An Example-Based Customization Sharing Platform to Support Educators with Using Feature-Rich Classroom Software

by

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Abstract

Educators often lack the time and resources to learn, integrate, and customize feature-rich software applications for their classes, and many struggle to keep up with the latest educational technologies. This dissertation introduces Customizer, a novel customization-sharing platform designed to streamline how educators can discover, interactively experiment with, and appropriate examples of their colleagues' software customizations in a widely-used learning management system (LMS).

To inform the design of Customizer, we carried out two studies that allowed us to gain a deeper understanding of educators' current approaches and challenges in learning and customizing their classroom software. In the first study, we conducted interviews with 20 K-12 teachers revealing the staggering variety of software tools being used in modern classrooms and highlighting the large extent to which educators rely on a social fabric of friends and colleagues for support with software usage and customization. In the second study, we analyzed posts from the Q&A forum for a popular LMS and found that educators' questions about more idiosyncratic customization needs frequently go unanswered.

To mitigate the challenges educators face in customizing their LMS, we designed, built, and evaluated the Customizer platform allowing educators to "peek" at their colleagues' setups and "borrow" their customizations. Finally, we carried out a two-week field deployment of Customizer to 10 instructors, which shed light on how instructors might integrate such a tool into their day-to-day workflows to improve LMS feature awareness, test out potential changes, and streamline their knowledge-sharing routines.

The central thesis of this dissertation is that *providing educators with in-context access to colleague-recommended examples of software customizations, and the ability to interactively experiment with and appropriate those customizations, can provide a useful and usable means to overcome the challenge of learning to customize feature-rich classroom software.*

Keywords: Software personalization, software customization, software learnability, educational technology, digital classrooms

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Table of Contents

List of Tables

List of Figures

Chapter 1

Introduction

1.1 Motivation

In recent decades, massive advances have been made in the field of educational technology — including software and hardware designed to be used by students and teachers in classroom settings. It has become common for modern classrooms at all levels to include technology in support of educational goals, enabling new activities and opportunities for students to engage with learning materials. For example, learning management systems (LMSs) are in widespread use to facilitate distribution and collection of course materials, grading, student collaboration, and many other use cases in classrooms around the world. Although a wealth of research in human-computer interaction (HCI) has been dedicated to the design and evaluation of learning aids and other educational software, including LMSs, that research has predominantly focused on the student experience of these tools.

Equally important, however, is the educator's own experience using these tools, whether for their own benefit or as a facilitator for their students. While some degree of institutional support may be available to help educators integrate certain software into their classes, it is commonly educators' own responsibility to discover and learn to use software applications that could benefit them and their students [104]. Since educators have limited time to focus on technology learning and integration amid their already-busy teaching duties [5], they may face added stress or burnout as a result [21, 197]. Furthermore, they may be hindered by a lack of necessary resources or infrastructure available at their school to support the more advanced technologies they want to incorporate into their teaching [5].

Compounding these barriers, each classroom's needs can vary depending on the grade level being taught, the subject matter, the teaching methods employed, and the needs and abilities of individual students. As a result, educators often need to *customize* the software they use in the classroom to better suit the unique needs of their class. In particular, general-purpose software applications are not necessarily well-tailored for classroom usage out-of-the-box to begin with, and may need to be configured to meet institutional standards (e.g., data privacy) or to sufficiently support the curriculum being taught. Furthermore, feature-rich educational software, such as LMSs, often offers educators only a "blank slate" that they must spend time learning to adapt to their classroom needs. In general, software customization can include a wide range of changes to the look-and-feel or behaviour of a software application that differ from its defaults.

A better understanding of educators' approaches to software customization could help designers of classroom software to better support teachers' varying needs. Although there have been some insights into software customization in workplace settings (e.g., [40, 123]), educators face unique work settings and circumstances not encountered in other workplaces. This leaves open the question of whether long-standing knowledge about how most workers customize their software can be applied to educators. In particular, educators must customize not only their own software experience, but also that of their many students. Their constant classroom responsibilities and lack of spare time may present further barriers to learning and customizing software beyond those faced by other domain experts. With all these factors in play, and the growing pressure to seek out and integrate new classroom technologies, how do educators cope with the need to customize their software on-the-job or troubleshoot software issues that arise during class?

Better supporting educators' ability to learn, use, and customize these tools could have wide-ranging benefits, and there is evidence that educators with greater knowledge about their classroom software may be more likely to see improved learning outcomes for their students [27]. There is further evidence that educators regularly engage in knowledge-sharing activities for different aspects of their jobs [165, 175], including their classroom technology [110], so it is worthwhile to better understand if and how educators share their

software *customizations* with one another. Knowledge workers in other domains are known to share their customizations with others — for example, software users who have made configuration changes to some aspect of the application will sometimes make those changes available for others to use [123]. Moreover, sharing customizations (both in the workplace and more generally) can help to introduce less technical software users to ways of using their software that might otherwise have been beyond their grasp, creating new opportunities for sharing institutional knowledge and improving ease-of-use.

My main goal in this dissertation was to design tools that support educators' software customization needs on the job. This first entailed seeking a better understanding of educators' customization and sharing activities, for which I conducted formative work to understand educators' current practices and perceptions regarding a broad range of classroom technology, focusing on their approaches to customization. I then built upon the understanding derived from these formative studies to invent and evaluate a novel approach, Customizer, that supports educators' software customization needs by facilitating example-based customization sharing among colleagues. As part of this platform, I implemented a novel, in-context exploratory mode [136] that enables experimenting with customizations in a risk-free way.

At the core of this dissertation is the following thesis:

> *Educators regularly lack the time and resources to learn, integrate, and customize feature-rich software tools for their classroom; providing them with in-context access to colleague-recommended examples of software customizations and the ability to interactively experiment with and appropriate those customizations can provide a useful and usable means to overcome these common challenges.*

1.2 Research overview

I created Customizer through a user-centered design process building upon two exploratory studies about educators' customization needs, proceeding through multiple design iterations and a usability study, and culminating in a full implementation and deployment of the system.

Overall, this dissertation takes a design-based inquiry approach to provide answers to a number of research questions about educators' technology usage and software customization:

1. How do educators discover and vet new software applications to use in their classroom?
2. To what extent do educators customize their classroom software, and how? To what extent do they share customizations with their peers?
3. What challenges do educators face in using and customizing software in the classroom?
4. How do educators make use of online help resources to learn about their classroom software? What types of questions do they ask?
5. How can the design of classroom software better support educators' unique customization needs?

I began by conducting an in-depth interview study with 20 K-12 teachers based around these high-level questions. In addition to uncovering the surprising amount of diversity in software tools teachers choose to integrate into their classes, this study also revealed the large extent to which teachers' social fabrics influence their approaches to software customization and the wide-ranging types of customizations they employ. Despite this widespread reliance on customization, this study further highlighted that many educators routinely feel hesitant to customize their software out of concern that their changes might negatively impact their students by adding complexity or breaking the tools they rely on.

In a second study, focusing on educators' online help-seeking, I analyzed the content of 250 posts on a help forum for a widely-used LMS. This study examined several cross-cutting themes throughout this corpus, and found that educators were asking a variety of questions about troubleshooting their LMSs, but found it difficult to receive timely help on these forums for many of the more unique and idiosyncratic customizations they seek to implement in their LMS. This was in part due to the difficulty of accurately conveying complex customization needs through these largely text-based channels.

Taking the insights gained from these two studies into account, I invented Customizer, an in-application example-based customization sharing platform for instructors. Customizer

enables educators to browse examples of software customizations used by their colleagues, and includes an exploratory mode [136] that allows educators to safely experiment with how those various customization options might affect their own software setups. Furthermore, Customizer lets educators easily appropriate those shared customizations for use in their classes without the need to navigate buried settings menus or seek outside help. To support knowledge-sharing and collaboration, it also provides the means for educators to author and share their own software customizations with others, alongside their explanations and rationale for using them.

To allow for a proper evaluation of its design in practice, I implemented Customizer as a browser extension atop the Canvas LMS, including the first full implementation of the exploratory mode concept. In designing and building this system, several more specific research questions arose about better supporting educators' customization needs:

1. How do educators learn to use and customize their learning management systems?

2. What methods do educators consider most useful in exploring the customizable features of a learning management system?

3. How do educators of varied backgrounds incorporate example-based customization sharing into their day-to-day course management workflows? What variations exist in how they apply and perceive these features?

To address these questions, I conducted a formative interview study with post-secondary instructors using early mock-ups of Customizer's features (N=10), deriving a set of design goals from the feedback. Pursuing these goals, I implemented Customizer on top of the widely-used Canvas LMS and conducted a usability evaluation (N=10) to assess whether instructors found its design intuitive and useful. Participants in this study mostly found Customizer easy to use, saw promise in the example-based approach, and appreciated that it could provide them with opportunities to explore potential customizations in their own contexts without the usual risks.

Although it was clear this approach had potential, lab-based usability studies alone could not provide insight into the nuances of how Customizer's example-based customization

sharing would be used and perceived were it integrated into instructors' day-to-day course management workflows. Therefore, to enable studying these aspects of Customizer in a real-world setting, I implemented new extensions to Customizer that added additional social sharing options and made it robust to long-term independent usage. I then conducted a field deployment of Customizer with yet another set of 10 post-secondary educators over two weeks, collecting detailed usage data and rich qualitative insights from follow-up interviews.

This deployment study revealed a number of ways that instructors could rely on Customizer's features to safely test out new ideas and potential changes to their courses, to streamline their usual routines for sharing software knowledge with their colleagues, and to improve their feature awareness in the underlying LMS. These findings pave the way for a variety of future design opportunities for HCI researchers and practitioners to harness example-based customization sharing as a way to better support educators' software customization practices. Beyond this, the research provides promising hints that this approach to customization sharing could be successfully applied to feature-rich software applications in more general domains outside of education.

1.3 Contributions and dissertation structure

The main contributions presented in this dissertation are:

1. Empirical insights into educators' experiences, motivations, and barriers with learning, integrating, and customizing software tools into their classrooms (**Chapter 3**)

2. Empirical insights into the categories and content of questions that educators ask about their learning management systems through online forums (**Chapter 4**)

3. Several implications for improving the design of classroom software and the online community hubs that support it (**Chapters 3 & 4**)

4. The design of Customizer as an example-based customization sharing platform to support educators in customizing their LMS (**Chapters 5 & 6**)

5. The implementation and evaluation of an exploratory mode to enable risk-free exploratory learning of a customizable, feature-rich LMS interface (**Chapters 5 & 6**)

6. Empirical insights from an initial evaluation of Customizer's usability, providing preliminary support for the usefulness of its conceptual model and novel design elements (**Chapter 5**)

7. Empirical insights from a field deployment of Customizer that demonstrate its usefulness in practice, its potential to improve educators' feature awareness, and evidence that it can streamline many aspects of their workflows (**Chapter 6**).

The remainder of this dissertation is structured as follows:

Chapter 2 provides an outline of relevant research literature and other works forming the background for this dissertation. In particular, it contextualizes this work among research into software learnability and help-seeking, end-user software customization, and use of educational technology.

Chapter 3 describes my exploratory research into how K-12 teachers discover, learn, use, and customize software tools for their classrooms.

Chapter 4 presents an analysis of questions posted by educators on the official online help forum for a popular LMS during the early months of the COVID-19 pandemic.

Chapter 5 introduces Customizer and describes the user-centered design process that I followed to create it and evaluate its usability for instructors.

Chapter 6 describes the field deployment of Customizer that I conducted to evaluate how instructors might use it in their day-to-day course management workflows.

Chapters 7 and 8 reflect upon the broader takeaways for designing classroom software that better supports educators' customization needs, the potential for example-based customization sharing to serve as a more general approach for improving the learnability of feature-rich software, and the main research contributions of my work.

Parts of this dissertation have previously been included in peer-reviewed publications (or have been accepted for publication). In particular, the content in Chapters 3 through 6

consists primarily of conference papers that I authored or co-authored, with the original publication listed at the head of each chapter. Some sections of Chapter 7 are partially drawn from these same publications where noted.

Chapter 2

Background and related work

In this chapter, I position my work within the broader research literature surrounding how software users learn and seek help for their applications, how software users customize their software, and how educators adopt and use technology in the classroom. Though individual chapters 3–6 each provide a more focused discussion of the literature most relevant to their respective studies, here I offer an overview of the major research areas that best contextualize my work as a whole.

2.1 Software learnability

Feature-rich software applications tend to present a steep learning curve that users must overcome in order to make effective use of them. Accordingly, a topic of great interest among HCI researchers is understanding how to "lower the barriers" to usage and make this learning curve more manageable.

2.1.1 Approaches to learning and seeking help

Although many software applications include some type of built-in help or formal documentation, it has long been known that users tend to shy away from relying on these when learning to use the software [170]. Among the reasons behind this, one major contributor to the difficulty of navigating these is the requirement that users understand the applications developers' vocabulary for the features they need help with, which may differ from the user's own vocabulary and mental model [62]. This is commonly known as the *vocabulary problem*, and is a pervasive challenge facing nearly any text-based software help system.

Instead, it is more common for users to try learning the features of an application through individual *exploratory learning* and *trial-and-error* methods [171]. However, because these methods are naturally error-prone and time-consuming [136], many users instead turn to social forms of help as they learn new software applications, such as community-based Q&A websites [112, 127, 183, 184].

2.1.2 Software Q&A and tutorials

There exist many online communities built to support software Q&A and tutorials, such as general-purpose websites like *Super User* [185] and *wikiHow* [95], as well as many more domain-specific communities and forums. Furthermore, the HCI community has made a number of research-driven contributions to this space. For example, systems like *LemonAid* [29], *IP-QAT* [133], and *Social CheatSheet* [200] integrate community-based Q&A on top of an existing application. Some systems (e.g., [74, 75, 200]) also provide tools for generating, sharing, and following software tutorials to demonstrate how to complete various tasks within an application.

2.1.3 Re-finding online help

While users can tap into this wide variety of online help resources to more easily learn a software application, they often face a further challenge when having to re-find helpful content that they have used in the past [16]. Some solutions have been designed to help with re-finding online resources in a general way, such as the *SearchBar* system that maintains a history of a user's specific search queries and then uses this to facilitate resuming interrupted tasks at a later date [144].

Other systems have focused on helping users re-find help content when they are actively learning an application. For instance, the *InterTwine* system directly links a user's actions within an application to their search queries and activity in a Web browser, modifying the interface of both to facilitate task-based re-finding of help content [58]. Similarly, my own past *CheatSheet* system's in-application memory aid maintains snippets and screenshots of previously-used help resources with links to the original content [199].

2.1.4 Learning by example

Another prominent method of learning a piece of software is by viewing examples of correct usage or of certain tasks being performed within it, usually taken from someone else's usage of the application. In particular, this approach has been used extensively to help novice programmers in computer science education environments [17, 76], as well as to familiarize professional programmers with the features of their integrated development environments (IDEs) [81, 147]. Some example-based systems use additional context, such as a user's own written code [13] to automatically retrieve examples that are likely to be relevant to the user's current task. In Chapters 5 and 6, I describe how I took inspiration from such systems when designing the example-based retrieval system for my Customizer system, which suggests example customizations based on contextual information such as the user's page navigation within a learning management system.

2.2 End-user software customization

In addition to more general software learnability concerns, software *customization* often presents its own learning curve beyond this, as users must discover not only which features exist and how to use them, but also what ways they are able to modify how those features look or work. Here I provide a comprehensive survey of the literature on software customization and related concepts.

2.2.1 The language of modifying software

The literature around customizable software relies on several closely-related terms, warranting a brief overview of the wording used to describe and classify interface changes:

Adaptation is usually taken to lie at the more general end of this terminology. Glahn [69] describes adaptation as making changes to a system's look & feel or its behaviour, based on external "contextual factors". ***Customization*** and ***Configuration*** tend to be used similarly as broad concepts in line with this definition. In some contexts, *adaptability* and *adaptivity* carry additional meaning about whether the changes are initiated by the user or the system [54, 151], but generally describe a system's flexibility to change or be changed

in accordance with different factors and situations [9, 60, 115] (discussed further in a later section).

Personalization often represents a narrowing of the scope of these terms to a user's personal contexts. For instance, Glahn [69] characterizes personalization as a "special form of adaptation" derived from the user's personal profile, such as their preferences or personal behaviour. The related term ***Tailoring*** can be seen to fall under the same definition (i.e., tailoring to a particular user or their use case) [125]. It is important to differentiate this definition from the automatic personalization of search results that is discussed in information retrieval literature (e.g., [67, 107, 178]). Although there are commonalities, my work primarily focuses on intentional *user-driven* personalization of an interface, as opposed to purely algorithmic server-side content filtering/sorting with no user involvement.

Individualization is a similar term with particular relevance to education. Within educational contexts, Wenglinsky [206] defines individualization as when "teachers instruct each student by drawing upon the knowledge and experience that that particular student already possesses". He further notes that "individualizing instruction seems to be effective. Students whose teachers received professional development on learning how to teach different groups of students [e.g., those with special needs] substantially outperformed other students" on measures of educational progress. This presents individualization as a promising method for improving student outcomes, and it should come as no surprise that modern teaching approaches like *personalized learning* make individualized instruction a centerpiece of their pedagogy [5, 157].

Despite these many definitions, there is little consensus within the literature on how to use each of these terms [79], and some authors simply choose to use terms like "adaptation", "customization", and "personalization" interchangeably when describing end-user modifications to an interface [77]. In my work, I aim to be somewhat more precise, reserving "personalization" as a term referring to high-level adaptations driven by personal needs or preferences. For more granular interface changes removed from personal context, I instead opt for either "customization" or "adaptation."

I also consider that the person who performs a customization may be different from the intended user whose needs motivated them in the first place (as occurs in many teacher-student scenarios). In particular, in cases where a teacher is adapting software tools both for themselves and for their students, I draw a clear distinction between "individualization" (when the teacher is making the changes to address individual student needs) and "personalization" (when the teacher is making the changes to address their own needs).

2.2.2 Classifying customizations along several axes

A number of researchers over the years have defined systems for classifying different types of software customizations, in pursuit of better understanding how we might facilitate these different types in more targeted ways.

Functionality, presentation, and content

Oppermann and Simm [152] classify software adaptations according to what part of the software is being changed: either its *functionality* (i.e., how it behaves) or its *interface* (i.e., how it is presented and what features can be accessed). The functionality adaptations could prominently include examples like recording user-generated macros and shortcuts, writing custom application scripts, and installing most application plugins/add-ons. On the other hand, common examples of interface adaptations might instead be changing the screen layout of an application's visual components, showing/hiding certain menu items or widgets, and making cosmetic alterations to the application's visual theme or colour scheme.

Similarly, Marathe [130] proposes a classification into "functional (task-based) and cosmetic (presentation-based)" customizations, while Bunt [18] offers categories of *graphical user interface (GUI)* customizations and *content* customizations. The last of these comprises adaptations to "*which* content is delivered, ... *how* content is presented, ... and *when* content is delivered to the user". In particular, she notes that content customizations regularly arise in educational contexts when online lesson content is individualized for each student, as is the case with some intelligent tutoring systems [32]. Chapter 3 details further findings from my own study that suggest that K-12 teachers often put substantial effort toward manually or semi-automatically individualizing content for the classroom software their students use.

Levels of difficulty and the customization gulf

A related classification is given by Haraty and McGrenere [78], in terms of what type of changes are involved. They distinguish between *basic* and *advanced* personalizations, where the latter are those which "go beyond changing the look and feel [of an application], and involve changing functionality". While advanced personalizations largely correspond to Oppermann and Simm's functionality adaptations, differences between the two arise when considering (for example) predefined application options that switch between different built-in system behaviours — these would not be considered advanced personalizations, because of their fully predetermined nature.

Along similar lines, Bentley and Dourish [10] draw a distinction between *surface* and *deep* customization, according to whether the user is "constrained to using the functions the system developer has provided" or is instead able to freely make changes to the system's behaviour. They identify a gulf between users' ability to customize at these two different levels, where the leap from surface to deep customizations entails a disproportionately large spike in the level of expertise needed to implement them.

In a sense, many of these works represent attempts to bridge some variation of this "customization gulf" [10], whether by designing artifacts that lower the barriers to more difficult types of customization, or by providing a better understanding of what influences customization behaviour on either side of the gap. For instance, Haraty and McGrenere's ScriPer system enabled almost all tested participants to complete several advanced personalization tasks regardless of their technical expertise, albeit with some mistakes [78]. Along similar lines, Maclean et al. designed the Buttons system with the express intent of "smoothing" the steep increases in the difficulty of performing increasingly involved forms of customization (see Figs. 2.1 and 2.2) [125]. Throughout my own work in this dissertation, I also aim to make both simple and challenging customizations more easily accessible to *educators*, who have many compelling reasons to customize their software but often suffer from a lack of time to properly "learn the ropes" and gain the necessary expertise.

