online Lab Notebook – a form through which students submit lab data, images, and written answers?
3. Describe your experiences in facilitating a course with a new Lab Notebook.
    - What went well?
    - What was challenging?
4. Describe your experiences in grading each Lab Notebook.
    - Word document Notebook
    - Custom online Notebook
5. Describe your experiences in facilitating GTAs in grading each Lab Notebook.
    - Word document Notebook
    - Custom online Notebook

6. What did you observe to be the *benefits* of using each Lab Notebook for *students*?
    - Word document Notebook
    - Custom online Notebook
7. What did you observe to be the *benefits* of using each Lab Notebook for *graders*?
    - Word document Notebook
    - Custom online Notebook
8. What did you observe to be the *drawbacks* of using each Lab Notebook for *students*?
    - Word document Notebook
    - Custom online Notebook
9. What did you observe to be the *drawbacks* of using each Lab Notebook for *graders*?
    - Word document Notebook
    - Custom online Notebook
10. Is there anything else you'd like to share?

## Appendix C. Negotiated codebook of emergent themes

| Code | Examples | Description | STP Heuristic (Jahnke et al., 2021) |
|---|---|---|---|
| **Ease of use** | Ease of use, simple, easy, straightforward, clear, simple, simply intuitive, user-friendly, easy to navigate, clearly laid out, obvious, steps are in order, sequence, too many steps | Ease of use refers to how easily the lab notebook can be used. Clearly laid out refers to readability of the platform interface, rather than the code "layout," which refers to formatting. | Easy to Use |
| **Integration** | Link, linked, connected, linkage, integrated, all-in-one, in one place, submit, URL, export | Refers to the lab notebook's lack of integration with Canvas LMS, desired capability is that the platform be more tightly integrated with Canvas; includes the experience of submitting the work, transferring it from student control to grader, making it viewable to grader; includes ability of grader to annotate on submitted assignment | Ecosystem |
| **Grading Process** | Grade, providing feedback, comments, rubric, points, grader, "playing treasure hunt", speed, efficiency, fast, slow | Process of instructor providing feedback; from grader perspective; referring to fast or slow grading; could also refer to how easy or hard it was to grade | Assessment |
| **Grading Functions** | Ability to zoom submitted images, grade by question, alphabetical sort | Gives graders controls over how they view student work and the order in which they grade the work; from grader perspective | Functionality |
| **Layout** | Consistent, repetitive, know what to expect, predictable, familiar, students know how text boxes work, sequence matches instructions, "formatting negligence" | Indicates that there was consistency, predictability; interface felt familiar, was intuitive; layout also refers to interference with formatting, such as when a large image is uploaded that disrupts the layout of the page | Page Layout |
| **Images** | Insert image, upload image, drag and drop, photo boxes, image format, image size, image type | Refers to ability of student to submit their images, whether the system accepts and saves their images, whether they display correctly for grader; it will also be coded as "layout" when it refers to layout changes due to image size issues. | Easy to Use |
| **Student viewing feedback** | Viewing feedback, feedback is wasted, unclear which question got points off, score transparency | Responses include whether the student view of their assessment is transparent – they can see and understand what they did wrong | Assessment |

| Code | Examples | Description | STP Heuristic (Jahnke et al., 2021) |
|---|---|---|---|
| **Emotions** | Morale, motivation, dread, drama, love it, perfect, works well, frustrating, redo, lost data, spending time sizing images, pain, liked it | Refers to positive and negative feelings that arise when working with the platform | N/A |
| **Preview** | View, able to see, not able to see, show up, look at, wasn't there, preview, review, confirm, complete | Refers to ability of student to review their work before they submit, to see what they submitted, to see what the grader sees | Functionality |
| **Reliable** | Ability to save; glitchy; robust across device types; timeout; expires; lost work; interoperability of systems/OSs | Refers to the system working as it could reasonably be expected to, including working on different devices and browsers, saving (auto-saving), not timing out unreasonably | Functionality |
| **Window switching** | Multiple windows, multiple screens, switching, back and forth, screen size, screen size changes | Refers to needing to have multiple windows open at once, whether for completing the lab, grading the lab, browser problems, or viewing feedback | Easy to Use |
| **Custom** | Existing tools all have problems, limitations (Canvas, Word, Excel); get what we want, no workarounds required, customize, customized | Refers to getting exactly what we want, avoiding limitations or pitfalls of existing tools; "course-level custom" | N/A |
| **Personalized** | Editable template, personal, customize to instructor voice | Refers to ability of faculty to personalize the questions, instructions, language, etc.; to their personal style or preference | N/A |
| **Pedagogical goals** | Engaged learning: supports the learning outcomes, gets faculty out of ruts; interactive, hands-on, reinforces a concept, | Refers to the tool supporting the learning outcomes or to engaged learning goals (e.g., transparent assessment practices) | Teaching/Learning Goals |
| **Notation** | Show work on math, symbols, equations, | Refers to use of mathematical or chemical notation or symbols, calculators, generating graphs, or ability to show steps of calculations | Functionality |

| Code | Examples | Description | STP Heuristic (Jahnke et al., 2021) |
|---|---|---|---|
| **Digital Divide** | Tech savvy, have to download/upload large files, internet access/high-speed internet connection, mobile learning vs. laptop/desktop access, smartphone access | Related to assumed tech proficiency, access to tech/device, and internet speed | Easy to Use |
| **Developer Feedback** | Feedback loop, user data collection, error reports, user-testing | Referring to media team receiving feedback from users about whether tool is working, what needs improved, for example | N/A |

## About the Research Unit at Oregon State Ecampus

### Vision

The Ecampus Research Unit strives to be leaders in the field of online higher education research through contributing new knowledge to the field, advancing research literacy, building researcher communities and guiding national conversations around actionable research in online teaching and learning.

### Mission

The Ecampus Research Unit responds to and forecasts the needs and challenges of the online education field through conducting original research; fostering strategic collaborations; and creating evidence-based resources and tools that contribute to effective online teaching, learning and program administration.

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