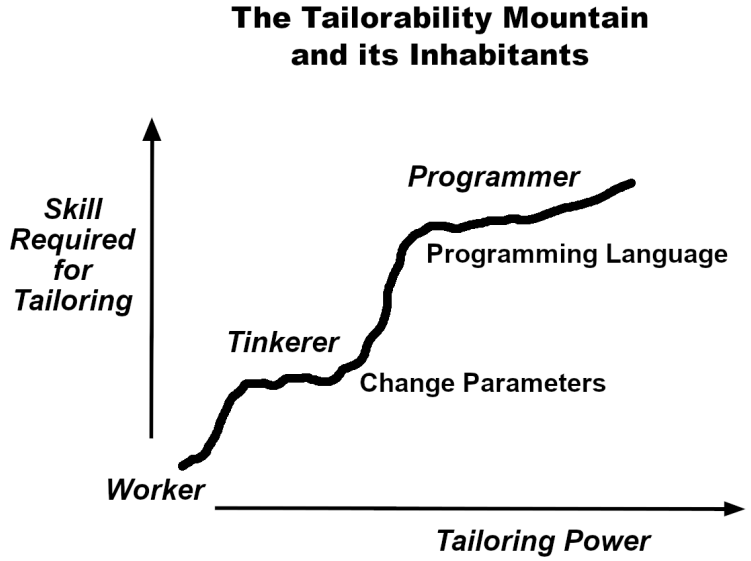

Figure 2.1: Maclean et al.'s visualization of the difficulty of making different types of software customization (tailoring), and the different user groups capable of them [125]. Note the steep cliffs separating the different groups according to skill, representing the disproportionately large hurdles that users must overcome in order to access more advanced customizations.[1]

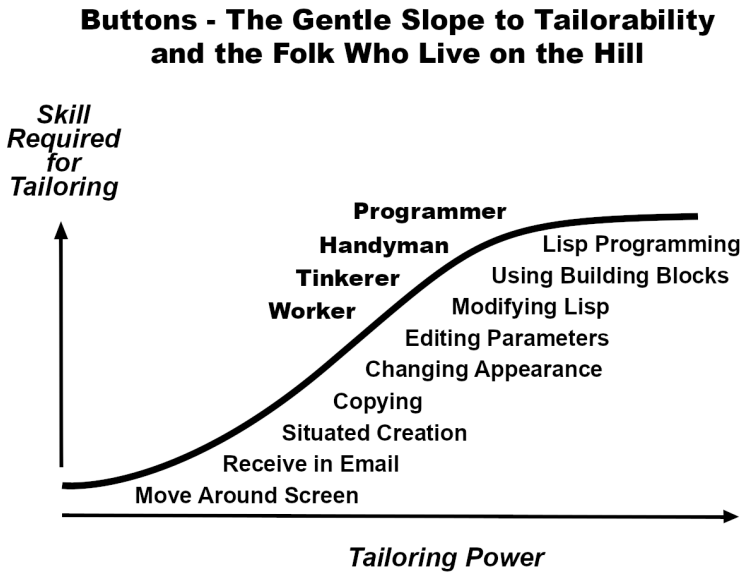

Figure 2.2: Maclean et al.'s preferable, "smoothed" version of the above figure (as exemplified in their "Buttons" approach), in which incremental increases in a user's skill with the software result in proportional increases in their ability to customize it [125].[1]

[1]Figures 2.1 and 2.2 are used with permission of the Association for Computing Machinery (ACM), originally appearing in Maclean et al.'s 1990 paper **User-Tailorable Systems: Pressing the Issues with Buttons**, published in *Proceedings of the 1990 SIGCHI Conference on Human Factors in Computing Systems*, pp. 175–182. Permission conveyed through Copyright Clearance Center, Inc.

2.2.3 Adaptive and adaptable systems

As noted earlier, another important distinction is how people perceive and interact with adaptable and adaptive systems. In an *adaptable* system, the user is provided with "tools that make it possible to change the system characteristics" and "it is up to the user to initiate the adaptation" [152]. In contrast, an *adaptive* (or *self-adapting*) system is one which "is able to change its own characteristics automatically according to the user's needs", often by means of artificial intelligence and user-tracking components [152].

The trade-off is clear: adaptive systems remove the burden of personalizing the interface from the user by automating this process, but give little control to the user; while adaptable systems give the user full control over this process, but also surface the full complexity and effort involved in learning to make adaptations [54]. There have been long-standing debates about which approach is more effective [138, 181], and there is empirical evidence to support the idea that people tend to have prefer one or the other in different scenarios. For example, surveys of visitors to e-commerce websites have found that most users "would rather customize a site themselves than have it automatically personalized for them" [150], while the SUPPLE system is highly successful in generating user interfaces that automatically adapt to the capabilities of users with motor impairments [65]. Moreover, for educational contexts the GRAPPLE system has found success in building adaptive learning environments that can change the media types and sequencing of lesson content to match a user's progress and learning styles [37].

In my line of research, I focus primarily on how users interact with *adaptable* systems (i.e., where the user is responsible for making the adaptations themselves). However, there is also a wealth of information retrieval research into adaptive recommendation systems that automatically personalize a set of search results presented to a user, based not only on a search query but also on personal factors such as interests and search history [67, 107, 178]. While these types of systems do serve to inform some features within our designs where appropriate, my core focus remains the explicitly user-controllable aspects of the system as opposed to these implicit, purely algorithmic, and often less transparent forms of adaptive personalization.

Mixed-initiative systems

An alternative approach is found in *mixed-initiative systems* [88] which support adaptive and adaptable modes of customization by attempting to find a sensible middle ground between the two extremes. In a mixed-initiative approach, "the system and the user cooperate to produce a customized interface" by combining full user control with "adaptive support to help them customize their interfaces effectively" [20]. Evaluations of mixed-initiative systems have shown promising results, particularly when the adaptive system's recommendations are accompanied by the rationale behind them [20]. These findings support and parallel some of our recent work on helping instructors customize their learning management system, both in how our system recommends potentially helpful customizations while still giving instructors full control over their implementation, and in how it surfaces rationale for each customization (though the rationale may be peer-generated) [202].

2.2.4 Broader outcomes of customizing an interface

A number of works have investigated large-scale changes to an application's UI to produce new conceptual models of how customization can take place. Some of these methods heavily alter the layout of an existing interface to make it more accessible to specific user groups, as in the SUPPLE system mentioned earlier [64, 65]. Furthermore, similarly widespread interface changes can be made to afford easier customization from the user's perspective, as in the Anchored Customization approach [162] which attaches application settings directly to "visual elements of the UI that are conceptually related" to them.

Other work has studied the broader-scale effects on usability that can result from customizing an application's UI, such as by altering the availability of less important features to promote easier navigation [137] and modelling the task performance of users who adopt different customization strategies [19]. Promisingly, the latter study found that "customization can be worth the necessary effort ... [with] particularly dramatic effect for Intermediates and Novices, who often see the payoff immediately.". Leung et al. also found that customizing an interface to hide complexity in a separate layer was beneficial for older adults learning to perform new tasks on it [113]. Considering that nearly 20% of public

school teachers in the US are over the age of 55 [57], approaches similar to this could make a substantial difference in many teachers' comfort with educational technology.

2.2.5 Understanding who customizes and why

Stepping back from the systems and interfaces, it is also worth our while to better understand the people who experience software customization first-hand and what their motivations are. Early studies of customization practices identified key user groups that are essential to the social fabric of customization, such as "translators" [123] who act as enthusiastic intermediaries between expert customization authors and the novices who rely on their expertise. Similarly, "tinkerers" [125] help to bridge the gap between high-skill (but low-availability) programmers with extensive knowledge of a system and ordinary workers who have little ability to tailor that system on their own. Mackay [124] also provides one of the earliest (and still quite relevant) breakdowns of the triggers that motivate customization behaviours and the barriers that hinder them.

Variations in timing and strategies

Furthermore, over longer periods of time, people often display very different strategies for how and when they choose to customize their software. McGrenere et al. identify *upfront* and *as-you-go* approaches to customizing [138], while our recent study of K-12 teachers found that they largely fall into *proactive* and *reactive* types of customizers [201]. Both of these schemes address an apparent divide between people who tend to front-load their customizations as early preparation for future needs, and those who tend to spread their customizations out over time according to their immediate needs and time constraints. Considering that educators regularly face intense time pressure in their jobs, it is intriguing to note that they still demonstrate a relatively even split between the two strategies in practice.

The psychology of customization

Considering the ways that adapting an interface can feel like a frustrating additional task, one is led to wonder what effect personalizing an interface might have upon the user's state of mind. Marathe and Sundar show that simply spending 10 minutes personalizing a

web page with one's own custom arrangement of interactive widgets and cosmetic visuals yields substantially improved sense of control and identity, suggesting that "customization features can be quite influential in helping shape one's self-representation" and promote a sense of self-realization [128]. Interestingly, they also note that a high psychological need for uniqueness and control correlate with seeking out interfaces that help to fulfill these needs [128, 129].

High-level goals of customization research

The reasons behind these customizations have also been a topic of several lines of research. In some cases, the goals behind the customization are broad improvements to the learnability and usability of the software [113, 137]. Other research on customized interfaces targets more specific improvements like reducing how long it takes to locate items in a textual list [193] or menu items in a GUI [30, 50, 52] without introducing detrimental effects to selection accuracy. From a methodology standpoint, Banovic et al. identify some shortcomings in the usual approaches to evaluating interface customizations, such as the fact that users often have little realistic reason or motivation to customize a piece of software in the context of a short-term lab study, compared to real-world scenarios in which users would stand to derive long-term benefits from doing so. They also note that insufficiently complex study tasks and within-subject experimental designs are likely to introduce unwanted bias when studying customization behavior. They then iterate on their study methods with these drawbacks taken into account, and demonstrate that increased awareness of customization options and the presence of social pressures can be beneficial in reducing the barriers to customization [8].

2.2.6 Exploring new customizations and associated risks

One challenge that software users regularly face is that learning how to customize their software often entails some amount of trial-and-error or "exploratory learning" [136, 171]. This is not always a viable option due to the fact that, depending on the software application, testing out unknown features could result in unintentional consequences such as loss of data or unwanted system states. Notably, for educators this risk is exacerbated by the fact that their software customizations are likely to impact their students as well, including any

problems that occur, and concerns about these risks hinder their motivation to customize in the first place [201].

McGrenere proposes that feature-rich interfaces could include an "exploratory mode" that gives users "an opportunity to explore the interface with impunity". She suggests that such a mode could work atop a "dummy document" and optionally revert any changes made to the system at the end of an exploration session [136]. Such an interface mode could serve to alleviate many of the aforementioned risks while also carrying the benefit of encouraging "just-in-time exploration" for learning the features of an interface. Leung et al. considered an exploratory mode in the design of their Help Kiosk system, though this feature was left unimplemented [114]. Chapters 5 & 6 will further elaborate upon my own design and implementation of an exploratory mode with a social component that allows course instructors to freely explore a colleagues' *shared* customizations as they would appear within their own setup.

2.2.7 Sharing customizations with others

Our last major category of customization research involves how people *share* their customizations with others after implementing them (and conversely, how they might receive shared customizations from others). Some of Mackay's early work provides a solid foundation for understanding how customization sharing takes place within an organization, in the context of software configuration files [123]. Importantly, she finds that only a small fraction of individuals actually take the time to create and share customizations to these files, but the presence of aforementioned *translators* provides a substantial boost in communication and sharing between different layers of the organization. More recently, Haraty et al. delved into the complex inner workings of online customization-sharing ecosystems, digital spaces built around a common application in which modders and other customization authors can publish and share their creations [79]. In a more domain-specific context, Bourguin et al. also present a system called ShareXP that is meant to facilitate sharing customizations of the Eclipse IDE [12].

2.3 Educators and technology usage

In this section, I discuss the broader literature concerning educators and their practices relating to classroom technology. It is worth noting that there can be large differences in teaching environment and requirements between K-12 teachers (i.e., elementary through secondary school) and post-secondary instructors. Some of these differences are readily apparent (e.g., different class sizes, different frequency of face-to-face instruction), while others may be more subtle (e.g., different degrees of access to technology infrastructure and support). Moreover, even within these two groups, there are numerous factors that can vary widely and have wide-ranging impacts on technology usage. For instance, consider the different expectations of technology usage between an introductory computer science instructor teaching a 300-student lecture, versus a classical studies instructor teaching an upper-year Latin seminar to a small handful of students. Despite these differences, we will see throughout this dissertation that many of the common attitudes, practices, and challenges educators face with software customization are remarkably similar across these various teaching situations.

This section mainly provides a high-level overview of how educators perceive and interact with classroom technology. Section 3.2 will go into greater detail about more specific aspects of classroom technology usage as they relate to this dissertation.

2.3.1 Educator perceptions of classroom technology

A large number of studies have sought to characterize how educators approach using technology in general and their attitudes about integrating technology in the classroom. For instance, An et al. performed an online survey of K-12 teachers in two US states, finding that the most common barriers hindering them from effectively implementing "technology-enhanced learner-centered classrooms" were a lack of available technology at their schools, a lack of time (to learn, experiment, etc.), and assessment constraints (e.g., standardized testing demanding a specific curricular approach that precludes large-scale technological innovation) [5].

Factors influencing classroom technology adoption

A large number of surveys of in-service K-12 teachers have highlighted factors that are particularly important in influencing how and when teachers choose to adopt new technologies in the classroom. Among the most common factors found are the amount of time teachers have [5, 71, 103, 161], their prior technology skills and experience [48, 103, 142, 155], their attitudes and beliefs about technology in general [48, 103, 117, 142, 191], having access to the necessary technology and infrastructure [5, 71], their experiences with professional development [5, 161], and school/district policies around technology usage [71].

While there are clearly mountains of evidence pointing toward these common factors in decisions to adopt classroom technology, it is unclear just how useful these insights truly are in understanding the many-faceted landscape of teachers' technology integration practices. Memorably, Zhao et al. chastise the education research community for "a conspicuous lack of attention to the complexities and intricacies of how classroom teachers actually incorporate technology in their teaching", the tendency to focus on "survey studies looking for correlates among the many variables influencing teachers' use of technology", and a "neglect [for] the messy process through which teachers struggle to negotiate a foreign and potentially disruptive innovation into their familiar environment" [209]. They go on to discuss several factors rarely considered by the survey studies, such as the need for teachers to interact closely with technicians and administrators to implement new tech (and the need to know who to contact in the first place), potential risks to student privacy, navigating parent concerns about childrens' tech usage, and negotiating shared usage of limited technology resources with other teachers at their school.

2.3.2 Digital classroom ecosystems

Beyond the study of individual technologies in the classroom, it is also important to zoom out and consider how these technologies interact with one another in practice, and how educators use them together within high-level workflows. As a starting point, the study of *digital ecosystems* covers many cases of many interdependent technologies working in tandem.

Although the term "digital ecosystem" has been used to describe a variety of disparate concepts (neatly outlined by Briscoe [15]), here we broadly use it to mean an interconnected collection of software or hardware components serving a common purpose. Furthermore, Chang and West [26] adopt a business-oriented perspective on what defines a digital ecosystem, but many of their defining characteristics can be seen to carry over to classroom environments as well. For instance, they define a digital ecosystem in terms of agents (or species) and an environment in which they interact, each with their own goals and their own roles. Those agents can be both humans and digital entities (like software applications or hardware setups), with interdependencies between them and a means of communication or cooperation for mutual benefit. They also identify the possibility for a "leading" agent within this ecosystem who facilitates this collaboration. In these definitions, it is not hard to see analogies to how a digital classroom operates — we can draw parallels to a community of students relying on multiple interconnected software applications to collaborate with one another, while their teacher(s) takes on a leading role in directing what digital agents are present and how the students can interact with them.

A related concept in software engineering and business contexts is the *software ecosystem*, a "collection of software projects which are developed and co-evolve in the same environment" [122], an abstraction that facilitates high-level analysis and allows us to characterize the interactions between the many systems involved [121, 122]. Of particular note are *e-learning ecosystems*, which usually include a combination of mechanisms supporting student preparation & onboarding, delivery of interactive lesson content, peer collaboration, instructor feedback & awareness, scheduling, organization, and a host of other interconnected needs for computerized learning [195].

My first study (described in Chapter 3) dives deeper into how teachers manage and personalize software ecosystems within classroom contexts. In that chapter, I detail the diversity in how teachers make choices about what software to adopt and how to integrate and adapt that software to best suit the needs of their students and themselves, further cementing the importance of considering digital ecosystems in educational environments.

2.3.3 Summary

Educators have a particularly pressing need to customize the software they use in the classroom to deliver their lessons most effectively and adapt to unique situations and teaching methods. Despite this, how educators experience the process of software customization is poorly understood. My research aims to bridge this gap by first seeking a deeper understanding of educators' needs, motivations, and current practices with regard to software customization. Building on this improved understanding, I design the Customizer platform to serve as a direct means of supporting educators' customization needs by surfacing relevant customizations recommended by their colleagues and allowing them to explore those customizations in a safe and familiar environment.

Chapter 3

Freedom to Personalize My Digital Classroom: Understanding Teachers' Practices and Motivations

My first study[1] sought to understand the landscape of K-12 teachers' use of software in the classroom through a series of one-on-one interviews. Because of the rapid pace at which educational technology has been advancing in recent years, this research served in part to provide an up-to-date picture of how modern classroom software integration takes place "on the front lines." In this study, I adopted a broad lens to examine how teachers discover, integrate, troubleshoot, and personalize their classroom software, what motivates their software choices and personalization behaviours, and what challenges they face in learning and using educational technology.

3.1 Introduction

Digital tools used in the classroom are part of a rapidly growing multibillion-dollar educational technology market [209], with millions of students and teachers signing up as the barriers to entry drop [38]. There is increased use of both hardware devices (e.g., desktops, laptops, tablets) and software tools (e.g., learning management systems, productivity suites) across many elementary and secondary schools ("K-12") in North America [126, 205]. This spans

[1]Portions of this chapter were originally published in Vermette, McGrenere, Birge, Kelly, and Chilana (2019). *Freedom to Personalize My Digital Classroom: Understanding Teachers' Practices and Motivations.* Proceedings of the 2019 CHI Conference on Human Factors in Computing Systems (CHI '19). [201]

both education-specific tools and general-purpose tools. Many school districts are making explicit efforts to lower the barriers for teachers to access tools for the classroom [141, 193]. This coincides with a recent "shift in the conversation" away from simply gaining access to promoting how best to harness technology to improve learning outcomes [193].

Teachers are increasingly being given latitude in all stages of integrating digital tools into their classroom: from exploring possible tools, to installing or embedding them, to personalizing them so they are appropriately adapted [24,80,172]. Teachers are "going digital" for a range of activities like distributing classwork, fostering student collaboration, and delivering assessments. In doing so, teachers have several choices of tools. For example, in many cases teachers can customize existing productivity tools like *PowerPoint* and *Word* to better support in-class usage (e.g., by installing plugins that add subject-specific features). Furthermore, teachers can personalize online learning platforms and management systems, such as *Google Classroom* or *Class Notebook*, to target certain grade levels, subject matter, curriculum standards, and teaching preferences. In a smaller but growing number of cases, some teachers are also under pressure to implement *personalized learning* goals that target student needs with individualized content, instruction, or assessments [23, 102], requiring additional changes to their digital classroom tools.

Although teachers are increasingly becoming the front-line end users responsible for setting up personalized digital classroom ecosystems, we surprisingly know little about their day-to-day practices of classroom software setup and usage. For example, how do teachers actually find relevant applications (among the plethora of choices available) and make decisions around what to integrate into their classroom? To what extent do teachers use these applications "straight out of the box" versus personalizing them for their classroom and individual student needs? What barriers do they experience? By improving our understanding of what motivates and hinders K-12 teachers when building and personalizing their digital classroom ecosystems, we can find ways to improve the design of educational software and offer teachers appropriate support throughout this process.

In this chapter, we take an HCI perspective to better understand teachers' software integration and personalization practices, across a range of grade levels and subjects. We

interviewed 20 K-12 teachers in North America who already had technology access and buy-in from their school districts, giving us a lens into their post-access motivations, routines, and barriers that influence technology integration in the classroom.

Our findings overall illustrate numerous ways that teachers rely on a combination of self-guided experimentation and help from colleagues for everything from discovery of new software to learning new ways to personalize it. However, teachers are held back by concern over potentially confusing students and a frequent need to troubleshoot real-time software problems in class, impacting teaching time and leading to unwanted tech support responsibilities. We discuss design implications to guide HCI researchers and industry in creating digital classroom tools (or features thereof) that lower the barriers to social troubleshooting and personalization sharing and promote a more consistent software experience in the classroom.

Our main contributions are in providing empirical insights into: (1) the factors that influence teachers' choices of what tools to integrate into the classroom and how, (2) their various methods of personalization and the motivations behind them, and (3) the day-to-day challenges teachers face throughout the software integration and personalization process. Ultimately, we provide an HCI perspective on the classroom-level realities of technology integration, harnessing educators' knowledge to improve the design of tools that teachers use daily and lower the barriers to successful classroom use.

3.2 Related Work

This work builds upon existing literature on the range of factors influencing teachers' technology adoption, social learning in workplace environments, the design of digital classroom tools, and software customization.

3.2.1 Classroom technology adoption by teachers

Prior research in education has explored various individual and external factors that affect teachers' motivation to adopt and integrate technology into the classroom. Teachers' decisions have been shown in surveys to be strongly influenced by their confidence and computer self-efficacy [155, 174], educational beliefs and attitudes relating to technology [48, 82, 103,

117, 142, 161, 191], and skills or experience with technology in general [48, 103, 142, 155, 160]. Circumstances at a teacher's school also play a role: teachers are more likely to successfully integrate new technology if their school already has up-to-date technology infrastructure [5, 71, 209] and if their colleagues and administrators promote a supportive school culture that rewards pushing the boundaries [209]. However, other research casts doubt on the idea that this improved access to technology is enough to meaningfully change existing teaching practices [35]. It is also well-known that teachers are routinely pressed for time, which negatively impacts their ability to integrate new technology [5, 71, 103, 161] and to properly vet and adapt new tools and resources to meet curriculum or privacy standards [55, 120, 135, 159, 160].

While these studies are valuable for understanding teachers' willingness and ability to adopt technology, they often assume teachers are using software tools as-is. In contrast, our study provides a more detailed account of the diverse ways teachers personalize those tools at multiple levels to better suit their classroom needs, and provides missing insights into how they come across these software tools in the first place.

3.2.2 Social aspects of how teachers learn on-the-job

Research has long shown that professionals across many fields find it useful and necessary to learn on-the-job in a workplace environment [47]. Informal workplace learning is commonly facilitated through interactions with colleagues [61]. Studies of teachers and teacher education have already explored informal on-the-job learning strategies from the perspective of both new and experienced teachers [85,86,119]. In particular, studies have shown how teachers find it valuable to be associated with particular *communities of practice*, namely a group that is passionate about a topic or an activity, where members of the group participate in collective learning and improvement [205]. Teachers value communities of practice for exchanging curriculum-related details [45], improving pedagogy, and reflecting back on policies and education strategies [165]. Increasingly, these communities are not just within a particular school or school district, but also moving online [90], allowing for greater participation.

Our findings shed light on how teachers' communities of practice value knowledge-sharing on the discovery and integration of software applications, and we uncover the tradeoffs inherent in leveraging these communities for in-class support and troubleshooting.

In addition to their informal communities of practice, teachers frequently participate in more formal professional development (Pro-D) opportunities offered by their school or district, sometimes concerning educational technology. An et al. evaluated current K-12 teachers' perceptions on Pro-D, and found a large majority of them believed that Pro-D programs had "helped them to improve their technology knowledge" [5]. However, they also point out major weaknesses in these programs, such as (1) being overly broad with few specific examples of how to implement technology in subject-specific ways, (2) covering far too much information in short sessions with insufficient practice, (3) often being aimed only at novice users, and (4) frequently covering technologies that are not available to them afterwards. Accordingly, they suggest the gold standard for Pro-D should involve subject-specific, hands-on practice with readily available tools so that teachers can transition directly into real classroom usage. Other recent studies have cast further doubt on whether technical Pro-D is meeting teachers' needs — for instance, a majority of respondents to Pittman and Gaines' 2015 survey said they had found tech-related Pro-D offerings less than adequate [161].

3.2.3 Design of digital classroom tools

In comparison with digital classroom tools designed for student use (which are widely studied [91,179,180]), there are comparatively few such tools designed specifically for teacher use or which prominently consider the teachers' own experience [73]. Among examples of this, Cramer and Hayes [34] document the design research process for a software application that alleviates teachers' cognitive burden and allows them to manage "digital economies" that introduce their students to financial literacy in the classroom.

There are several good examples of research artifacts designed for K-12 classroom management that are built as *ambient displays* [1] or based on principles of *peripheral interaction* [6], to integrate seamlessly into teachers' busy routines. For example, the *FeetForward* system [2] provides a foot-based interface for activating personalizable operations on the classroom's

interactive whiteboard, with the intention of the foot interactions becoming peripheral and effortless over time as teachers adjust to them. The different foot pedals in this system can be personalized to activate different whiteboard functions (such as switching applications, opening a certain menu, or taking a screenshot) according to the teacher's own needs and contexts. Interestingly, the personalizability of this system showed great promise as the different teachers using it had their own unique routines and challenges in using their whiteboards normally. For instance, a teacher who couldn't easily reach the top of her whiteboard decided to personalize a pedal to access the menus that were out of reach for her.

The *FireFlies* system [7] similarly relies on peripheral interaction with two open-ended physical teaching tools to help teachers multitask with secondary tasks more effortlessly. *ClassBeacons* [3] is another more recent peripheral interaction design that uses colored lights ("beacons") distributed throughout the physical classroom to allow teachers to perform reflection-in-action while teaching, effortlessly reflecting on how well they are dividing their time across different groups as they roam around the classroom.

Our current study, by contrast, seeks to provide a bird's-eye view of the process of how teachers integrate a wide variety of software tools into their classroom. As we describe later on, it is rarely smooth sailing after the decision to adopt new software, and studies of individual tools often do not address the high-level challenges that arise day-to-day in digital classrooms, in which many teachers must manage a growing array of tools that interact with each other. In fact, a majority of schools now encourage students to bring their own devices to school for classroom activities [33], adding further complications to the range of technology teachers must aim to support with their teaching methods.

Bring-your-own-device policies and personalized learning

Interestingly, a long-term study of the implementation of a "bring-your-own-device" (BYOD) policy in K-12 schools by Parsons and Adhikar [158] yielded only a modest set of complaints from teachers, but the students and parents surveyed raised a greater number of concerns. The teachers in their two-year study identified some difficulties with BYOD making their jobs more complex (e.g., having to keep track of many more passwords, and having to troubleshoot network connectivity issues across a range of devices), and some teachers

were more reluctant than others to fully realize the potential of their students' devices for classroom activities. On the other hand, many parent concerns centered around the increased amount of time their children were spending on their devices both at school and at home, with worries surrounding technology addiction and diminished social contact. Overall, the somewhat positive view that most teachers in their study had towards BYOD could indicate that many common issues with BYOD implementation in schools may be more isolated, or that these issues may gradually smooth themselves out over time as all parties involved become more accustomed to dealing with them. In our study, we interviewed several teachers whose schools had only recently adopted a BYOD policy, and who identified a number of concerns complementary to those raised by the teachers and parents whom Parsons and Adhikar surveyed.

One pedagogical approach that BYOD can support is *personalized learning*. While the popular meaning of this term has achieved "buzzword" status and has shifted somewhat from its original intent, its core idea focuses on providing individualized, learner-centered instruction [5, 157] and evidence demonstrates that these principles can be implemented to great effect in modern classrooms [5].

3.2.4 Insights into software customization

Customization has been studied in the HCI community for decades, from a variety of angles. In terms of *what* gets customized, research addresses adaptations at the user interface level such as variations in which features are present/visible or not [19, 137], or changes to the layout and access points to features [63]. Other work focuses on the mechanism for making adaptations to the interface, in order to facilitate making customizations in the first place [162]. At a broader level, research has looked at the extensibility of a software tool in terms of the functionality it offers [78] or interoperation of several software tools [125].

A crosscutting theme of much of the above work is variation in the goals — *why* customization is being done. While some research has targeted improving software learnability [113] and general usability [137], much of the work focuses on improving efficiency in terms of providing faster access to used features [52, 193], sometimes for users with special needs [64], and to make the software more useful [78].

From a different angle, there has been research that characterizes the individuals performing the customization and their approaches. For example, the "translators" [123] and "tinkerers" [125] capture dimensions such as a user's motivation and level of expertise. Upfront vs. as-you-go approaches [138] capture the timing in individual customization strategies. Others have looked at the relationships between customization and an individual's sense of control and identity [128], and the role of customization authors in customization sharing ecosystems, online spaces through which customization authors can host and share them with others [79].

There is no agreed-upon definition for customization [79]. The terms customization, personalization, and adaptation are often used interchangeably. If anything, customization tends to refer to lower-level interface adaptations, while personalization tends to be used to describe higher-level adaptations. In particular, in our usage of the these terms, a high-level instance of personalization might involve multiple low-level customizations all toward the same overall goal.

Our study asks how and why *teachers* personalize their software at all levels, from their individual software customizations all the way to more extensive changes to their digital classroom ecosystems as a whole. This is significant because classrooms differ fundamentally from more general workplace environments where customization has often been explored. Furthermore, the literature largely focuses on customization for one's own software and workflows, whereas customizations in the classroom can impact many students as well.

3.3 Method: Interview Study

We used a semi-structured interview approach to tackle our research questions about how teachers discover and integrate digital classroom tools, including their personalization habits and what challenges they face throughout this process. Our goal was to recruit interviewees that represented a broad cross-section across grade levels and subjects. We recruited from two school districts that already had a vision for digital immersion and had existing partnerships with large, multinational software companies, such as Microsoft, affording them opportunities for early adoption of classroom technologies.

Table 3.1: Participant Details

P# and Gender	Grades Taught	Yrs. Teaching Experience	Subjects Taught
P01 (F)	6	11–15	General
P02 (F)	3	6–10	General
P03 (M)	6/7	11–15	General
P04 (M)	8	11–15	Math, Science, Tech
P05 (M)	6–8	21+	General
P06 (M)	6–8	6–10	Explorations
P07 (M)	10–12	6–10	Math, Social Studies, Business
P08 (F)	9–11	21+	History, Keyboarding
P09 (F)	10/11	11–15	Science/Chemistry
P10 (M)	9/12	21+	Science/Biology
P11 (F)	9/10	< 1	Science
P12 (M)	9	21+	Math, Science
P13 (M)	6	6–10	English, Math
P14 (F)	7/8	6–10	Science
P15 (F)	6–8	11–15	Explorations
P16 (M)	5	21+	General
P17 (M)	11/12	16–20	Physics
P18 (M)	8	16–20	General
P19 (M)	4/5/9	16–20	General (4/5), Science (9)
P20 (F)	6–8	11–15	Info Tech

3.3.1 Participants and School Districts

We carried out one-on-one interviews with 20 participants (8F, 12M), thirteen done in-person at their school, and seven interviews over Skype for convenience. All participants were recruited through emails distributed to teachers by district staff in two public school districts. District 1 is an urban district in the United States, with over 70,000 students in a city with population around 500,000 and a median household income of around USD 45,000. District 2 is a suburban district in Canada with over 30,000 students serving a population of around 150,000 with a median household income of around CAD 75,000.

As shown in Table 3.1, the participants' classrooms range from Grades 3 through 12, with half of them teaching exclusively at the intermediate (6-8) level. These teachers were distributed among twelve different schools: four in District 1 and eight in District 2. The teachers in our study taught a variety of different subjects, though some elementary and

intermediate teachers either did not report any specific subjects or mentioned teaching more than three different subjects — these are listed with the subject "General".

We informally assessed the majority of our teachers to be "tech-savvy" based on a combination of their technology experience, educational background, and how they described themselves in the interview. For example, 16/20 participants had at least 6 years of experience using classroom technology, 6/20 had degrees in educational technology, and 12/20 verbally self-identified as "tech-savvy", "tech guru", "early adopter", or "tech support specialist." Although we did not try to sample based on teachers' attitudes toward technology, it nonetheless turned out that all of the participants in our study expressed enthusiasm about educational technology and its adoption in schools. Our participants alluded to other teachers at their schools who were more hesitant to use technology in the classroom, but despite our best efforts to engage these more tech-averse teachers to hear their perspectives, we received no responses from them.

3.3.2 Semi-structured Interviews

Before starting the interviews, participants completed a brief questionnaire about demographics, teaching experience, software and hardware use in the classroom, and experience with technology-related professional development. We began each interview by asking participants to describe their class routine with a focus on the role of technology.

The first major focus of the interview was on teachers' initial experiences in discovering and setting up digital tools for their classroom and any challenges they faced during that process. We also asked teachers about the extent to which they would discuss their tech-related discoveries with others, and their strategies (if any) for resolving the challenges that they may encounter.

In the second half of the interview, we focused on whether teachers were simply using their tools as-is or customizing them in any way. We verbally defined customization as "any long-term changes to how an application works beyond the defaults" and gave a few demonstrative examples to help them better understand the scope of our questions. We then asked about specific ways they had customized their toolset, where they learned about these customizations, and any challenges they faced when implementing them.

Each interview lasted between 40 and 60 minutes. After the interview, participants were given a $20 Starbucks gift card. Every interview was audio-recorded with permission and later fully transcribed to facilitate analysis.

3.3.3 Data Analysis

For our analysis, we used the *ATLAS.ti* software to perform open coding on the transcripts and explore our data. Where possible, we present count data for occurrences of specific behaviors, and identifications of tools or practices. However, our main focus was using a data-driven inductive analysis approach [187] and affinity diagrams to identify key themes relating to our main research questions. We began the analysis by having three members of our research team do an initial open coding pass on four interview transcripts. After several discussions and revisions, we arrived at a coding scheme used to analyze the remaining transcripts. The first author then used the revised coding scheme to iteratively analyze all twenty interviews and shared insights with team members in weekly meetings. Some examples of recurring themes that were highlighted in our coding scheme were day-to-day challenges of working with different digital classroom tools, proactive and reactive customization habits, and instances of classroom ecosystem personalization (all of which are discussed in the Results). Based on evolving results, we iteratively came up with additional foci for analysis and further refined our emerging themes around teachers' integration of digital classroom tools and related personalization practices. As we neared 20 interviews, our ongoing inductive analysis solidified consistent recurring themes rather than surprising new findings.

3.4 Results

We begin by presenting the high-level picture, characterizing personalization in terms of the software tools teachers chose to include within their digital classroom ecosystems and their motivations for those choices. We then step back to unpack the different approaches teachers took to discover and integrate those tools into their classrooms. Of particular interest is how teachers were personalizing their tools at a more granular level to ensure they were well-integrated — we characterize UI and content-level customizations for the classroom context. We then highlight the barriers that teachers face throughout the integration process.

Table 3.2: Largest categories of software used in the classroom

Tool category	# Tools (/107)	Examples
Presentations	11	PowerPoint, Prezi, Keynote, Sway
Quizzing & assessment	10	Kahoot!, MS Forms, ClassMarker
Math exercises & games	9	Desmos, Prodigy, Matific, XtraMath
Education platforms/LMS	8	OneNote Class Notebook, Moodle, Google Classroom, Edmodo
Image & video editing	7	Photoshop, Premiere, iMovie
Text & document editing	6	Word, Google Docs, Acrobat
Communication	5	Skype, FaceTime, Voxer, MS Teams
Online educational resources & videos	5	Khan Academy, Brainpop, OpenStax
Website editing & blogs	5	Edublog, Wikispaces, Dreamweaver
File management	4	Google Drive, OneDrive, SharePoint

We did not see any notable differences in our findings between the two school districts, so we present our findings in aggregate.

3.4.1 Classroom-level Adaptations: How Teachers Personalized Their Digital Classroom Ecosystems

The software tools that teachers were using were not haphazard, but rather the result of purposeful adaptations to the broader toolset of their classroom to accommodate various teaching activities and student needs. We define these high-level toolset changes (the selection of tools to use) as *classroom ecosystem personalizations*. Every teacher described performing this type of personalization to some degree, by picking and choosing which software tools to integrate into their classroom from among a vast array of options.

Teachers use a diverse range of software tools

Across all of the interviews and questionnaire responses, the 20 teachers described 107 distinct software tools that they had tried to use or were currently using. Although teachers also mentioned using several hardware tools (e.g., interactive whiteboards, robotics kits), these were much fewer in number (11) and we restrict our remaining results to software usage. On average, each teacher was using over 15 distinct software tools in the classroom (P14 being the highest, with 30 different tools). Teachers frequently built much of their

daily class routine around the use of certain software tools, including productivity software, learning management systems (LMS), and interactive quiz tools. Table 3.2 outlines the 10 largest categories of tools (spanning 70 tools), while the remaining 37 tools covered a broad range of niche purposes like keyboarding, language learning, programming, and 3D modeling.

Teachers have diverse motivations for personalizing their digital classroom ecosystems

Teachers cited a variety of motivations for their high-level personalizations, which mostly fit into three broad classes: (1) seeking software alternatives that more closely aligned with their classroom activities, (2) meeting student needs, and, (3) enhancing their own productivity. These motivations were cross-cutting and often related closely to the way multiple tools interacted to form workflows or to complement each other's functionality. For instance, P14 described addressing what she felt was inadequate support for her common classroom activities in PowerPoint by abandoning it in favor of adopting Google Slides:

"With [PowerPoint], I couldn't review [student work] unless they shared it with me, so there were additional steps of sharing that file with me and then sharing with other people then they have to formally submit the file before I can comment... whereas Google Slides or Google Docs it's always a live file. They can make modifications, I can comment on the side, they can respond back, and it was just a lot easier to work with." (P14)

Another situation that illustrated more student-focused motivations was how P02 switched her Grade 3 students from using PowerPoint to using Sway for presentations because she felt it was simpler to use for children their age.

Ecosystem personalizations involving more complex multi-tool workflows for generating, editing, or sharing content were often driven by the teacher's desire to improve efficiency, such as streamlining repetitive yearly data entry tasks. However, some of these personalizations were described as workarounds for usability issues in a particular tool:

"Certain glitchy things that I can do in Word that I can't do in OneNote, I've resorted to saying, 'Students, this isn't working out on OneNote because it's very glitchy. Go to Paint and do it in Word or... some other program. Then just copy/paste it into OneNote'" (P15)

In certain cases, these workflows involved a hierarchy among the tools, with certain ones added entirely to complement an existing tool. The goal was to address some shortcoming or gap in functionality — using the new piece of software as if it were a makeshift plugin for the original tool. For example, P12 found a new video-hosting tool to work around certain video hosting challenges on student blogs:

"Students in my class make a lot of videos... You need a place to host the video... and it's better to embed the video in [Edublog] than to upload it. We only have like 50 megs per Edublog account... So Flipgrid is another piece of software where we can host the videos, up to 90 seconds is free... Flipgrid allows for that." (P12)

Bring-your-own-device policies further enable personalization for student benefits

In describing their classroom ecosystems, a major recurring factor involved *"bring-your-own-device"* (BYOD) policies at their schools, whereby students are encouraged to bring a laptop, tablet, or other mobile device from home for use in the classroom. Of the 20 teachers, 13 of them were in BYOD environments, and in several cases they described how this had enabled attempts to individualize their instruction or had emerged naturally from those same attempts. For example, P10 detailed how he and his school had gradually arrived at a BYOD environment through small-scale improvements for some students with learning disabilities:

"Some kids really thrive with the computer... I had a student who had a lot of learning disability with writing... So I made the exam digital, the assignments digital, I got it so that he was typing things in. His writing was horrific — but he pulled off a 97 in the class. And I thought 'This is exciting, this made a disability vanish... Let's expand this to the entire school, and let's try BYOD'... Now we've got kids that have got learning disabilities and this is really, really helping them." (P10)

3.4.2 Discovery and Integration of Digital Classroom Tools

With such a diverse range of digital classroom ecosystems described by our participants, we wondered how teachers went about discovering tools in the first place and how they

proceeded to integrate them into the classroom. We considered the whole process of setup, installation, day-to-day usage, and attempts to do in-application customizations.

Formal professional development is of limited use

A few teachers (6/20) had independently attended regional or national ed-tech conferences to stay up-to-date on leading-edge technology for their classroom, and all 20 of them had attended formal professional development (Pro-D) workshops on various topics related to digital classroom tools. However, despite attending these Pro-D events, only 5/20 teachers said they had learned about new software from such district-level events, and only 4/20 from external Pro-D offered by local businesses or universities. Teachers explained that Pro-D did not meet their needs because it only addressed a small selection of tools (often those widely used in their district), and covered only the basics:

"What ends up happening at the Pro-D level is that it's often for beginners... I started going to other workshops, and then realizing I was kind of ahead of everybody else in the room... wasn't necessarily helpful for me" (P18)

Furthermore, Pro-D workshops would sometimes introduce a tool without having the participants actively set it up for immediate use in their classrooms. This led to wasted Pro-D time, as some teachers reported forgetting what they had learned or losing their motivation to try it later.

Teachers are largely self-directed and experimental

In contrast to these formal Pro-D sessions, our teachers most commonly described self-directed strategies for seeking out new software tools and felt that the onus was on them to independently discover and learn to use them:

"Yeah, it's all on us, I feel, as teachers... There's not a lot of, 'Okay, we're going to let you play with OneNote for a bit' or even 'Here's five steps to customize your OneNote.' It's all like, 'There's OneNote, figure it out.' For me, it's just... a lot of just hacking, trying to figure it out myself." (P12)

Most teachers (14/20) explained how they had turned to performing their own online searches to find software for their classroom needs, either within curated software lists (e.g.,

Office 365 suite) or simply trying to describe their task-specific needs into a general-purpose search engine.

Teachers rely on colleagues for discovery and integration

Most teachers depended on professional social circles at their school for discovery and integration of software. Especially in comparison to Pro-D events, more teachers preferred small-scale informal learning environments. Such informal approaches most prominently involved simple word-of-mouth between colleagues. For example, 13/20 teachers mentioned asking colleagues for technology tips or expressing an unmet classroom need that other teachers had addressed with certain software tools:

"I'd talk to other staff... I know that there's some staff that do a lot of different video projects. I'd ask them what they recommend in terms of software, apps, or different things... If it's something that I know the specific person that I want to ask, I'll just go talk to them face to face." (P07)

Furthermore, about half of our participants (8/20) had also participated in small, loosely-organized groups of teachers with shared interests in technology for classroom use. For example, P07 described how both word-of-mouth and these types of small group sessions had played a large role in his decision-making for integrating software:

"When I started hearing from other people how helpful [Class Notebook] had been... I figured I'd look into adopting that, and so then I went to different sessions within our school that teachers who'd been using it for a semester or two were putting on... It was quicker just to go and learn from somebody else than to try to navigate all of it on my own." (P07)

In some cases, district software policies limited teachers' ability to use new tools they had found online, and internal discussions with colleagues were often more productive in discovering and integrating new software:

"I would go looking for 'open source video editor' or something like that... but of course... the district has to ensure that we don't put at risk the technology and the infrastructure by installing apps with malware in it... People in our district know what limitations we have and also what opportunities we have as well. So, I think discussions within the district are way more fruitful than just throwing it out there or even searching." (P16)

Social media and video subscriptions are becoming increasingly valuable

Outside of their colleagues, half (10/20) of the teachers said they had also discovered new tools via social media (most prominently, Twitter, Facebook, and Pinterest), where they would regularly come across suggestions from friends or influential educators they had chosen to follow:

"People post anywhere nowadays what might be helpful or interesting to use... If I'm looking on Facebook and somebody put a link there saying 'Hey, this is a really cool thing to use in class,' I'm probably more likely to use that." (P02)

Additionally, 7/20 teachers had discovered new software for their classroom by attending online webinars (e.g., *Classroom 2.0*) or subscribing to ed-tech video channels for regular updates and new ideas.

3.4.3 Beyond "Out-of-the-box" Usage: Personalizing Individual Tools and Class Content

Beyond the considerable effort that teachers invested in selecting tools for their classrooms, we further wondered to what extent teachers needed to then adapt and tailor those tools to adequately support their classroom needs.

We noticed that teachers often were not simply using their tools as-is: all 20 teachers described customizing the interface or content of individual software tools beyond the defaults as part of their integration process. These included common examples like changing built-in privacy options within a collaborative online platform for student work and installing software plugins that added new features to their learning management system.

Overall, our participants described 128 distinct instances of these tool-level customizations. To better understand the types of customization that took place and their purposes, we tagged each of these either *UI customization*, involving changes to a software application's user interface or feature set, or *content customizations*, involving changes to the software's delivery or generation of content. We found that 58/128 instances were strictly UI customization, 35/128 were strictly content customizations, and the remaining 35/128 were related to both the UI and content.

Table 3.3: Examples of the most widespread varieties of customization

Customization Type	**Teachers (/20)**	**Example**
UI Customizations		
Changing UI preferences/options	9	*"I'm still figuring out some of the privacy options on Teams... can the kids comment on one another?" (P14)*
Installing software plugins	9	*"I've added the Learning Tools [plugin] as well... I do have some students who are EAL or... need some help with reading, and it's been a helpful tool for them." (P18)*
Changing visual layout	5	*"I needed to have yellow, the highlighting tool, really handy. I customize everything along the top... I change the ribbon layout so that it's all ready to go." (P12)*
Cosmetic theme/color changes	5	*"In the Edublog platform there was a theme customization option... so I just picked the one that I felt was the most appropriate for the look that I was going for." (P07)*
Content customizations		
Creating reusable template content	8	*"I'll have a basic template for a rubric that I would use... and then I would just have to add in for whatever assignment it would be." (P07)*
Adapting or individualizing content/subject difficulty	4	*"I can choose a story that's basically for certain readers... but a different level for other readers... it makes education more accessible to every learner." (P01)*
UI + Content customizations		
Meticulous organization of content structure or setup	12	*"If it's in blue, that means you have to go to role assignments... I try to make it idiot-proof... I send these out to them one at a time so when they first open it they'll have today's lesson" (P08)*

As shown in Table 3.3, some examples of UI customization were minor or cosmetic in nature. But, we saw a surprising number of more complex examples where teachers had made large-scale changes to enable or disable entire features (e.g., by installing plugins to add new functionality). A common example was installing the *Learning Tools* add-in for OneNote to provide reading and writing assistance to students with learning disabilities or ESL needs.

Among the more interesting examples of content customization were instances of teachers personalizing the content delivered to students for online exercises and educational games, such as changing the grade level, difficulty, or subject matter to be individualized to a student's needs. For example, P02 described various ways she had exercised full control over the content delivered to her students, sometimes even for just a single student:

"[Prodigy]'s a free app that I started using last year... [stude-nts] do battles and then the battle is doing an equation... But I have control over it... I have them all set up in third grade [difficulty], but then this one kid I have, he's doing fourth grade. But I can actually be more specific... I set it up for common core standards, and so they'll be put through anything, addition, subtraction, money, time, whatever." (P02)

The instances of customization that somewhat blurred the distinction between UI and content customizations most commonly consisted of teachers meticulously organizing the structure of content within an LMS or class website/blog, such as by color-coding pages by type and subject or including RSS widgets to keep students updated on changes. In such cases, the content teachers were curating also formed the UI that students navigated to complete their coursework.

Teachers are motivated to customize the software UI and content to benefit students and themselves

As with their ecosystem personalizations, teachers' tool-level customizations were often motivated by specific students' needs that ended up benefiting the whole class:

"I look for ways I can use technology that might be targeted towards one student in there, but also be beneficial to other students. Who else might benefit from a low-text method of

storytelling? My refugee students, my low readers, this guy who's got a learning disability... same thing with augmented reality, helps the same group of people." (P19)

Teachers' own efficiency needs often drove more basic customizations, such as changing the location and layout of certain UI elements for quicker access to frequently-used features (e.g., for presenting or grading):

"For me, [my custom layout] seemed to flow better. This [panel] is on that side, like when I'm giving notes, I expand it this way so it clears up my screen down below so that I can access the pens up top." (P17)

In a few cases, these self-driven customizations were highly important parts of teachers' day-to-day workflows. For instance, P12 found certain UI customizations in MS Office so valuable that he had spent time recreating all of them with each new major update that *"changed the rules"*.

The initiative to personalize varies among teachers

Another key distinction emerged around teachers' timing and motivations for both their tool-level customizations and their higher-level ecosystem personalizations alike. When finding new applications, content, or other resources for their class, some teachers would almost always modify and adapt these for their class upfront; we call these teachers *proactive customizers*. It was common for proactive customizers to seek out content from other teachers or from a variety of online sources and combine parts of these together to build their own lessons and class materials:

"I always modify it. I think it's very rare that I've ever used anything straight from [an online search], because often you might use parts and pieces... you usually have to customize at some point." (P09)

Other teachers, whom we call *reactive customizers*, instead tended to use new tools and resources unmodified, "straight out-of-the-box", and then would only make changes later on after they encountered problems or other unmet needs became apparent:

"I pretty much use it as is, but then as needed... like when I found out that student, 'Oh, he already knows all that stuff, I gotta do something else'... I start looking for how to adapt

it and customize it for a need... The programs that I'm more familiar with or that are very easy... I do use them more as... so the default first and then as needed" (P02)

Proactive approaches to customization were described by 8/20 teachers, while reactive habits occurred more commonly, for 11/20 teachers. P10 expressed both proactive and reactive tendencies on a case-by-case basis and is not included in either group. Perhaps not surprisingly, proactive customizers were responsible for about 54% of all customization examples, despite comprising only 40% of the participants, and tended to have more teaching experience than reactive customizers.

3.4.4 Barriers to Integrating and Personalizing Digital Classroom Tools

Throughout the process of integrating and personalizing software for the classroom, teachers were often hindered by several key barriers, most prominently a worry about their personalizations negatively impacting students, challenges with troubleshooting in BYOD classrooms, and strain on the social fabric they relied on for real-time assistance. Our findings here foreshadow several design opportunities which we unpack more fully in the Discussion.

Potential for student confusion or difficulty

Although all teachers made efforts to personalize their digital classroom ecosystems, they also described several reasons about why they sometimes chose not to personalize. For example, one broad concern was that introducing too many different tools into the classroom routine would overwhelm students, or that certain tools would be too challenging for their students to use. Even P14 noted this concern, despite having 30 distinct software tools in use:

"It's been a learning curve as well, teaching the kids to launch Office 365, how to find Teams, how to find assignments, how to find some of the files. I didn't even broach into OneNote because I felt like it was overwhelming to teach them not only Teams, then PowerPoint, then OneNote as well." (P14)

This concern frequently extended to their tool-level customizations as well — 11/20 teachers cited a worry that their students would find the tools more confusing or harder to use if they were more heavily personalized:

"I would love to figure out how to have one [Class Notebook] content library that then branches into two separate classes that I can choose from... However, that then can lead to confusion because the students then go back into the content library and if the one class covered it and the other class didn't, then they'd be like, 'Hey, we missed something.' Or they get worried that they're supposed to know something that we didn't cover." (P09)

Beyond these student-related concerns, many teachers also expressed worry about increasing their own troubleshooting and support load by introducing too many UI changes.

Difficulties troubleshooting in BYOD classrooms and beyond

We found that 8/20 teachers were concerned that they would have difficulty using software they had customized, either because they might *"break things"* or require additional troubleshooting support in the future. Some teachers described efforts to keep their software consistent with what students see or with other teachers' setups, often to facilitate troubleshooting and minimize adjustment for students:

"Just because it's something that the students are actively using as well, it's a little bit easier if there's less customization because that keeps it consistent between what they're seeing and what I'm seeing. If I change my layout or style of it, and theirs is still something different, then it becomes harder if there is an issue... and I'm trying to figure out what the problem is. So in that way, having a little bit less customization can be helpful." (P07)

Beyond their own customizations, a more specific issue that frequently contributed to some teachers' troubleshooting load was a BYOD policy. When students could bring their own devices, there was an increase in inconsistencies in software interface and functionality between platforms, device types, and application versions (e.g., desktop vs. web versions). These circumstances impeded teachers' ability to troubleshoot effectively when issues arose on unfamiliar platforms.

Furthermore, some teachers described applications that were incompatible or simply failed to work entirely on certain device types, resulting in even more difficulty creating a consistent classroom environment in which every student has the same access and opportunities:

"We have bring-your-own-device here. We have everything... iPads, Macs, Surface, regular Windows laptops. Trying to get all of those, I felt like I was one of the Microsoft

engineers trying to figure out, 'Okay, how do we do this with a Samsung and what are some workarounds?'" (P12)

In cases like these, the design of some software was at odds with the reality of classroom usage, where the need for a uniform, consistent interface among students clashed with the need for platform-tailored experiences. However, this is not to suggest that BYOD policies are to blame — as noted earlier, they can have numerous other beneficial impacts on the classroom. In contrast, P20 highlighted some challenges that arose in part from a lack of BYOD at her school: when students are using shared school-owned devices, attempts at customizing are often discouraged as detrimental to other users:

"Sometimes [students] will rearrange the icons [on a school-owned computer], or they'll change the background, and it's like... 'This is not your computer... It is used by other children in the school... You cannot be sure that the changes that you're making are not going to affect someone else.'" (P20)

Even outside of BYOD contexts, teachers still encountered many usability issues that required troubleshooting. For example, a common theme concerned unreliable syncing of student work between devices or with a centralized file store. Occasionally, these syncing problems had resulted in loss of work, but more often they were simply a source of frustration and lost time. Many other instances of troubleshooting were ultimately the result of students using technology in unexpected ways (e.g., accidentally dragging the position of a scanned multiple-choice worksheet after highlighting their answers, or even downloading a virus).

Challenges in maintaining social support channels

In addition to addressing students' troubleshooting needs, some teachers also acted as the primary troubleshooter for other teachers, which had a substantial impact on their time. Although it was typical for the teachers to make some initial efforts to fix these technology issues on their own, in more difficult cases they turned to their colleagues for help. Most participants (15/20) described being on either end of this type of informal social troubleshooting, frequently amounting to *"grabbing someone from across the hallway"* who had more experience with the tool:

"Here there are people that are more competent than me... There's a guy down the hall I go to all the time for help and so forth, he's really good at that." (P04)

Because these issues arose during class time and could cause interruptions, there was often a sense of urgency attached to these requests for help. In cases like these, the help-giver would sometimes need to briefly disrupt their own class to perform a tech support role for other teachers:

"It's the whole just-in-time support system and I have really tried to make sure that teachers can come and if it's a quick thing, pull me out of class. Go ahead. Somebody else can watch my class for three minutes and make it so that your SMART Board projector works or whatever." (P16)

There was usually a small group of 1–3 teachers at the school who would bear the brunt of these help requests and other questions about software tools, acting as *"tech support hubs"*. In addition to on-demand tech support, they reported frequently needing to guide other teachers by providing software tips and sharing examples of their own personalizations. However, the outcomes of this were mixed — other teachers with less background in technology or less familiarity with the software often needed additional one-on-one help to implement these suggestions. Sometimes these teachers had an official secondary role as the site contact for technology or the technical support lead. In fact, many of the teachers mentioned that they or one or more other teachers at their schools were acting as "technology integration specialists" or other district-appointed roles to provide such support.

However, more often the teachers fulfilling these roles did so in an *unofficial* capacity, including several of our participants. Among these, we saw substantial variation in how teachers felt about performing these extra duties. Some, like P16 above, were more than happy to take time out of their day to help with setup and troubleshooting, while others found this aspect of their role overly time-consuming or frustrating to deal with:

"I'm not available to troubleshoot all the time. My time is very limited... A lot of the time when teachers are using these tools with students the problems need to be solved in real time... 80% of the time that's not an option, because I have other things to do." (P20)

3.5 Discussion

Our study of K-12 teachers has contributed insights into how teachers discover and integrate software applications into their classrooms, the multiple layers of personalization underlying their use of these applications, and the barriers they face throughout the entire process. It was particularly surprising to see the sheer variation in software tools (both productivity and dedicated LMS software) between teachers, even among those teaching at the same school. Although the influx of student-owned devices into classroom settings and the rise of open educational Web applications are changing the landscape of teachers' technology options, their increasing freedom comes with the additional responsibility to learn about and support their technology choices on their own. Our findings paint a picture of the remarkable effort teachers are putting in to build and personalize their digital classroom ecosystems in a way that works well for their own circumstances and their students' needs.

We now reflect on the opportunities and challenges arising from this process to identify opportunities for future HCI research to improve the design of digital classroom tools.

3.5.1 The importance of teachers' social fabric in personalizing digital classroom ecosystems

Although teachers are already known to collaborate and share with colleagues for reasons related to pedagogy or student management [103, 117, 155], our study shows that even the tech enthusiasts among teachers face additional barriers when trying to integrate new digital classroom tools. Just as other workplace studies have shown the difficulties of learning and integrating technology on-the-job [118, 145, 156], our study shows that teachers face similar challenges in keeping up with new requirements for learning and troubleshooting hardware and software. While informal social learning is helpful in this respect, it is often not enough. Also, if the teacher is the help-provider for colleagues, he or she can feel overwhelmed with frequent troubleshooting requests.

The technology-related sharing networks among teachers are valuable in all aspects of discovering, learning, and customizing tools. However, these networks are over-stretched when day-to-day usability issues arise, forcing teachers to abandon valuable teaching time to instead be troubleshooters for students or other teachers.

3.5.2 Teachers' Personalization Practices in a Larger Context

The defining characteristics of teachers who were proactive customizers bear some superficial similarity to tinkerers, a distinct group of software users who express curiosity and enjoyment of exploring and tailoring their software, lying between highly technical "programmers" and less technical "workers" in terms of expertise with software [125]. Although some of our participants align with this description, we find proactive/reactive to be an appreciably different characterization deriving from noticeable differences in their willingness to trade time spent customizing now for time spent supporting or troubleshooting these customizations later. The distinction motivates more focused questions, such as whether more easily discoverable software customization facets [162] or lower risk of introducing unwanted software behavior might encourage more proactive customization.

It was also clear that many of our participants, particularly those who performed official or unofficial tech support roles at their schools, often fulfilled the role of translators [123] by disseminating useful customizations and tool suggestions among other teachers at their schools. This further highlights the important role of these "tech support hub" teachers play in helping teachers find the knowledge and skills they need to personalize their classroom ecosystem.

Our findings overall demonstrate a key tradeoff that teachers face when working with digital classroom tools. Should they personalize liberally and accept that it may create new challenges and a greater need for troubleshooting, or should they limit their personalizations as much as possible? Although some teachers like P12 were readily willing to accept this tradeoff for the benefits of their personalized setup, many teachers were more hesitant to personalize due to risk of student confusion (e.g., P14), impacts to support load (P16), and difficulty maintaining classroom consistency (P02). Although we acknowledge that there is no one-size-fits-all solution that can fully avoid all the challenges that teachers face, there is opportunity for future work to mitigate some of these difficulties and facilitate personalization in the classroom.

3.5.3 Design Implications and Future Directions

We make the following recommendations for improving the design of digital classroom tools by incorporating more collaborative aspects of teachers' day-to-day work and methods for lightweight sharing of personalizations.

Facilitate sharing personalized setups between teachers

Teachers commonly relied on informal word-of-mouth for sharing tips and instructions to achieve a desired software setup or to avoid common pitfalls, but their reliance on the "translators" at their school during class time created additional burdens. Furthermore, it is not always simple for teachers to quickly evaluate whether a new setup is a good fit for their classroom and personal needs. To alleviate this, we recommend that digital classroom tools provide the opportunity for teachers to give others "peek-level" access to their personalized setup. Other teachers could then view and try the setup out for themselves, and easily import it in part or in full into their own classroom (provided that potentially-sensitive information stored within, such as student work and grades is not included).

Provide risk-free "sandboxes" for testing the impact of new features or customizations on other users

Concerns about accidentally "breaking things" via attempts to customize were in line with more general barriers to customization that have been explored [124]. However, teachers' worries notably extend further, to the potential impact these failed attempts could have on their students and their ability to successfully deliver lessons as planned. This perceived risk could be addressed by including "sandboxed" environments in digital classroom tools for teachers to tinker and experiment with potential customizations, reducing the likelihood of unintended student-facing consequences. For example, use of "exploratory modes" (e.g., [114]) may help reduce the stress and troubleshooting load facing teachers and holding back their drive to customize. Furthermore, since teachers commonly learn about and troubleshoot their digital classroom tools in social settings, having the option to "de-customize" these tools on a temporary basis could help to work around the variations between teachers' individual setups and ease the process.

Design for interface consistency and interoperability across student and teacher platforms

Given the growth in BYOD policies [33], there is a need for classroom software to work in a consistent manner for students and teachers using a range of devices and platforms. Although it is common — and perhaps even considered best practice — for a software application's interface and functionality to be tailored to the styles and capabilities of the different platforms it resides on, this is fundamentally at odds with a classroom-specific requirement for a uniform interface that looks and works the same way for all students and the teacher in the classroom. We have seen the struggles that teachers encounter while trying to support many different versions of an application or dealing with the ensuing inconsistencies and incompatibilities. These could be largely avoided with a stronger focus on consistency. In sum, a larger question raised by our study is: how can we reconcile the design practice of device-appropriate interfaces with the need for uniformity across devices in a teaching environment? These challenges are a natural part of the transition as schools move away from more traditional situations (with a small number of shared classroom computers or only school-wide computer labs) toward more modern digital classrooms with diversity of student devices in use.

3.5.4 Study Limitations

Given that most of the teachers in our study expressed a high degree of knowledge or enthusiasm about technology and were working in school districts where digital immersion was a priority, caution is needed when generalizing our results. These design implications may not be as effective at addressing the needs of teachers with little technical background or in schools where usage of digital classroom tools is more constrained and poorly-supported. Our study is an early important step in exploring the space of teachers' digital classroom tool usage from an HCI perspective, and future work should consider expanding the demographics to broader teacher and school populations. We faced some challenges in recruiting teachers (e.g., from non-urban environments, less tech savvy) to participate in our one-on-one interviews; a less invasive method, such as online surveys, could be used to reach a broader population and complement our qualitative insights.

3.6 Conclusion

We carried out 20 interviews with K-12 teachers to investigate how they discover, learn, and customize digital classroom tools. Our key findings highlight the sheer number of tools integrated into day-to-day teaching practice and shed light on their means of discovering and integrating new tools, how they personalize these tools to better suit their classroom and teaching vision, and the barriers they have to overcome during day-to-day usage. Our findings point to the need for better supporting the close-knit communities among teachers, including better mechanisms for sharing personalizations, such as "peek-level" access to other teachers' setups. We further show how student needs are often a strong motivation driving teachers' personalization practices, but teachers are hesitant to take student-facing risks with their software. In Chapters 5 and 6 of this dissertation, we will introduce designs that aim to address these key issues by facilitating in-application personalization sharing and mitigating the risk of experimenting with software personalization.

Finally, bring-your-own-device situations impact software integration and classroom dynamics — both positively and negatively; interface consistency across devices is a key challenge for teachers which has the potential to worsen with time. The HCI community has the opportunity to play an instrumental role here. Ultimately, schools and their teachers must start preparing now for digital classrooms of the next decade, in which using a computer in class may well be as ubiquitous a concept as using a pencil and eraser.

Chapter 4

Setting up, Troubleshooting, and Innovating on the Delivery of Online Instruction: A Case Study of an LMS Q&A Forum

The findings from Chapter 3 provided a detailed look into the many factors that influence teachers' attitudes and practices around classroom software and personalization. Because so many teachers mentioned online help as one of their primary learning tools, we sought to gain further insight into how this online help-seeking took place for them and whether their queries bore fruit. We adopted a more focused scope, conducting a case study[1] in which we looked at how they asked and received answers on a Q&A forum for one of the most popular learning management systems.

This work was conducted during the early months of the COVID-19 pandemic, during which a vast number of educators needed to hastily shift to remote teaching methods. For many, this entailed learning unfamiliar software on short notice, including lecture streaming tools and learning management systems.

[1]Portions of this chapter were originally published in Ramesh, Vermette, and Chilana (2021). *Setting up, Troubleshooting, and Innovating on the Delivery of Online Instruction: A Case Study of an LMS Q&A Forum.* Proceedings of the Eighth ACM Conference on Learning @ Scale (L@S '21) [166]. This work was a collaborative effort in which both Kavana Ramesh and I had substantial roles in the planning, data collection, analysis, and writing.

4.1 Introduction

Recent years have seen widespread adoption of various software tools in both K-12 and post-secondary educational environments [131]. Among the most popular of these software tools are *learning management systems* (LMSs), which encompass a wide array of features ranging from assignment submission and grade-keeping to more advanced use cases involving student collaboration, online lecture delivery, and conducting assessments. The feature-rich user interfaces of LMSs can present a substantial learning curve to those unfamiliar with using them [202, 207].

Past research has demonstrated that course instructors rarely have enough spare time to learn the features of their LMS in depth [5], given their busy schedules and primary focus on other teaching duties. While navigating the complexity of LMSs and other digital classroom tools, instructors regularly turn to their colleagues for in-person collaborative help [201]. However, the ongoing COVID-19 pandemic has left few in-person help options for many instructors around the world who have had to quickly adapt to fully online or hybrid teaching methods [109, 167] on their own. Most of these instructors have been migrating their in-person courses to an LMS which may be entirely unfamiliar to them or require them to learn many new features on short notice.

Although there is growing evidence that instructors often participate in online communities for professional development and to learn from their peers in other schools and organizations [22, 53], we know little about how they use such communities for learning and troubleshooting digital classroom tools, such as LMSs. For example, most popular LMSs today augment their documentation and tutorials with online forums or Q&A websites that provide access to a valuable community focused on helping users learn and share their LMS-specific experiences. However, we lack insights into how these forums get used, what types of issues get discussed, and to what extent instructors are able to find relevant answers. By better understanding how instructors currently make use of online Q&A communities in setting up and troubleshooting LMSs, we can gain insight into key usability issues affecting LMSs and move toward developing more targeted technical support and community-based support approaches.

To investigate how instructors make use of online communities to learn and seek help for complex LMS features, we conducted a qualitative forum content analysis of posts from the official Q&A website [99] for *Canvas*, currently the most widely-used LMS in US-based higher education [44], with over 30 million users [148]. Our analysis uncovers many insights into the challenges LMS newcomers face in getting help with first-time setup, and instructors' drive to collaboratively build meaningful shared experiences with (and between) students. We highlight several ways in which instructors desire to innovate on their teaching methods and seek advice on adapting their existing routines to an online environment. But, in doing so, we also point out that forums may not always be ideal for supporting instructors' idiosyncratic needs related to customizing their course setups, as many such questions often received no replies or could not be easily resolved by the community.

This chapter contributes empirical insights into the key themes and types of questions asked by instructors and examines how these questions are addressed on a popular LMS discussion forum. In particular, we highlight the growing need for targeted help to address instructors' more nuanced questions surrounding innovative teaching practices and LMS customizations. We present design implications for improving community integration within LMSs and other classroom software, as well as opportunities for better adapting these tools to the unique and pressing needs of instructors, especially given the rise of remote learning and teaching practices.

4.2 Related Work

Our work builds upon existing research in HCI and learning sciences on instructors' classroom teaching practices, their use of educational technology, and their use of community-driven help forums.

4.2.1 Instructors' use of LMSs and other digital classroom tools

For many years, several research works have shed light on instructors' practices and motivations in learning to use and integrate digital tools in their teaching, as well as the barriers hindering effective use of such tools. Past work has examined how K-12 teachers experience the setup and usage of digital classroom tools including LMSs [201], the benefits and

drawbacks of LMS use among post-secondary instructors [111], and the factors influencing LMS adoption among university faculty [66]. A variety of novel technologies aim to help teachers manage their classroom effectively [3, 4, 87] and to support the creation of impactful learning experiences within an LMS [43]. The student experience with LMSs has also been widely studied [25, 146, 188, 189], sometimes finding a large gulf between how students and instructors perceive the system [46].

In this chapter, I focus on instructors' learning and troubleshooting experiences as they tend to rely heavily on *communities of practice* [165, 205] for social learning and support with their teaching. In particular, instructors regularly form peer groups to discuss and seek support for their classroom software, including LMSs [201]. I contextualize these findings through the lens of online communities of practice and aim to provide a broader understanding of how instructors rely on this online community support for learning and guidance with their LMSs.

Finally, some recent work has sought to explore the role of software customization in instructors' day-to-day use of educational technology [201], and to design LMS extensions that encourage this customization in a social context [202]. This study lends further weight to the importance of this perspective, finding that a substantial portion of help requests on an LMS forum were related to customizing the user interface in some way.

4.2.2 Help-seeking strategies in online forums

Analysis of posts in online help or Q&A forums has long been a useful strategy for uncovering insights into the motivations, struggles, and help-seeking strategies of a group of individuals sharing common activities or interests [182, 184]. For instance, past work has characterized the different ways that students ask math questions on a calculus forum [196], explored what types of career advice responses are most valued in an online career support community [192], and examined the differences in argumentation style between experts and newcomers on a programming language help forum [190]. Hudson et al. [89] examined several community-based software help forums to uncover what aspects of an initial help-seeking forum post tend to prompt requests for further clarification from help-givers. Some researchers also suggest methodologies for conducting qualitative research using managed online forums as

an asynchronous alternative to in-person focus groups, and highlight some practical issues in doing so [92, 93].

Prestridge [164] analyzed teachers' posts across a school year in an online forum focused on information technology, finding that their participation fostered a sense of community and contributed to their professional development by encouraging constructive dialogue that "enable[s] teachers to transform their pedagogical beliefs and practices." In this chapter, I further investigate the role these online communities play in instructors' collaborative jobs, particularly when their teaching and related interactions are taking place primarily in an online setting. This has distinct implications not only for how instructors seek help from one another in learning their LMS, but also for the effective design of LMSs and other classroom software in general.

4.3 Forum Content Analysis

To understand the role that web-based help communities play in how instructors learn to use their LMSs, we conducted a content analysis on the questions posted to *Canvas Community* [99], the dedicated online help forum for the Canvas LMS [97] (described further below). Canvas is currently the most widely-used LMS for higher education in the United States, and it has growing international usage as well [44]. As such, we believe that analyzing this LMS and its help forum can provide a case study representative of the broader issues affecting instructors across similar platforms. Our data collection for this study was influenced in part by the ongoing pandemic that has forced many instructors to transition to teaching online this past year.

The following research question guided our inquiry: *How do instructors make use of online community-driven help forums to collaboratively learn and troubleshoot an LMS to build and improve their online courses?*

4.3.1 About Canvas and the Canvas Community forum

Like many popular LMSs, Canvas provides a means for teachers to build web pages for their course that make use of a variety of educational features. Some built-in features of Canvas enable the delivery and marking of quizzes and assignments, grade-keeping, posting

announcements, and running forum-style discussion boards for student and instructor participation. Instructors can arrange their course content into modules and custom pages, and gate progress according to student learning milestones. More advanced features allow instructors and school administrators to embed third-party content and tools, such as those implementing the Learning Tools Interoperability (LTI) specification [94]. Canvas Community is an official online support resource for the Canvas LMS, comprising a community-driven Q&A forum, a variety of usage guides and documentation, and additional hubs for product suggestions, role-based discussion, and other topics. For this study, I sampled and analyzed posts from the Q&A forum section, though many of these posts also make reference to guides and discussions elsewhere on the Canvas Community website. I primarily focused on the question body text of each post, which instructors submit to the forum via the authoring page shown in Figure 4.1.

4.3.2 Pilot sample to derive codes

We took a multi-step qualitative approach to perform the content analysis. We began by examining the content of the 50 most recent questions on the Canvas Community forum (during June 2020). We sought to understand the kinds of questions forum users were asking about using the Canvas LMS and what type of pain points they described. We saw a wide range of questions in this data, from struggles in setting up a new course, to troubleshooting the appearance of a setup from the perspective of students, and even asking for suggestions for integrating third party applications. We also observed some patterns in the types of questions being asked by the users (e.g., how-to questions about a feature or whether a feature exists) and tried to classify them by broad categories of help requests proposed in prior work (e.g., [176]). After our initial examination of the data, we took an open coding [187] approach to develop a coding scheme to segment the posts based on the types of questions that were being asked, and the types of issues that were being referenced.

4.3.3 Development of codes and reliability

Next, we extracted a different sample of 80 recent posts that had over 50 views from the forums and iteratively applied our coding scheme. The sample was independently coded

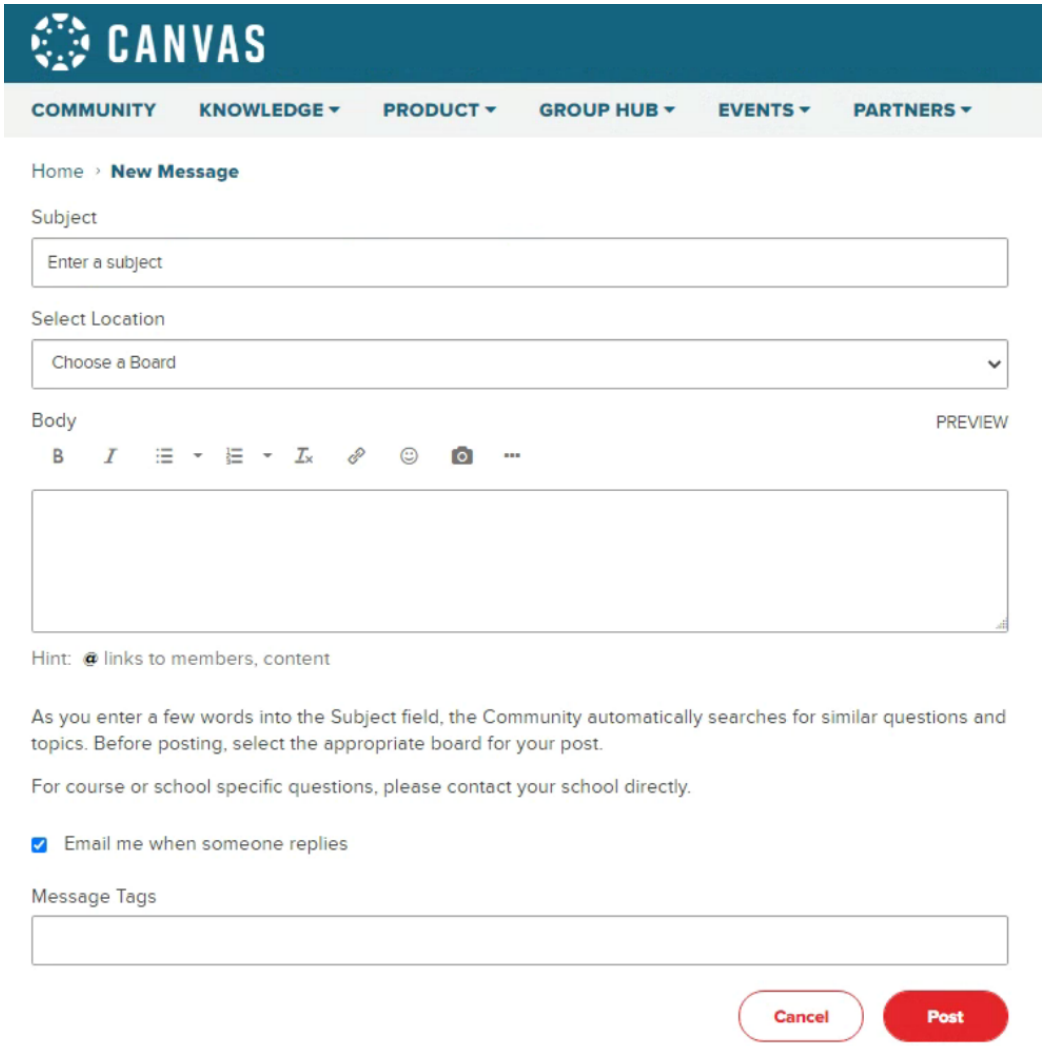

Figure 4.1: The Canvas Community "New Message" page, where instructors compose their questions.

by two researchers over three iterations, discussing disagreements after each pass and independently revising the codes. All of the co-authors extensively discussed each code and its relevance and performed multiple iterations to refine the coding scheme. Our final coding scheme had codes such as (not exhaustive): **(1)** *"how to question about feature,"* **(2)** *"seeking best practices,"* **(3)** *"where is this feature,"* **(4)** *"troubleshooting UI,"* **(5)** *"student-facing UI issues."* **(6)** *"administrator issues."* We noted that many of the codes that we derived showed that within the forum community, much of the discussion and types of questions asked were related to the user interface of Canvas. To check the reliability of our final coding scheme,

Table 4.1: Types of questions

Type of question	**Freq.**	**Example**
"How-to" questions about a feature	32.4%	*"How do I enter grade in gradebook?"*
UI troubleshooting questions	27.6%	*"I was using conference [...] and tried to upload a power point but I was unable to. [...] I was able to upload a video. What am I doing wrong."*
Questions about best practices	23.2%	*"I need to go in and adjust grades for quite a few students. What is the easiest way to do this?"*
"Where is this feature" questions (incl. requests for new features)	16.8%	*"Is there a Character Limit option for New Quizzes? I would very much like to see this feature added."*

we computed the inter-rater reliability on the final pass of the coding scheme applied to this sample by two independent researchers, resulting in a Cohen's kappa score of 0.89.

Finally, we applied this coding scheme to a larger sample of 250 posts from the Canvas community forum.

4.3.4 Analysis of the larger sample

To derive our larger sample, we began by collecting basic metadata (URL and creation timestamp) for every question posted to Canvas Community's "Question Forum" section between March 15, 2020 and July 15, 2020 – there were 7647 such questions in total. We selected this time frame as it corresponded roughly with the time during which many schools and universities in North America (and elsewhere worldwide) were in the process of moving classes online. This metadata was scraped from the web-accessible list of questions posts using a script to navigate between pages and extract the information. Our scraper included reasonable delays to avoid causing large usage spikes on the Canvas Community servers.

We then extracted a uniform random sample of 250 question posts from this set, and ran another script to scrape the question body, tags, replies, views, likes, and other data from the Q&A page for each question. One coder performed an initial pass over the sample and found 11 posts that were unsuitable for our analysis (e.g., not in English, or a blank question body). These posts were removed from the sample and replaced with new randomly-selected posts from the remaining data set, maintaining a sample size of 250.

In this sample of posts, the average number of views per question was 66.9, ranging from a minimum of 7 to a maximum of 1701. Although 109 of the 250 posts included tags (which were optional for authors to add), we found these tags were too varied, idiosyncratic, and inconsistent to derive a meaningful analysis separate from the question body text. This inconsistency may have been attributed to limits of the Canvas Community forum at the time of analysis as it did not support "smart" tagging, or AI based recommended tags. On average, each question in our sample received 1.38 replies. Additionally, only 12 posts had received any likes.

We focused our analysis on examining the question body text of each forum post and applied our coding scheme accordingly. We split our sample in two with each half coded by a separate independent coder. Based on our reliability score on the pilot sample, we were confident that our coding scheme was representative of the types of questions asked in the forum. After this first coding pass, we segmented the data by high-level question types (listed in Table 4.1). The most frequent questions were how-to questions about features of Canvas (32.4%), followed by posts about troubleshooting UI issues (27.6%) and questions about best practices (23.2%), such as seeking recommended strategies for course setup or feature-specific tasks. The remaining questions were mostly about where to find a feature, whether a feature existed, or whether a new feature could be added to Canvas.

We next explored the content of the question posts within each segment and observed that there were some cross-cutting themes that emerged across each question-type segment of the sample (listed in Table 4.2).

At the time of the analysis, the forum posts did not provide explicit information about each user's role within their school (e.g., instructor, student, administrator). Based on the post details and context, we could infer that the majority of the posts were written by instructors in schools, colleges, or universities. In fact, out of 250 posts, we found that only a minority of posts (5.6%) appeared to be from non-instructors, including 8 posts by students, 2 posts by parents, and 4 posts where the author seemed to be an administrator or IT support staff.

4.4 Results

Our analysis uncovered several cross-cutting topics throughout the different question types. Table 4.2 shows the representative themes: 1) navigating the first-time setup experience, 2) facilitating shared LMS experiences between different users, and 3) innovating on course delivery. Another small number of posts (4.8% of our sample) did not fall into these because they were either fragmented or lacked context. We expand on the three key recurring themes below and provide excerpts from our data set (labeled with #) for support.

4.4.1 Theme 1: Navigating the first-time setup experience

We found that about a fifth of the questions in our sample (47/250, 18.8%) were related to setting up a course for the first time or configuring various individual Canvas LMS features. This was not surprising given that our sample reflected a time-frame where many teachers around the world had moved to online teaching for the first time.

Many of these posts (32/47) concerned the initial setup process for a Canvas course, such as defining the course structure and initializing basic features. Around half of these were written by users who indicated that they were *"new to Canvas"* or were using Canvas *"for the first time."* These questions ranged from learning how to accomplish relatively simple tasks (e.g., *"How do you set up course navigation menu?" (#167)*) to more involved setup procedures (e.g., *"I would like to add a new blank sandbox or delete all the information in an existing one. How do I do this?" (#10)*).

Of the posts on navigating setup, over a quarter (13/47) were questions about seeking best practices. For instance, in one post an instructor wanted to find a better way to support student collaboration: *"I am trying to cross list my sections in Canvas so that the students can participate in a group discussion. I don't see the cross list tab on the right side of the screen [...] Is there another way to connect my classes?" (#12)*. In many cases, the authors of these questions would simply indicate an end goal or list the difficulties in their current setup, in the hope that other users might know a better way of achieving it: *"I've organized my modules into categories, but there could be 12 topics within a module. I would like to distinguish them easily from each other." (#186)*.

4.4.2 Theme 2: Facilitating shared LMS experiences

Nearly a third of our sample (82/250, 32.8%) were posts related to student-motivated aspects of course delivery, such as facilitating student collaboration or managing access to different pages of the course. Given that our sample reflected a time when many instructors were shifting their courses online, it was understandable that creating an environment of shared learning and collaboration without face-to-face meetings would be particularly challenging.

Many of these posts (35/82) were from instructors struggling with the disparity between their own interface and what their students could see. Some posts (12/82) mentioned using the "Student View" feature in Canvas (which allows instructors to test their course from a student's perspective) or troubleshooting discrepancies between the different perspectives. Most frequently, instructors had enabled a feature or added content for students to interact with but were surprised to learn that their students couldn't see it: *"I have enabled and saved the announcements tab to be seen by students [...] However, it still has an eyeball [icon indicating visibility] by announcements but students can not see it." (#81)*

Another frequent topic in this theme involved instructors seeking guidance on how different features would affect students in ways the instructor could not easily test: *"How does the extra time assigned a student for quizzes and exams work? Does the student's time run out and then the extra time starts? How do they view this in their quiz or exam?" (#83).* Some instructors also expressed interest in features or help resources aimed at better supporting their students, such as #31: *"Is there a guide for how students can upload videos to Canvas as a file submission for an assignment?"*

A substantial portion (33/82) of posts were about instructors wanting to support student collaboration or communication with each other. Many cases involved uncertainties in setting up group work environments or group discussions for students. In #13, the instructor was unsure how to enable a peer assessment process for written work: *"I've put them into groups of 3, but I think that if I use 'Collaborate' they will only be able to see one of their documents. How can I best set it up so they can respond to documents from the other group members?"* Further challenges arose in clarifying what information was visible to students, often to avoid confusion: *"kiddos are really confused about information in the gradebook from [...]*

before we went online virtual. I want to clean up the gradebook so they can only see the assignments they [need to be] worried about" (#52). Commonly, instructors were seeking better ways to keep students up-to-date on course information, set up reminders, and help students actively engage with the course in the absence of face-to-face meetings.

Another third of the posts (24/82) in this theme highlighted the struggle of managing appropriate access to course content among students, parents, and other instructors as they try to navigate the online course delivery experience. For instructors, access issues often related to making sure their students and collaborators were able to successfully enroll in the course and access content on time, e.g.: *"My colleague wanted to enrol to a course provided by Canvas [...] She didn't received any confirmation [of] her enrolment. What should we do?" (#112).* Other cases involved making sure particular user groups were granted access to certain course content: *"I just [had] a conference in Canvas with few attendees. How can the students not on the conference access the recordings?" (#118).*

4.4.3 Theme 3: Innovating on course delivery

Another major theme that emerged in our analysis was about instructors seeking methods to innovate on teaching practices and customize their LMS for online delivery. A sizable segment of our sample (109/250, 43.6%) fell into this category.

In view of the time frame for our data collection, it was not surprising to see that many of these questions were about new features and methods for facilitating remote learning. Frequently, instructors were looking for suitable replacements in the LMS for elements of their in-person teaching practices, such as migrating an existing routine or activity to the online setting. Several posts described situations where a lesson designed for face-to-face instruction seemed impossible or too complex to replicate within the LMS: *"I usually have a on-site hands-on anatomy lab practical [...] With the COVID-19 crisis, I need to do it online and thought of choosing to only show students one station/question at a time with pictures [...] can I limit the time for each question/station to 1.5 minutes and allow students to return to stations [...] that they flagged for 10 more minutes?" (#76).*

Table 4.2: Cross-cutting Themes

Cross-cutting Themes	Freq.	Summary of findings
Navigating the first-time setup experience	18.8%	– Seeking best practices for basic LMS features – Novice users learning simple tasks
Facilitating shared LMS experiences	32.8%	– Largely how-to and troubleshooting questions – Student-facing UI issues – Supporting student collaboration and communication – Managing shared access to courses and content
Innovating on course delivery	43.6%	– Adapting teaching practices to online settings – Troubleshooting video features and online assessments – Customizing the LMS to support new workflows

Nearly half (49/109) of the posts in this theme concerned setting up or troubleshooting video-related features, such as video assignment submissions, online lecture recordings, and tips on embedding videos in Canvas course pages.

For instance, some instructors faced challenges in exploring unfamiliar video tools, compounded by the difficulty of managing the student perspective of the LMS: *"During an online conference with the students [...] I share my screen. However, the students see only half of the slide. Can you please help on this?" (#14).* As video features may have been unfamiliar to a wide range of instructors, many questions in this theme concerned best practices for using videos, such as finding workflows for asynchronous lecture delivery, e.g.: *"One option [...] is using the 'Record/Upload media' button within the Rich Content Editor. [...] is it a good approach, does it stream them properly, or should I instead look to videos uploaded via Studio?" (#25).*

A further third (39/109) of the posts in this theme asked about managing online assessments, such as LMS-based quizzes, exams, and assignments. Among these, key questions concerned integrating external tools to prevent students from cheating in online exams (e.g., LockDown Browser [169]), and to ensure that assessments were administered equitably for different student needs, e.g.: *"Is there a tool like Immersive Reader that will read quizzes to students in Canvas?" (#57).* Some instructors who made attempts to adapt their existing assessment methods to the online setting occasionally faced difficulty in fully implementing

their ideas. For instance, one computing teacher explained that they want to deliver a *"MS WORD [...] assessment task [...] business letter [...]. Usually, students do it in class on laptops where teachers are monitoring them but now with the new online and remote learning, is there a way to do it?" (#33).*

We also found that instructors (and potentially some school administrators) were frequently seeking out way to make customizations to Canvas to smooth the transition from in-person to online teaching. These customizations took the form of various changes to the default user interface, such as altering what Canvas features were available to students in their course, the order they appear in the navigation, or the visual theme of their course: *"I was wondering if there was a way to colour the different aspects in a module as above. [image shown] So that at a glance students could have a visual cue to where they are expected to upload or complete assignments" (#177).* Many posts centered on integrating third-party tools into the LMS to add new features or to streamline instructors' workflows: *"Can Canvas/Kaltura add an option to combine individual Kaltura student videos into one final student group video? [...] This saves a lot of (unnecessary) work" (#188).*

4.4.4 Analysis of unanswered & unresolved questions

Although the Q&A forum for Canvas offers a space for questions to be discussed and answered, we observed that around one-fifth of the posts were still left unanswered (i.e., with 0 replies). Also, although on average each question in our sample received 1.38 replies, we saw some indication that even questions with numerous replies did not actually resolve the original author's issue. This was particularly evident in posts where an instructor was asking a question about innovating or customizing the LMS to meet a unique need or goal. In fact, almost a third (28.4%) of the questions relating to the theme of innovating on course delivery did not receive even a single reply.

Our analysis revealed that simpler setup-related questions often received answers from forum moderators or support staff linking to a related Canvas community guide. Yet questions about more complex or particular setup practices that alluded to instructor's unique needs were often left unanswered. For instance, one instructor received no replies to a question (#63) asking how to migrate their custom weighted grading scheme from another LMS that

catered to the particular needs of their nursing faculty. Most unanswered questions related to facilitating a shared learning environment were about troubleshooting the pertinent challenge of communication with students despite a disparity between instructor and student views of the LMS: *"How do I ensure comments in comments box is not visible to student? The eye with the line through it is on but the students is still receiving the comments before I post the grades." (#145).*

It is worth noting that nuanced questions concerning the unique challenges of transitioning to online course delivery were also often left unanswered by the community, e.g.: *"I need help posting a Powerpoint presentation with audio. [...] When I tried to upload to Canvas it forced me to download the file and I couldn't get the audio to play" (#109).* Instructors faced further challenges in finding help with customizing their courses to adapt to newly asynchronous environments or to suit other unique goals, such as in post #30 which received no responses from the community: *"I am trying to find ways for students to engage with each other a-synchronously. [...] I would like peers reviewing an assignment to be able to see what other peers have posted."*

Moreover, even among those posts that did receive replies, it was not always the case that the original question was resolved. Particularly in cases where instructors sought to innovate, they would sometimes end up having idiosyncratic needs that proved difficult for the community to answer successfully. For instance, in one post about uploading a recording: *"I just did a 16+ minute video using the webcam to...diagram on a whiteboard...then I discovered there was no visual, [...] the visual is nothing but a green screen throughout [...] Why did this happen?" (#20).* This post received 6 replies (which was well above the average of 1.38 replies), yet the responses did not succeed in solving the problem to the satisfaction of the author. Later in the thread, the author commented, *"I was hoping someone from Canvas would tell me the 'video' part of my upload was stored somewhere on Canvas' [...] Oh well..."*.

In summary, while the majority of help-seekers appeared to find the help they needed from community responses, a sizeable segment was still left with little to no support, especially

when facing challenges with time-sensitive course adaptations and complex innovations with the LMS. We elaborate on some avenues for addressing these issues in the next section.

4.5 Discussion

Our findings (summarized in Table 4.2) shed light on a number of key issues that instructors face in the course of learning, setting up, using, and troubleshooting their LMSs. Since we only studied one instance of an LMS help forum, there should be some caution taken in interpreting the findings. However, we note that Canvas currently has the largest market share among LMSs in the US and is consistently growing its market share in several international regions [44], indicating that it is likely a suitable model for this exploratory research. It is also worth noting that the sampled time period overlaps with the considerable changes in teaching practices brought on by the COVID-19 pandemic. While our results may lose some applicability under more ordinary teaching circumstances, the findings nonetheless shed light on many of the unusual difficulties facing instructors during this time period.

Based on the key insights from our work, we now reflect on the broader themes and suggest recommendations for improving LMS design and the design of online communities for instructors.

4.5.1 The value of community-based learning for instructors

At a high level, our findings illustrate a number of ways in which participating in the Q&A forum proved beneficial for instructors as they received replies for around 80% of their questions. It appeared to be particularly valuable for newcomers to the LMS, as they tried to make sense of the numerous features or understand how the LMS differs from other software they might be used to. Although we have found some evidence that the forum provided assistance with "learning the ropes," it remains unclear to what extent these community solutions could help support novice-to-expert transitions [31] among software-using instructors. While there is some debate about the practical value of communities of practice for new instructors [72], initial explorations of online communities of practice have shown promise for broader teacher professional development [83, 173].

We also saw several instances of instructors seeking features or changes that would require administrator-level changes to their school's Canvas account — cases where the online community was unable to offer help beyond directing the help-seeker to contact their school's administrator. In such cases, there is need for more localized institution-level solutions (e.g., sub-forums, peer groups) allowing instructors to seek LMS help from smaller tight-knit communities. Members of these communities can coalesce around a shared interest of improving their online course delivery, bringing together instructors, administrators, and other stakeholders.

4.5.2 Challenges in providing support for LMS customizations

A recurring sub-theme in the how-to questions posted by instructors concerned how to customize the Canvas user interface or its content. Consistent with other studies in educational contexts [201], many of these customizations focused on the student experience rather than the instructor's own needs to customize their environment, an important distinction from more widely-studied customization activities in personal use contexts. Given that LMSs tend to be highly feature-rich with numerous customizable options, it is perhaps not surprising that this aspect of their usage presents a significant barrier to learnability.

Many of the customization-related questions were often narrow in scope (e.g., configuring a certain course-wide setting, integrating third-party tools). But, a large number of questions were also about more complex customizations where instructors tried to convey a detailed picture of their goals or efforts in customizing a whole course. Unsurprisingly, for these more heavily customized courses with many idiosyncratic changes, instructors faced more challenges in getting help, with many such questions receiving no responses at all.

The lack of support for customization-related questions may simply indicate that fewer help-givers were familiar with these advanced topics to confidently respond to them. However, it also points toward opportunities for better filtering users based on role and expertise level to direct more advanced users toward these types of questions where their expertise could be valuable. Past research has found that it is common for teachers to rely on one or more go-to "tech expert" teachers at their school for troubleshooting and help with customization [201], a model that could be valuable to emulate in a Q&A forum setting. Furthermore, additional

research could investigate how instructors working remotely are innovating course delivery and customization to better understand what factors influence receiving more timely or better quality answers. Some recent tools, such as Customizer [202], have been designed to facilitate the process of customizing an LMS through in-application example-based sharing mechanisms, but there remain further opportunities to facilitate course customizations for different instructor needs.

4.5.3 Implications for designing LMSs and support resources

Our analysis uncovered a variety of persistent issues that warrant the attention of researchers and practitioners in the HCI and learning sciences community. We now discuss several recommendations and opportunities for improving the workflows and experiences of instructors as they learn, use, and seek help for their LMS.

Promote expertise-based participation in online communities.

Many of the instructors' questions posted to the Canvas Community Q&A forum alluded to differing needs and problems which could not necessarily be resolved by other instructors. For example, some posts sought solutions to site-specific problems that needed to be addressed by IT staff or administrators at the author's own school. In a few cases, IT staff were even asking their own questions about resolving technical nuances in setting up a school-wide Canvas instance. This presents a challenge for newcomers with different roles (instructors, administrators, students, etc.) who are struggling to find content and answers to questions relevant to their own needs, particularly with complex software such as LMSs. We believe this issue can be tackled through thoughtful personalization of the help-seeking experience that better caters to each user's role, such as by filtering or promoting the help content most relevant to that role. Promisingly, after a more recent update in late 2020, the Canvas Community now initially directs new users to more specific "group hub" forums depending on their role.

Provide more in-place guidance for remote teaching features.

There is a pressing need for clearer built-in instructions or tutorials detailing how to transition to using "fully-online teaching" features like those for conducting live lectures, recording videos, or protecting academic integrity of online exams. LMS designers should strive to use terminology that instructors are most familiar with or provide easy ways to provide translations from in-person to remote instruction within the application. Additional support for setting up these features can serve to mitigate the high number of help requests and problems instructors have been facing, particularly given the recent surge in usage of LMSs in remote learning.

Aim for consistency between instructor and student interfaces.

Given how commonly teachers faced confusion over subtle differences in visibility or functionality between their own Canvas view and that of their students, LMS designers should prioritize consistency between the two wherever possible. The Student View feature in Canvas is a useful starting point, but as the instructors' Q&A indicated, viewing the changes consistently in heavily customized courses could still be challenging. More broadly, this issue of consistency lends further weight to recent, more general calls to action on interface consistency in classroom software [201].

4.6 Conclusion

This study has provided insights into the types of questions that instructors ask on a community-based help forum for Canvas, currently the most popular LMS being used worldwide. We have identified a wide range of topics instructors struggle with when setting up their courses, troubleshooting the software, and in using the LMS to innovate on their course delivery. Our findings also shed light on some of the key difficulties instructors face in transitioning to remote learning as they try to ensure a consistent, customized course experiences for their students. From these difficulties emerge a number of opportunities for LMS designers and researchers to address areas that are less intuitive and streamline the experience of course setup and management.

Chapter 5

Peek-through Customization: Example-based In-context Sharing for Learning Management Systems

The studies in Chapters 3 and 4 provided a solid foundation for understanding educators' software customization needs and the common barriers that they encounter. In this chapter,[1] I build upon this foundation to design Customizer, a system that facilitates the discovery, exploration, appropriation, and sharing of software customizations for learning management systems (LMS). I undertook a user-centered design process beginning with interviews of post-secondary instructors to guide the design ideas as they evolved. Arriving at a set of clear design goals, I then implemented a prototype of Customizer and conducted usability tests to gauge how instructors felt about the design and the prospect of using it to customize their LMS courses.

5.1 Introduction

At both post-secondary and K-12 schools worldwide, instructors are increasingly using learning management systems (LMS) to fulfill a variety of educational needs [36, 154]. To adapt the features and settings of an LMS to their course, instructors often have to perform some amount of *software customization* (e.g., tailoring to the course subject, grade level,

[1]Portions of this chapter were originally published in Vermette, McGrenere, and Chilana (2020). *Peek-through Customization: Example-based In-context Sharing for Learning Management Systems.* Proceedings of the 2020 ACM Designing Interactive Systems Conference (DIS '20). [202]

teaching methods, or student accessibility needs). Widely-used LMSs tend to be feature-rich with many customizable options, presenting a steep learning curve that instructors must overcome to make effective use of them. A key challenge that instructors have to tackle is taking time out of their busy schedules to figure out how to navigate and customize their LMS and other educational technologies [177].

In recent years, different LMS-specific support systems have emerged, such as online help, documentation, and hands-on training [66]. Many instructors nonetheless prefer social forms of help [201], such as "over-the-shoulder" learning [194], allowing them to get in-person task-specific advice from a more experienced colleague by looking at how they have customized their LMS. However, this type of learning can be time-consuming and challenging to coordinate among busy instructors, so cannot always be relied upon.

Even beyond educational technologies, a common challenge with customizing feature-rich software is that users are hesitant to take the risk of customizing [137]. In addition to the initial effort and time investment needed to customize, users are also concerned about the potential troubleshooting that will be required if the customization goes wrong. Instructors, in particular, are a class of users who routinely face difficult troubleshooting challenges in experimenting with their digital classroom setups [201].

Given the difficulties instructors have with relying on in-person help, we wondered about the possibility of alternative semi-social approaches to support software customization. In particular, we were curious about this question: if instructors had tool support to "peek" at and experiment with examples of their colleagues' course customizations in a risk-free manner, within their own LMS, would it help them more easily learn how to customize their own courses?

We began by conducting a formative interview study with post-secondary instructors aimed at better understanding how to support their strategies for customizing LMSs. These interviews elicited feedback on some early design concepts for LMS customization sharing tools. The findings highlighted instructors' frequent use of examples from other instructors' courses as templates and inspiration, but also the degree to which they rely on exploratory learning to fill in the gaps when social help is unavailable. In light of these findings, we

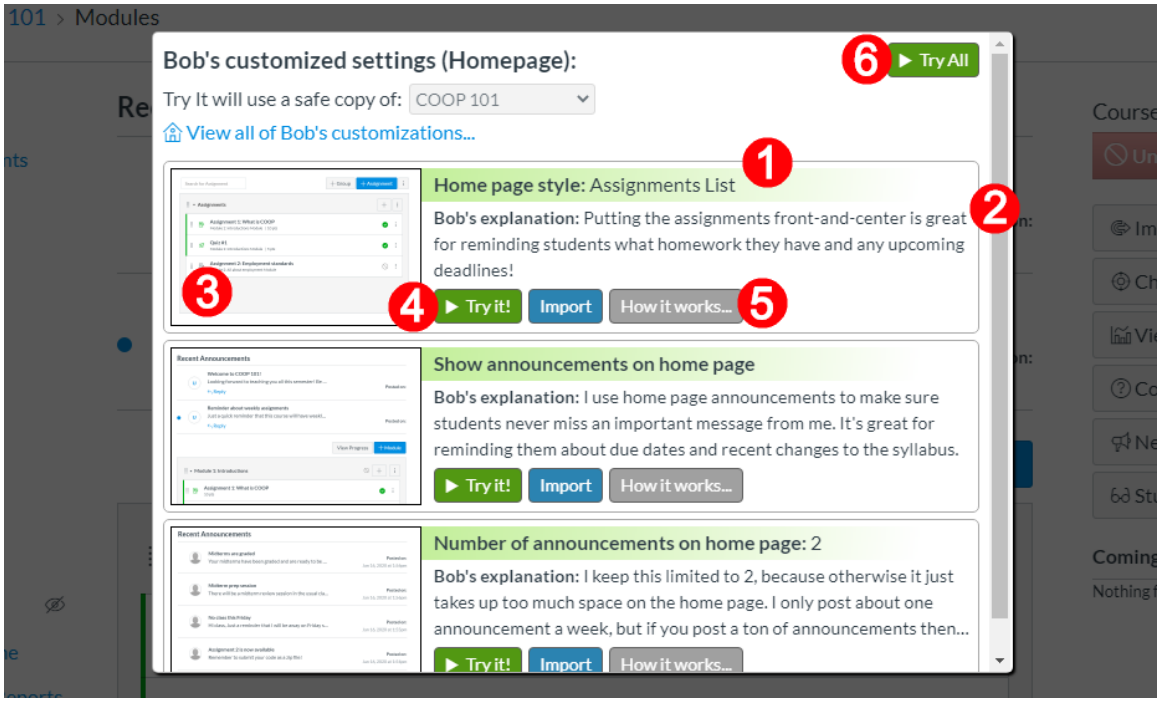

Figure 5.1: The Customizer dialog opens on top of a user's course homepage in the Canvas LMS, displaying three customizations that another instructor (Bob) has made to his own course homepage. The user can browse and explore each of Bob's customizations. Each "customization card" contains (1) the name of the customization, (2) Bob's freeform written explanation for it, (3) a preview image of the result, and (4) buttons to *Try It* in a safe test environment or *Import* it into the current course. The *How it works* (5) button expands out longer explanations and shows extra metadata about the customization's complexity and where it takes effect. The user can try all of Bob's customizations at once (6), or try any combination of customizations together by clicking multiple cards to select them.

sought to facilitate this exploration of examples by designing *Customizer*, a novel platform to support *example-based customization sharing* (Figure 5.1). Using Customizer, instructors can discover examples of peer-generated customizations relevant to the LMS page they are on. Moreover, Customizer provides instructors with an *exploratory mode* [114, 136] inside their LMS, letting them "peek and try" these shared customization ideas without the risk of breaking their real courses. Customizer also provides tools for instructors to analyze and reflect upon their own customizations and share them with colleagues.

To evaluate this design, we developed a prototype running atop *Canvas*, a widespread LMS with currently more than 30 million users [148]. We ran an observational usability study with 10 post-secondary instructors in which they expressed the usefulness of having access

to in-context customization examples and an environment in which they could safely explore how the changes would affect their course. In addition to identifying many ways to improve the design, participants described several different use cases for the exploratory mode beyond the original design intention, and were enthusiastic about generalizing Customizer to other non-LMS applications.

The main contributions in this chapter are: (1) empirical insights into how instructors experience the process of setting up and personalizing an LMS, and how they share their knowledge and artifacts during that process; (2) the design and implementation of a novel example-based, in-context customization sharing platform that allows instructors to discover example customizations for their courses, freely experiment with those possibilities in on-the-fly sandboxed copies of their real courses, and easily share their own customizations with others; and, (3) a usability study that provides preliminary support for the usefulness of our "peek and try" conceptual model, as well as several ways in which the design could be extended.

5.2 Related Work

To contextualize our empirical findings and designs, we draw upon literature on instructors' usage and perceptions of digital classroom tools, example-based peer-to-peer knowledge sharing, and insights into appropriating and sharing software customizations.

5.2.1 How instructors use and perceive digital classroom tools

Studies on instructors in educational technology and HCI fields have contributed numerous insights into how learning management systems and other digital classroom tools are used and perceived. For example, Lai and Savage [111] discuss the roles, advantages, and shortcomings of LMSs in higher education, arguing that educators need to innovate to make the most effective use of their LMS, and that it is not enough to use them as "mere information transmission tools". While a great deal of the literature on educational technology focuses on the student perspective, some research has looked into instructors' perceptions and motivations on technology integration [48, 66, 177], the design of classroom technologies to

better support educators' needs [1, 3, 7], or more generally how instructors discover and integrate new software into their personalized "digital classroom ecosystems" [201].

This chapter complements this existing work by investigating the practices specific to customizing an LMS and designing a novel instructor-centered platform for sharing in-context examples of LMS customizations.

5.2.2 Example-based peer-to-peer knowledge sharing

It has been well-studied how educators often form *communities of practice* to share ideas and insights with one another [165, 205] and rely on their social connections to learn how to use and customize their digital classroom tools [201]. Within these peer groups, it is common to learn about software features and seek help through ad-hoc in-person interactions (e.g., looking at examples of a colleague's software via over-the-shoulder learning [194]), but this can be time-consuming and frustrating for the tech-savvy teachers who end up fulfilling an "unofficial tech support" role for colleagues on top of their teaching duties [201]. Our work seeks to alleviate these frustrations by surfacing peer-authored customization examples within an instructor's LMS and letting them remotely explore the effects of trying out their colleagues' customizations.

We draw inspiration from general-purpose systems that have built in-context crowdsourced software tutorials [133,200], Q&A [29,133], and action/command suggestions [59,134] into web-based interfaces as a shareable help mechanism. Other systems like Unakite [116] provide the means for programmers to collect and share web-based code snippets with information about the trade-offs of different code solutions. Moreover, there is a long history of using example-based aids to assist programmers, both for novices in classroom environments [17, 76] and for professionals working with an integrated development environment (IDE) [81, 147]. Notably, Brandt et al. designed the *Blueprint* interface for retrieving example-centric code snippets based on context from the user's code within an IDE [13].

Our Customizer design takes these ideas beyond retrieving static examples for viewing, allowing the user to interactively experiment with LMS customization examples in the context of their own courses, and directly import those examples into their courses.

5.2.3 Appropriating and sharing software customizations

Early research into software customization highlighted the many triggers and barriers that influence users' customization practices [124]. Software customizations have since been characterized and compared according to a number of dimensions, such as what aspects of the user interface they modify [18,78] and the degree of user control over the changes [49,137]. Some studies have looked more closely at the personal side of customization, identifying key groups of users such as "translators" [123] and "tinkerers" [125] who in many ways bridge the gaps between expert customization authors and less experienced users. Furthermore, there has been evidence suggesting the importance of seeing a customization in action [49] and reading the rationale behind it [20] to improve users' understanding of its benefits. It has been proposed that feature-rich applications can help users by offering an *exploratory mode*, where they are free to tinker with interface features and learn in a risk-free manner atop a "dummy document" [114, 136]. To our knowledge, Customizer is among the first systems to fully implement this concept.

Importantly, several works have studied software customization not an individual activity, but as a highly social one in which sharing occurs frequently. Mackay [123] detailed how software configuration files get shared and modified among colleagues within a company. More recently, Haraty et al. [79] explored how user communities come together in online *customization sharing ecosystems* that let them upload and share their customizations with one another. We also see parallels between our work and other domain-specific approaches to customization sharing, such as the ShareXP system [12] for software developers to share customized IDE perspectives.

Although past literature has uncovered the barriers that make it challenging to share customizations in general, software customization practices in the context of an LMS are underexplored. In fact, classrooms present an atypical scenario because the changes instructors make to their LMS and other classroom are meant to improve *students'* software experience, not necessarily their own [201]. We aim to partially address this gap with our studies of instructors' approaches to customization and their use of a novel customization-sharing tool.

5.3 Formative Study

To gather insights into LMS customization habits and to inform the design of our system, we conducted interviews with 10 participants who were instructors or teaching assistants at a large public university and had recently used and configured an LMS for their course. Our high-level research questions for this study were:

RQ1: How do post-secondary instructors and TAs learn to use and customize learning management systems?

RQ2: What methods do post-secondary instructors and TAs see as promising or useful for exploring the customizable features of a learning management system?

5.3.1 Participants

Our participants (4F, 6M) were all between the ages of 19–60 and had used an LMS within the past four months to teach a university-level course, either as the instructor or as a TA. Our goal was to have a mix of instructors and TAs with a range of experience. To that end, we took a hybrid sampling approach, drawing on the personal contacts of the research team and advertising on two different university mailing lists, followed by snowball sampling to recruit the remaining participants. The 3 instructors (P01, P08, and P10) had 11–15, 21+, and 16–20 years of teaching experience, respectively. Among the 7 TAs, 3 had less than a year of teaching experience, and the remaining 4 had 1–5 years.

The majority (6/10) of participants had been teaching a computer science or math course, with the others teaching design, business, economics, or mechanical engineering. All participants described having used Canvas (the LMS deployed by their university) in their teaching role, and most (8/10) were also using other educational technology in their class beyond an LMS (e.g., Crowdmark, iClickers, XAMPP).

5.3.2 Procedure

We began by asking participants to fill out a brief demographic questionnaire. We then carried out semi-structured interviews, each lasting 30–45 minutes, asking about their past learning and usage of LMSs, their routine for setting up and customizing a new course, their

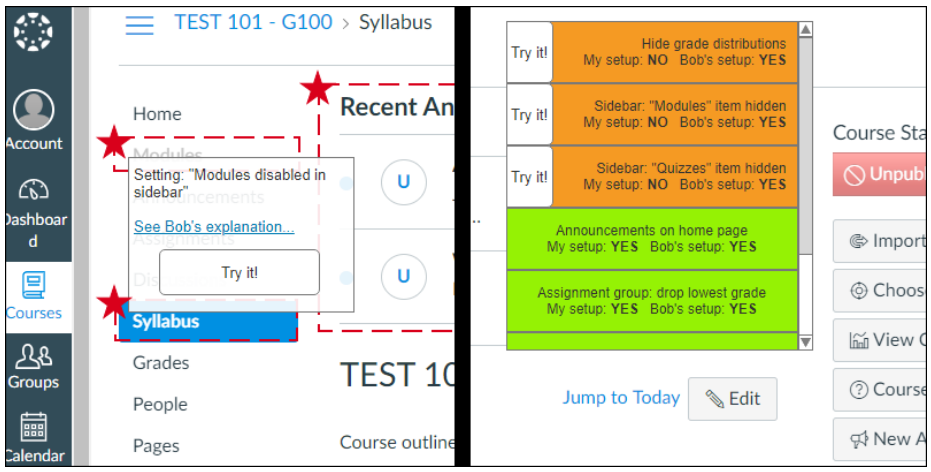

Figure 5.2: Two examples of the design mockups shown to participants. Left: mockup 1, showing badges and explanations on customized features. Right: mockup 2, a high-level list comparing course customizations between two instructors.

tendency to share their configurations with peers and colleagues, and common challenges they had encountered throughout these tasks.

Following this, we showed them 3–4 different mockups of novel design ideas for sharing and browsing customizations within Canvas LMS, eliciting their feedback about the usefulness of each design and their ideas for improvement, both verbally and in drawn sketches. These mockups evolved over the course of the formative study, as we iterated on the designs to incorporate the most frequent feedback into them. They included designs which (1) visually marked customized features of an instructor's Canvas course with red borders, icons, and explanations from the creator; (2) added a panel listing out a high-level overview of the customized features throughout the course; (3) displayed an interactive split-screen of two differently-customized courses overlaid on top of each other; and (4) added a sidebar showing some customizations that other instructors had done. The mockups presented were partially interactive (as *Axure* prototypes overlaid atop a Canvas screenshot), and participants were encouraged to play with them and imagine how they might work in practice. The first two mockups are shown in Figure 5.2.

The interviews were audio-recorded and later transcribed to text for analysis. Participants were each offered a $20 gift card in appreciation of their time (3 declined).

5.3.3 Key Findings and Design Goals

Participants described several ways in which they had learned to use the features of an LMS, but among the most common was exploratory learning, where they would simply try out interface features and explore the interface on their own until they felt they had a reasonable understanding of the range of features and how to use them. The second most common learning method was asking for task-specific help or instructive examples from a more knowledgeable colleague. However, these interactions were described as time-consuming and highly dependent on personal availability.

Sometimes it helps to just know what other people are doing... I know I can find a solution based on what other people have done and I can try it and see if it works, but sometimes it's just a really specific thing and I can't get what I need from the Internet. (P05)

Visual customization cues are very helpful

Among the design mockups shown, participants consistently noted a preference for ones that attached visual markers to customized elements of the page (e.g., Fig 5.2, left). While they had some concerns that there might be too much visual clutter in certain cases, the utility of these visual cues for *discovering* what has been customized was generally seen to outweigh the potential for clutter.

The thing I like about this is the red boxes with the star [indicating customized elements] because I don't have to worry about other jargon...if I only know what things they've changed, that actually helps because I know where to look instead of having to scan through each item of a list...it's really helpful. (P05)

In contrast, the idea of listing customizations in a central location *without* visual referents was mainly deemed helpful to self-identified "power users" who were fond of having all the information in one place, while others felt it could be overwhelming unless there were robust ways to filter it according to location or difficulty.

Instructors value expert explanations

Both instructors and TAs overwhelmingly felt that having a written explanation of *why* a customization was made would be very useful, particularly if it was written by the original creator detailing their intentions and experiences.

I think [explanations] are very helpful because sometimes it's not obvious... especially for someone who's less knowledgeable about Canvas, it's a bridge between pedagogical goals and Canvas features...If there was a way for me to view a course that had almost like a bit of a commentary or a viewpoint about pedagogical benefits or approaches for features that are being used, that would be extremely valuable. (P08)

Participants had similar feelings about adding additional contextual information like what scope of the application is affected, for a clearer idea of how extensive a change is and what it does. Furthermore, several participants also added that they could benefit from seeing a step-by-step explanation of *how* to set up each customization manually, often for the sake of learning more about the LMS features:

Give me a point-by-point explanation, or steps... like it's awesome if you just give me the whole [course], but I would like to learn too, I would like to know how to go about it and make alterations to it, just so that I'm completely familiar with what I am doing to my own course page. (P07)

Based on these findings, we derived four design goals for a system to help instructors find and share LMS customizations:

DG1: Encourage exploration. Because exploratory learning was so common among instructors, the system should allow users to explore and see the effect of different customizations.

DG2: Facilitate discovery of relevant examples. Given instructors' tendency to seek out example customizations for help and inspiration, the system should suggest relevant examples of customizations from other instructors.

DG3: Highlight customizations with visual cues. The system should take advantage of the visual nature of many customizations to make them stand out at a glance.

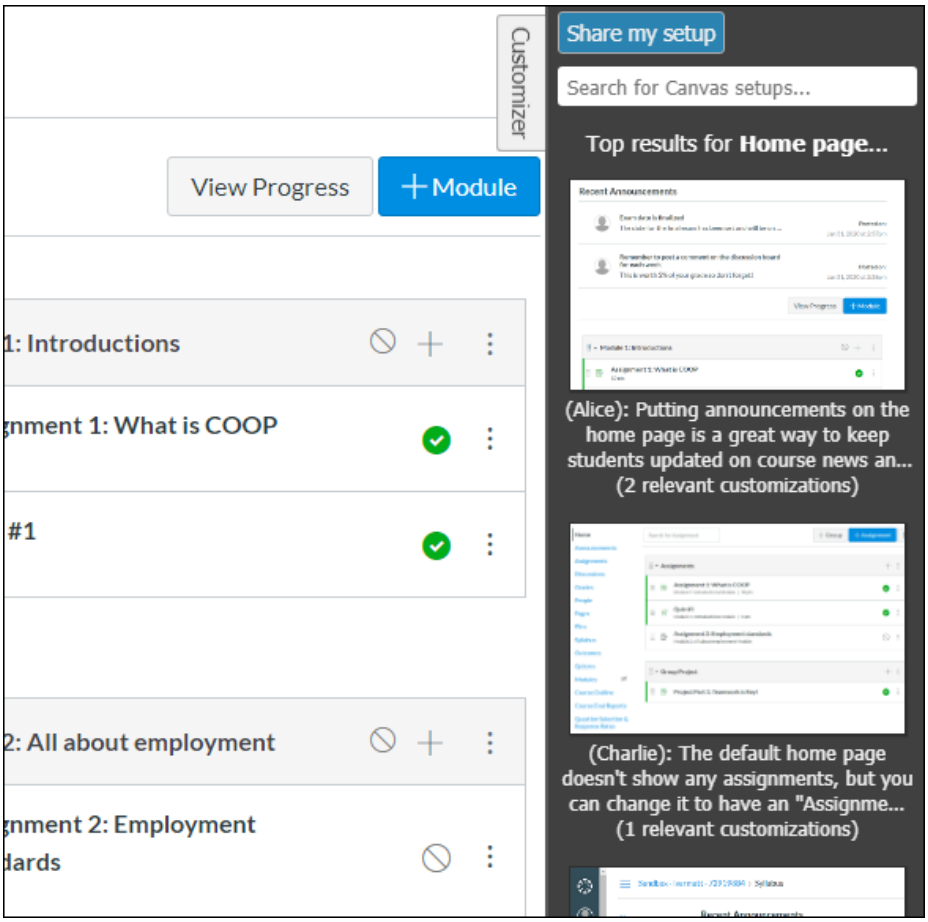

Figure 5.3: The Customizer sidebar, here shown opened on a Canvas course home page, lists several shared course customizations that are relevant to the user's current page. Each customization shows a preview of the visual result and the author's explanation. Clicking one of these customizations opens the full Customizer dialog (see Figure 5.1) with the clicked item highlighted. The user can also use the search bar to quickly find other instructors' customizations by freeform query. The means for them to share customizations from their own courses is provided as well.

DG4: Enhance customizations with rationale and context. Instructors who share their customizations should be encouraged to provide information on *why* and *how* they made those changes to help other users assess relevance and difficulty.

5.4 System Design of Customizer

After several rounds of brainstorming, sketching, and iterative prototyping based on the above goals, we arrived at a design for Customizer, split across three main modes of interaction. Addressing DG2 and DG4, Customizer's *Discovery interface* provides a streamlined way to

find new customizations and explanations that others have shared without having to leave the application user interface. Addressing DG1 and DG3, the *Exploratory interface* provides a safe interactive testbed environment for experimenting with customizations shared by others. Lastly, Customizer also includes an *Authoring interface* which allows users to easily share their own customizations and add explanations.

We selected Canvas as the underlying LMS for exploring the design space since it has widespread adoption in both post-secondary and K-12 schools [148] and is available as an open-source project [98]. Like other LMSs, Canvas consists of many smaller sections (e.g., Assignments, Quizzes, Discussions) each with many individual pages, encompassing hundreds of ways instructors can further customize their courses.

5.4.1 Discovery Interface for finding customizations

As the entry point into Customizer, the discovery interface (Figure 5.3) enables users who *want* to customize to find relevant ideas for what to do and explanations for why and how to do it. We adopted a design similar to systems such as *Social CheatSheet* [200] and *Unakite* [116], adding a collapsible sidebar on the right side of Canvas web pages that lists customizations relevant to the current page, that have been shared by other instructors. The relevant customizations are presented with a preview image and a brief explanation written by the author.

Browsing and filtering by context

Customizer automatically uses the page URL as context information to determine which customizations are relevant to show in the sidebar. Navigating to a different page of the Canvas LMS will trigger the sidebar to update its contents with customizations that affect the user's current page or closely-related sections of the LMS. Alternatively, the user can also search through all of the shared customizations via a freeform query in the sidebar's search field, which matches customizations based on their descriptions and explanations. In this case, the sidebar (Figure 5.3) would list the search results instead of the page-filtered customizations (but customizations relevant to the user's current page are still ranked higher in the list).

Interactive customization cards

When the user clicks on one of the customizations in the sidebar, Customizer overlays a dialog on the user's current page showing a list of interactive customization "cards" (Figure 5.1). By default, the list shows all customizations shared by the same author that can affect the current page. Upon the dialog opening, the list automatically scrolls to and highlights the customization that was selected from the sidebar. From there, the user can easily browse any closely-related customizations from that author's *customized setup* (taken here to mean the aggregation of all the customizations applied to their course).

Each of the customization cards provides a descriptive name for the customization (e.g., "Don't let students attach files to discussions") and shows an image preview of what the customization does. Fulfilling DG4, it also shows a written explanation of the customization author's rationale for including this in their setup. For longer explanations, the full text can be opened by clicking the *How it works* button on each card. If the author did not provide any explanation of their own, a default description of the customization's purpose is provided as a placeholder in most cases, adapted manually from Canvas documentation guides [96]. The card header is shown with a background color indicating how complex the author felt this customization was to set up or maintain (green, yellow, or red), to help decide whether the customization is appropriate for their Canvas expertise level.

The list is initially filtered to show only customizations related to the context of the user's current page. These contexts (such as "Discussions", "Gradebook", and "Assignments") connect the available customizations to distinct areas of LMS functionality for ease of navigation and to avoid overwhelming the user. Additionally, the dialog header has a link to *Show all customizations by <author>* if the user wants to see more.

The customization cards are selectable and allow multiple selections at once for quickly importing or trying out combinations of customizations together.

Finally, each customization card has a *Try It* button to immediately test out the customization, and an *Import* button allowing the user to immediately copy any customization into one of their own courses (explained further below).

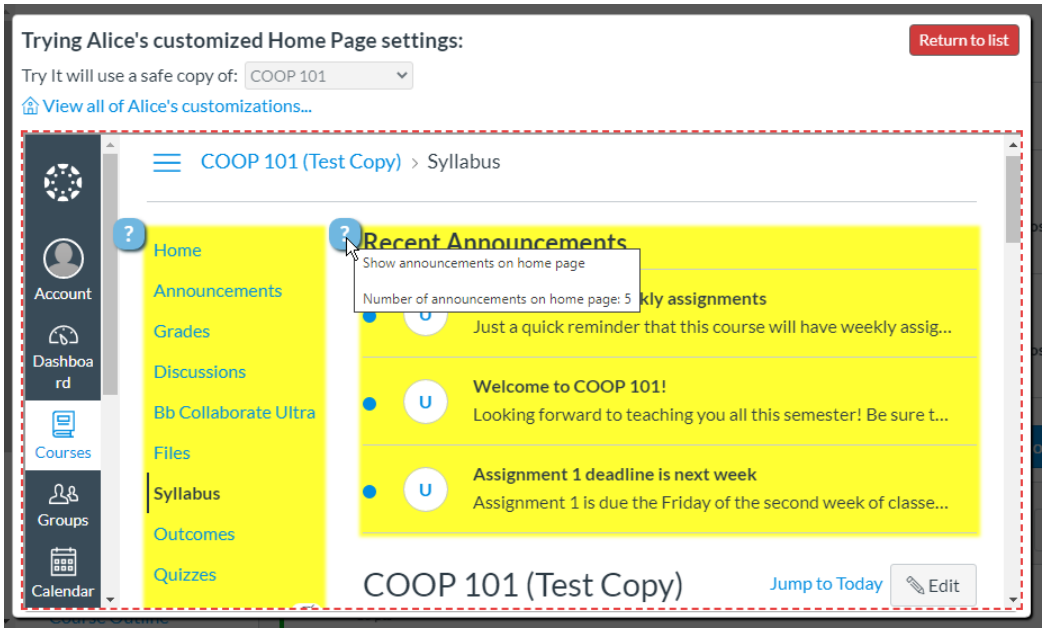

Figure 5.4: The *Try It* feature spawns an on-the-fly interactive testing copy of the user's course content, with another instructor's customizations applied to it. Those customizations are highlighted in yellow and marked with a small badge that provides more information. Here it shows a customized navigation bar and the addition of a Recent Announcements section on the Syllabus page.

5.4.2 Exploratory Interface for trying out customizations

Once the user has discovered a customization that interests them, they can import that customization directly into one of their own courses, or use Customizer's *Try It* feature (Figure 5.4) to safely experiment with the customization before they commit to making any changes.

"Try It" feature for risk-free interface exploration

Customizer implements an exploratory mode [114, 136] for the Canvas LMS by creating an on-demand "sandbox" environment in which new customizations can be experienced and experimented with safely (i.e., without the risk of making inadvertent changes to one's live courses). The exploratory interface creates a new course on-the-fly for these testing purposes, mimicking the user's existing course by copying its content and settings, and then applying the selected customizations on top. Prior to clicking *Try It* (Figure 5.1(4)), the user can select which of their courses they want to mimic, or can opt to try it in a new blank

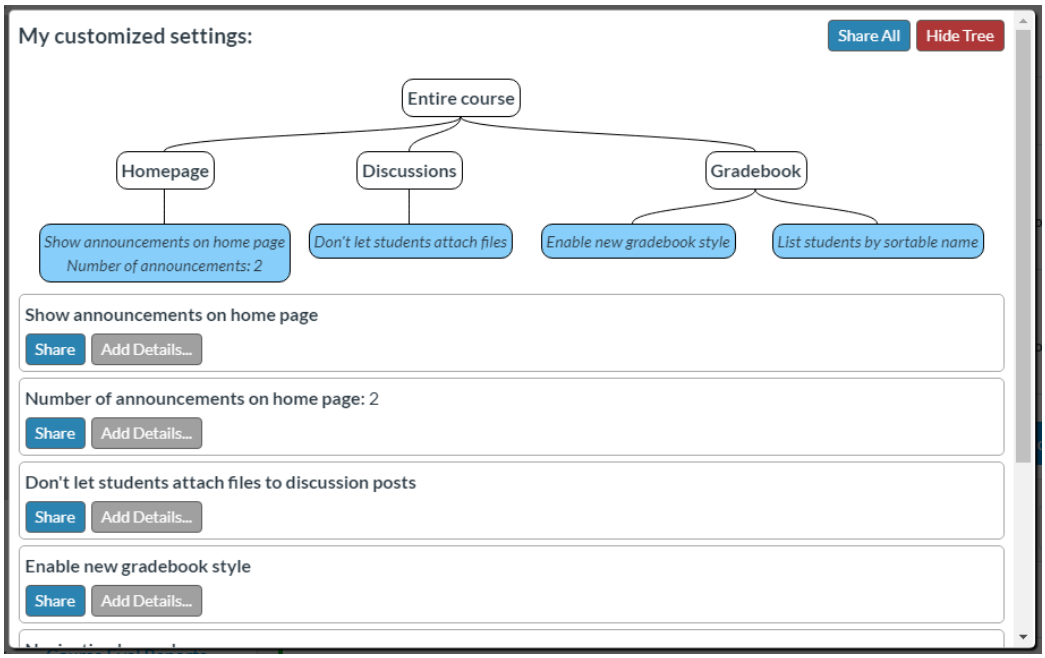

Figure 5.5: The authoring interface lets users analyze their course customizations, add explanations, and share them with others. The tree view visualizes where in the interface those customizations take effect.

course with only the default content. Within this generated sandbox course, the user is now free to make any changes they want without worrying about unintended side-effects, as the copy is entirely separate from their real courses and not linked in any way. Following DG3, Customizer highlights any page elements in the sandbox that have been altered by the active customizations, and adds a small badge indicating which customization is causing the effect.

From exploration to implementation

If the user is satisfied that the customization they have just tried will work well for their course, they can click the *Import* button to apply that customization to one of their real courses. A warning popup is first displayed to ensure that the user understands that the customization will potentially be visible to other course participants immediately, and encourages them to test it with the *Try It* feature first. In this way, users can make use of the exploratory mode to experiment with a variety of features and then keep only the ones they liked.

5.4.3 Authoring Interface for sharing customizations

For instructors who *have customized* their courses (or are in the process of doing so), an authoring interface is provided for them to (1) keep track of what features they've customized, (2) organize them into logical groups, and (3) share those customizations with others.

Analyzing a course's customizations

Customizer provides users with the ability to quickly analyze an entire course and generate an overview of what settings have been modified from the defaults (Figure 5.5). The results are displayed both as a context-sensitive list (automatically filtered by which LMS pages are affected by each customization), or as a tree visualization showing the hierarchy of different LMS components and the changes made to them.

Annotating with explanations and additional metadata

In keeping with DG4, Customizer provides a way for customization authors to attach their own free-form explanations to each customization. This creates the opportunity to provide, for instance, one's rationale for making the change or any steps necessary to create or maintain the customization. Furthermore, this enables customization authors to reflect upon the changes they have made to their courses and can serve as a future reminder of what steps were taken to arrive at their present setup or why they made certain choices. Customizer also keeps track of the most recent actions taken in Canvas and uses this information to generate template "how-to" instructions for customizations made by the user.

In addition to these explanations, two other types of metadata are attached to each customization: (1) the complexity/difficulty of a customization on a 5-point slider (selected by the user), and (2) information about which Canvas pages are affected by the customization (generated automatically).

Sharing customizations with other instructors

Users can share their customizations (or collections thereof) with their colleagues by clicking on the *Share* button attached to each individual customization or to an entire shared course.

The user may select a subset of the customization cards shown after analyzing their setup if they only want to share a part of their setup but not the full package.

5.4.4 Implementation Details

We implemented Customizer as a Google Chrome browser extension, made to work on top of the Canvas LMS. We decided to use a browser extension over other potential implementations (such as the Learning Tools Interoperability standard [94]) to facilitate fine-grained manipulations of the HTML DOM for some of our features. It is likely that our design could be adapted to other formats with some engineering effort. Each course is represented by a collection of all of the settings and structural changes that have been made to it — essentially a "diff" between the current course and a freshly-created default one. The possible settings captured in this collection comprise nearly every built-in means of changing the UI or structure of a course, short of modifying the LMS source code directly. Customizer is also able to detect and install external plugins (Canvas "apps") that add new functionality to the application.

The exploratory *Try It* interface leverages several existing Canvas features for (1) creating new "sandbox" courses for testing, (2) importing/exporting course settings and content, and (3) resetting a course back to its defaults. The generated sandbox course is displayed within an HTML iframe inside the customization dialog (see Figure 5.4).

5.5 Usability Study

To evaluate the extent to which the design of Customizer meets instructors' needs, we ran a usability study with 10 additional educators who had recently taught a course using an LMS (none had participated in the formative interviews).

5.5.1 Methodology

During our study, we collected data through a demographic pre-test questionnaire, three observed usability tasks (described in detail below), a post-task usability questionnaire, and a brief follow-up interview. Participants were encouraged to think aloud while completing the tasks. Sessions were audio-recorded and transcribed for analysis.

In addition to some basic demographic information, the pre-questionnaire asked participants about their teaching experience and their past/current use of LMS or other similar tools. The post-task usability questionnaire consisted of several 7-point Likert scale responses assessing the main features and goals of Customizer. Finally, the interview probed further into various threads such as how using Customizer compared to instructors' past course-creation experiences or their usual workflow, and how well the participant understood the "peek and try" conceptual model underlying the system.

This study protocol received ethics clearance at two universities where instructors were recruited. Participants were each given a $20 gift card in appreciation of their time.

Participants

Our 10 additional participants (3F, 7M) included a university professor, 3 post-doctoral researchers, and 6 teaching assistants who had all taught a university-level course within the past two years. All were between the ages of 19–40, with different levels of completed education (5 Bachelor's, 1 Master's, 4 PhD) and had experience teaching courses in subjects such as, Computer Science, Engineering, English, and Design. All but one of the participants had some prior experience with using Canvas, and five had also used another LMS.

Usability Tasks

Our study included three usability tasks designed to provide a broad coverage of all of Customizer's features. The first two tasks were made to be basic and advanced "consumer" tasks, respectively. Both asked participants to use the discovery and exploratory interfaces to look at other instructors' setups and decide how they should customize their own course. The third task was designed as a basic authoring task to familiarize the participant with viewing and sharing their own customizations. Each task was assigned a time limit (differing by task, see below), though if a participant reached this limit while still making progress and not overly frustrated, they were given two more minutes to try finishing the task. The content available in Customizer was bootstrapped by the research team (in consultation with other instructors) with six fictional customized setups, comprising 44 customizations (24 distinct, the rest overlapping between instructors), and ensuring that each part of the

first two tasks had one or more customized setups that were related to it. Participants were also given a brief (2-3 minute) demo before the first task to give them some basic familiarity with the Customizer interface and its available features.

Task 1 (10 minutes) described a scenario in which the participant is setting up a course and needs to model its look and feel after other instructors in their department who have shared their setups through Customizer. This was an introductory task consisting of three simple subtasks: (1) enabling/disabling some optional discussion board features, (2) changing the course homepage to show additional information about upcoming assignments and announcements, and (3) choosing one of two optional course features that enable real-time collaboration with students. The goal for participants was to compare these different Canvas features based on viewing other instructors' setups and reading their explanations, before deciding which customizations to use themselves.

Task 2 (10 minutes) presented the participants with a screenshot of two non-standard Canvas features (buttons for embedding YouTube and Wikipedia content in the page editor), and asked them to find a way to add those features to their setup. This functionality required the addition of external "apps" to the Canvas course, and would generally be challenging to figure out for a novice Canvas user. This task described a scenario where it is the middle of the school term and making untested changes to the live course setup could carry the risk of impacting students. We wanted to create an opportunity for participants to use the *Try It* feature and explore the customizations before importing them.

Task 3 (5 minutes) asked users to "pay it forward" by using Customizer to share one or more of their customizations from the prior tasks. The goal here was to encourage the participant to explore how the authoring interface works, so the task was left largely open-ended.

We iterated on the tasks several times based on pilot testing to strike a good balance between challenge, allotted time, and comprhensibility. Because participants' prior experience with Canvas varied, certain subtasks may have been more or less challenging for different participants. However, we designed all of the tasks to be sufficiently open-ended that they

would elicit exploration and decision-making rather than relying solely on knowledge of the Canvas interface.

Data Analysis

We relied on regular discussions among the research team during data collection to identify key emerging themes from the task observations and interviews. After 10 participants, we had begun to see many recurring findings rather than new insights. We then used affinity diagramming to categorize our findings and bring the key themes into better focus.

5.5.2 Findings

Contrary to expectations, participants had more overall difficulty completing Task 1 (the "basic" task) than Task 2. Only 7/10 participants completed Task 1 within the allotted time, while all participants were successful at completing the other two tasks on time. This was likely at least partly due to learning effects, as the order of tasks was not randomized. Related, most participants' approaches to completing Task 2 were not qualitatively different from Task 1 — what would ordinarily be considered an "advanced" task (installing external plugins to add new course functionality) appeared to have been made conceptually simpler through Customizer's design.

From our questionnaire results, almost all participants found Customizer easy and enjoyable to use, with only one participant (P02) indicating that it was slightly confusing. A large majority of participants indicated that they would like to try Customizer with their real courses (9/10) and in other non-educational contexts (9/10). Every participant indicated that they would likely recommend Customizer to a friend or colleague, and 7/10 participants said they would rather build a course with Customizer than without it.

Through our observations and post-task interviews, we gained many deeper insights into participants' experiences with Customizer's in-context discovery interface, the exploratory mode, and the built-in authoring system. The participants also shared their thoughts about ways Customizer could be useful in application domains other than LMSs.

In-context discovery of customizations is intuitive

Most participants were quick to rely on Customizer's in-context discovery mechanism, intentionally starting each task by navigating to a Canvas page they felt was the most likely location for it before opening the sidebar there. Notably, most participants seemed to use this contextual mechanism preferentially over the search bar for finding relevant customizations. This was particularly noticeable during the first task, where participants were seeking customizations to a few different settings in Canvas, and related customizations could be found easily in the sidebar on Canvas pages relevant to those settings (e.g., navigating to a discussion thread to find discussion-related customizations). P01 was especially happy that Customizer was fully built into the existing Canvas page:

"It's good to have something that is built-in. Most of the time I actually need to Google, I need to figure out the underlying system... Or there's always like a help button, but it brings me to a separate page... So I like the fact that [Customizer] is built-in. I don't need to go anywhere else." (P01)

Viewing shared examples provides a confidence boost

Three participants mentioned that having access to shared example customizations helped them feel more confident about making similar changes to their own course:

"If I see someone else took the time to set that up and post it [to Customizer], then it must work. So I feel like I have a little bit more confidence in that feature seeing that someone else has implemented it and wants to share it with other people." (P07)

In particular, seeing that multiple people had performed the same or similar change provided further confidence in that customization's usefulness:

"I'll import the announcements as well because I think that's useful to have, and that was common between the three profs, so that's also an indication that it has been useful for more people...it gives me more confidence... Having the number of people that recommended that [customization], it did increase my confidence." (P08)

Similarly, some participants desired to see indicators of how popular certain customizations were among all other users, to get a better sense of what the most helpful customizations

might be. Some also expressed wanting to dig further and see which customizations were the most widespread among other instructors teaching the same course subject as them.

However, two participants (P02, P03) were slightly concerned that Customizer might lower the barrier to customizing *too much*, thereby leading to instructors making changes without careful consideration of their consequences. Interestingly, part of P02's confusion had to do with the act of customization being oversimplified:

"I prefer full control... but for me it was oversimplified. I usually feel that when things are oversimplified I lose my control... It's almost like drag-and-drop, but instead of dragging, you just click on import...I kind of feel that the [customizations] provided by Customizer are just black boxes. You don't get any control for customizing them by your own needs." (P02)

How-to and rationale-based explanations are helpful

Most of the participants described finding it useful to see explanations attached to each customization: *"Reading Bob's explanations is really helpful in deciding what they [customizations] do" (P01).*

Interestingly, several participants drew a distinction between two different types of written explanations (which were not otherwise distinguished by Customizer): those which describe the author's *rationale* for a customization, and those which describe *how to use* it. Participants valued explanations of rationale for deciding whether a customization would match a desired use case, or to compare the benefits of different customizations, while how-to explanations were valued for details related to tweaking or reverting the changes.

People value the exploratory mode for many different reasons

In keeping with our original design goals, a large majority of participants found the *Try It* feature useful for risk-free exploration of customization options:

"Without [Try It], it would be kind of stressful... Because there is this sort of worry of screwing up your course and because real students are using it. And you're like, 'What if they're looking at this right now, and then I break something? ... Will I break this for people that are using this right now?'" (P10)

In particular, multiple participants appreciated the *Try It* feature as it more fully gave them the *"other instructor's perspective" (P01)* with permission to make changes and experiment. Participants found this to be an advantage over current LMS features that allow instructors to share their setup with viewing privileges only.

More surprising was the number of different use cases that participants articulated, unprompted, for the *Try It* feature. For instance, some participants described how they were using it to confirm their intuition about what exactly a given customization does, especially when the functionality was not apparent from the customization's name or explanation:

"Oh, here's one [customization]. I think this is what I want... Okay, from the description I'm not actually sure, so I'll Try It then. I think it's probably right because it showed YouTube... Ah yeah, there you go, so it's the right one to import." (P04)

Several other participants were using the exploratory mode as a visual comparison tool, to explore two or more instructors' course setups and spot any major differences:

"This one is Bob's, I see there's an assignment on the home page. So I'm clicking the Assignments one first, just because I saw Alice's announcements... Oh, Alice doesn't have announcements, she had assignments only, so I think that I'll probably just import the two from Bob." (P06)

Some of these participants expressed a desire to see new features or extensions to the prototype that would make these comparisons even easier, such as the ability to view two *Try It* windows side-by-side, or to mix and match customizations from multiple instructors in a single *Try It* environment. However, other participants wanted to perform these comparisons with something more akin to a list-style "diff" of two instructors' setups, rather than an interactive exploratory mode.

Beyond "peeking": trade-offs with over-the-shoulder learning

We asked participants to compare their experience with Customizer to other strategies they had used in the past to learn features of an LMS. Several participants described in-person demos as one of these strategies and raised the existence of a trade-off between the amount of time or coordination required and the richness of the interaction. Although over-the-shoulder demos allow for real-time, personalized Q&A sessions, it can be a hassle

to find and coordinate mutual free time. Furthermore, P07 pointed out that even in an in-person scenario, there is little room to experiment with tweaks or explore new ideas because he wouldn't want to make accidental changes to other instructors' real courses any more than he would to his own:

"If you had someone else and they just opened up their Canvas and they're like, 'This is how we did it,' you wouldn't have this environment where you could try something, or it might get published to a front-facing part of their Canvas... So, I think the sandbox feature with this [Customizer] is nice, because you have the freedom to really mess things up... then you can just exit out, and your actual courses are fine." (P07)

Sharing customizations can help oneself in the future

When using the authoring and sharing tools in Customizer (during the third task), 4/10 participants went beyond the task requirements by adding a written explanation and a complexity value to their customizations before sharing them. Several noted that in addition to helping other instructors, their annotated customizations would be especially valuable for *themselves* down the road, as a way to quickly recall what they had previously changed, and why or how.

"I guess I would even use this as a reminder for myself, to collaborate with myself because I may not use it for only one course, right? [...] So I would say my own customization also adds value to myself in the future. I can reflect for myself about 'Oh okay, this will be useful, I can do it differently if I know about this feature.'" (P04)

Customizer has potential to generalize beyond LMSs

From our post-task questionnaire, 9/10 participants agreed (5+ on a 7-point Likert scale) that they would like to use Customizer in other contexts outside of education. In the interviews, they described many different applications where Customizer could be useful. For instance, some of their examples included integrated development environments for programming, website builders, and image/video editing applications. Often they described how their typical use of these applications included tasks such as installing plugins from

a public repository, navigating lists of shared templates, or working collaboratively with shared customized layouts.

5.6 Discussion

We now step back to discuss some of the broader implications of this research and potential next steps.

5.6.1 Building in-application instructor communities

Many of our participants expressed a desire to see more community-like features within Customizer, such as user profiles and the ability to link different setups together (e.g., "See @Bob's setup for more similar ideas"). Others wanted the ability to ask questions of the customization author within the interface, or by allowing multiple instructors to explore and modify a shared course setup collaboratively. In particular, such Q&A and collaboration features could be a way to close the gap in interactivity between our design and in-person knowledge sharing, making it easier to get the benefits of over-the-shoulder interactions. Furthermore, the ability to collaboratively customize a course could be helpful in providing remote troubleshooting when things go wrong. At some schools and universities, there may also be many other people involved in course design and setup, such as instructional designers or learning experience designers. Customizer could serve as a platform to better connect these roles with instructors for communicating course standards and best practices.

Although we designed Customizer to accommodate one-on-one sharing between colleagues at the same school, we can see potential benefits to broadening the sharing mechanism to include larger communities of instructors. This could also be seen an extension of more general-purpose help-based communities (e.g., Super User [185], Social CheatSheet [200]) restricted to the domain of LMS customization for course instructors.

5.6.2 Improving relevance with personalized recommendations

Our participants appreciated the in-context retrieval of example customizations based on their navigation of the Canvas interface, and this idea could be further extended to provide more personalized recommendations of customizations. For instance, future extensions to

this idea could use information about the course topic, instructor preferences, and frequently-combined customizations to further discern which customizations an instructor is likely to consider the most helpful.

5.6.3 Customizing for oneself vs. others

Although we focused on instructors' practices in customizing their LMSs, an important consideration here is that the instructors' goals for customization are not necessarily to improve *their own* productivity or efficiency, as is often the case for other kinds of software customizations (e.g., [124]). Rather, for LMSs and many other digital classroom tools [201], the end users targeted by these customizations are *students* whose user experience may be greatly affected by the changes made.

It is also the case in Canvas (as in many LMSs) that students have many customizable options of their own to change the features of their LMS interface. It could be fruitful to study how students perceive the course customizations their instructors work so hard to set up, and what might influence their own decision to customize (or not) within educational applications.

5.6.4 Incentives for sharing customizations

Our usability study of Customizer focused on understanding how instructors discover and explore potential customizations, with a smaller focus on the authoring and sharing mechanisms. It is well-known from past research that most people are far less willing to author and publish content than they are to consume it [163], which raises the question of whether a system like Customizer could be sustained by only a small number of content creators. However, past research has shown that communities of educators often rely primarily on a small handful of tech-savvy colleagues for much of their tech support and troubleshooting needs [201], who would perhaps be willing to take the lead on these authoring tasks. Not only would this be beneficial to all of the instructors who have access to their knowledge base of example courses, but it could also help to reduce some of the burden facing these "tech support hubs" by offloading some of their ongoing support roles to Customizer. Future

work could investigate the possibility of providing additional incentives for instructors to share their customized setups as examples for others.

5.6.5 Example-based customization in other contexts

We heard many different possibilities from participants about how Customizer's reach could be extended to improve their workflows in applications other than their LMS. We believe that the general idea of discovering, exploring, and authoring customizations within an application UI can be extended to other applications with some engineering and design efforts. A key challenge would be enumerating and representing the varied possibilities for customizing different applications. Nonetheless, our studies suggest there could be substantial benefits in making customization examples more easily discoverable and explorable within the context of other applications.

5.6.6 Limitations

Our in-lab task-based usability study provided a useful window into how instructors perceive example-based customization sharing in limited settings, but it provides few insights into their real-world usage of such a system. To fully understand how it might change instructors' behaviour, Customizer needs to be explored through a larger-scale longitudinal deployment. Furthermore, our Customizer prototype was only implemented and tested on top of one widely-used LMS. While different LMSs share a core set of similar features (e.g., assignment submission, gradebook mechanisms, communication features, online quizzes), there may be large differences in the set of customizations available for altering those features and the degree of freedom afforded to instructors. Though the design is generalizable, some additional work would be needed to migrate the implementation beyond the Canvas environment.

5.7 Conclusion

In this chapter, we have introduced the concept of in-context example-based customization sharing and designed the Customizer system to realize it within an LMS. With Customizer, instructors can quickly discover relevant customizations for their LMS and interactively explore them in the context of their own courses. Our studies with instructors have yielded

important insights into the potential benefits of peeking at and experimenting with other instructors' LMS setups.

Chapter 6

Uncovering Instructors' Diverse Practices and Perceptions: A Field Deployment of a Customization-Sharing Platform that Supports Course Management

My usability study demonstrated that there was strong potential for Customizer to impact how educators approach software customization, and indicated the soundness of the design as a whole. Although we had gained promising insights, it remained unclear whether instructors' enthusiasm for the concept would persist in more realistic scenarios where they had access to Customizer during their day-to-day workflows over a longer period of time. Since lab-based usability studies could not easily probe these real-world situations, I opted to conduct an in-situ deployment study[1] examining how instructors used Customizer on their own time over two weeks. This study aimed to provide a more ecologically valid perspective on how instructors might integrate example-based customization-sharing features into their workflows.

6.1 Introduction

Educators are known to have wide-ranging software needs and often have to spend time *customizing* their classroom software to adapt to the unique demands of their subject, grade

[1]Portions of this chapter were originally published in Vermette, Ramesh, McGrenere, and Chilana (2022). *Uncovering Instructors' Diverse Practices and Perceptions: A Field Deployment of a Customization-Sharing Platform that Supports Course Management.* Proceedings of the 2022 CHI Conference on Human Factors in Computing Systems (CHI '22). [203].

levels, teaching methods, and student needs [201]. For example, instructors may customize the look-and-feel of their user interface (UI) in a way that differs from the default settings, or may integrate different add-ons into their software to extend its functionality. However, for many of the feature-rich applications that are commonly used by instructors, it can be difficult and time-consuming to understand all the different ways to customize their UIs [27]. This problem is particularly acute when considering applications like learning management systems (LMSs) that are deeply integrated into a variety of teaching activities and workflows, and which force new instructors to confront the problem of starting with a "blank slate."

To address these challenges, instructors often seek help from other instructors who can share their experiences, materials, and useful customizations [201]. While some existing tools (e.g., [100, 101]) offer mechanisms to share course materials, this content sharing alone is not enough — instructors still need help with customizing different software features. Similarly, online venues like question-and-answer (Q&A) forums can help, but getting timely and relevant answers can be challenging, especially for unique use cases that are difficult to convey through a forum [166]. Instead, instructors commonly prefer to seek help directly from their colleagues [201], often via over-the-shoulder learning approaches [194]. However, finding shared time in each other's busy schedules isn't always possible, and without active support it can be difficult for instructors to replicate a colleague's customizations in their own contexts. Compounding this, the massive shift to remote teaching during the COVID-19 pandemic has served to introduce additional barriers to seeking technical help from peers. In light of all these constraints, it is difficult for instructors to make necessary and valuable customizations to their courses in a way that meshes with their existing workflows and does not add too much overhead to their jobs.

Unlike in other domains where forms of software customization have been studied (e.g., workspace tailoring [40], accessibility [65]), instructors are not the only intended target of their own software customizations, as they must also make changes that impact their *students'* learning experiences. Instructors must therefore consider several domain-specific nuances when customizing their classroom software, such as students' data privacy and accessibility needs. Accordingly, it is not surprising that many instructors are hesitant to tinker with

and customize their software in the first place [105, 153, 201]. Although some systems for sharing customizations between instructors have been assessed in lab settings [202], it can be challenging to obtain realistic insights into users' customization practices within these limited short-term sessions [8]. As a result, there is not yet a clear understanding of how domain experts, including instructors, actually harness these tools as part of their complex everyday workflows and contexts. Instructors' unique needs and situations in customizing their software present an opportunity to more deeply understand how a novel in-context customization sharing approach might alleviate domain-specific challenges with software learnability.

In this chapter, we investigate the nuances of how instructors might use an example-based customization sharing platform in the course of their regular teaching duties. We implemented a deployment-ready version of *Customizer*, an in-context platform where instructors can discover and experiment with shared customizations within their LMS [202]. Customizer enables instructors to "peek" at example customizations shared from their colleagues' LMS courses and safely explore how those changes might fit into their own courses. We extended Customizer's design with additional social features to evaluate how instructors would use it on the job as a means to answer a key research question relating to instructors' customization sharing:

> *How do instructors of varied backgrounds incorporate example-based customization sharing features (i.e., peeking, trying, importing, authoring) into their day-to-day course management workflows? What variations exist in how they apply and perceive these features?*

Adopting a case study approach [208], we conducted a two-week field deployment of our extended Customizer tool with 10 post-secondary instructors at a large North American university. Through this study, we collected in-depth insights into instructors' workflows and their usage behavior, perceptions, and experiences, to explore the phenomenon of in-context customization sharing among instructors. We aimed to understand the nuances of their behavior and assess the strengths and weaknesses of incorporating customization sharing into their approaches to course management.

Promisingly, every instructor in our study indicated that the example-based customization sharing concept was helpful as it allowed them to discover potential improvements to their courses. Our findings further reveal that instructors are willing and able to leverage such sharing in a variety of ways, including improving their feature awareness through serendipitous learning, gaining self-sufficiency in how they learn about their LMS, and overcoming their hesitancy to test new features (which has been identified as a key barrier in past work [201, 209]). Importantly, many instructors described how Customizer's authoring features streamlined their approaches to knowledge-sharing with their colleagues.

The primary contribution in this chapter is a collection of rich empirical insights into how instructors with different teaching expertise and technical backgrounds perceive and interact with an in-application example-based customization sharing ecosystem. These insights extend past research on customization sharing in other domains [79, 123], further emphasizing the value in understanding the complex interplay of expertise, work practices, and social perceptions that drive how customization sharing ecosystems impact people. We also demonstrate the practical usefulness of an *exploratory mode* [136], which provides a safe and collaborative middle ground between trial-and-error and external help resources, to support instructors' broad range of customization needs. Additionally, this chapter's secondary contribution is an extension to the original design of Customizer that enabled a real-world investigation of our research question.

6.2 Related Work

This work builds upon research into how instructors use and learn classroom software, how instructors and other users customize their software, and current approaches for sharing customizations.

6.2.1 Instructors' approaches to learning and using classroom software

A wide range of research has examined software use in both K-12 and post-secondary classrooms, documenting the many factors that influence educators' decisions to adopt and use educational technology, including their level of technology experience [66] and computer self-efficacy [48]. However, instructors routinely face barriers such as a lack of time to learn

new technologies and scarce institutional support for this process [5, 71, 201]. In light of these challenges, some researchers have highlighted the importance of better understanding instructors' diverse needs and attitudes surrounding the use of LMSs and other educational software in order to deliver appropriate support [56, 132].

One way that educators commonly support each other is through *communities of practice* [205] for sharing software knowledge and tips among colleagues [165, 201]. For educators, these communities often form around informal face-to-face communication [201] and varieties of over-the-shoulder learning [194, 202], but they may be more challenging to maintain in remote-work environments [42].

Much work has likewise explored the design of software for classroom use, though largely with a focus on student usage and with comparatively little research seeking to improve *instructors'* software experiences [73]. Notably, An et al. propose a broader framework to support the design of "teaching augmentation" tools [4], such as those that provide educators with new personalizable hardware or software capabilities to rely on during their teaching routines (e.g., [2]).

Our work adds new knowledge about how using an in-application software extension that connects instructors and their colleagues into a community for sharing *software customizations* might alleviate some of instructors' on-the-job software learning challenges.

6.2.2 How instructors and others customize their software

Several works have investigated different facets of how users customize their software, examining how different types of customizations (e.g., which features are available vs. changing the look of an interface [130, 152], and content changes [18]) and their varying levels of complexity [10, 78] can influence how users approach them. Moreover, users' decisions to customize are influenced by a wide variety of intrinsic and extrinsic motivational factors [124, 128]. Instructors, in particular, rely on a wide range of UI and content customizations, with motivations ranging from personal productivity to accommodating student learning disabilities. Instructors vary in how proactively they seek out and implement these customizations [201].

Some research has explored anchoring customizable settings to the interface elements they modify, in lieu of a centralized settings panel [162]. Importantly, Banovic et al. point

out the challenge of examining customization behaviors in short-term lab studies where participants may feel little motivation to customize without any long-term benefits [8].

A widespread theme in customization research is that many users are hesitant to customize their software at all [123, 136, 201]. One proposed means to overcome this barrier is for interfaces to incorporate an *exploratory mode* that allows the user to freely make changes and learn about the effects of potential customizations without any lasting consequences [114, 136, 202]. Additionally, information about why [20] or where [49, 162] a customization is useful can help users to understand and make effective use of it. There is further evidence that software customization can reflect and influence one's sense of control or identity [128].

While my research in prior chapters examined how instructors customize their software in educational contexts [201, 202], there remain gaps in our understanding of how to best support instructors' nuanced customization needs, especially amid their busy workflows and student-focused engagements.

6.2.3 Sharing customizations and learning by example

While software users may discover useful customizations through incidental learning [51] or trial-and-error, it is also common for users to share application-specific customizations with each other [123]. Haraty et al. provide insights into how online *customization sharing ecosystems* function for users to share and publish their customizations in specific domains like game modding and productivity tools [79]. In contrast, our work examines an *in-application* customization sharing mechanism that is tailor-made for the unique needs of instructors.

The domain-specific nature of educators' customization sharing bears some similarity to other expert domains such as software development, where researchers have built tools to foster customization sharing in the form of IDE plugins [41] and IDE workspace layouts [12]. More generally, some work has also explored benefits of sharing example code snippets between developers [13] or harnessing online code examples [81] for learning and proficiency. However, unlike most software developers, instructors do not necessarily have a formal technical background to rely on, which can put software customization further out of reach for many of them. Instead, some instructors have shown interest in mechanisms that may allow them to borrow examples of customizations from more experienced or tech-savvy

colleagues [202]. In this chapter, we extend upon these prior designs to examine how the availability of an in-application customization sharing ecosystem can realistically impact their workflows for building and managing their courses.

6.3 Extending the design of Customizer

To study how instructors make use of example-based customization sharing in the field, we opted to build upon the *Customizer* platform [202]. It is the only prior work to our knowledge that facilitates customization sharing for instructors. It has features that enable both discovery and experimentation with example customizations shared by others, and it also supports sharing one's own customizations. Here we give a summary of Customizer's original features and the extensions we made so that instructors could use it in the context of their own courses during our field deployment.

6.3.1 Original Customizer system

Customizer is implemented as a browser extension that inserts a collapsible sidebar (original in Fig. 5.3, extended version in Fig. 6.1) into pages of the widely-used Canvas LMS [97]. This sidebar provides context-aware recommendations of customizations relevant to the current page. Users can expand a customization to see the original author's rationale behind it as well as information about what parts of the LMS it affects. Importantly, Customizer also provides an "exploratory mode" [136] via its *Try It* feature, in which the user can interactively try out one or more shared customizations within a safe environment that mimics their real course. This enables them to experiment risk-free with any new features or customizations that interest them. The customizations that can be viewed and tried this way range from fairly basic changes affecting course navigation or content presentation, to more advanced customizations such as installing Learning Tools Interoperability (LTI) apps that add new functionality to the LMS. While Try It does not copy any student data (e.g., enrollments and grades) from the original course, instructors may still experiment with many grading-related changes using the built-in "Test Student" (essentially a pretend student enrolled), which is included with every course by default.

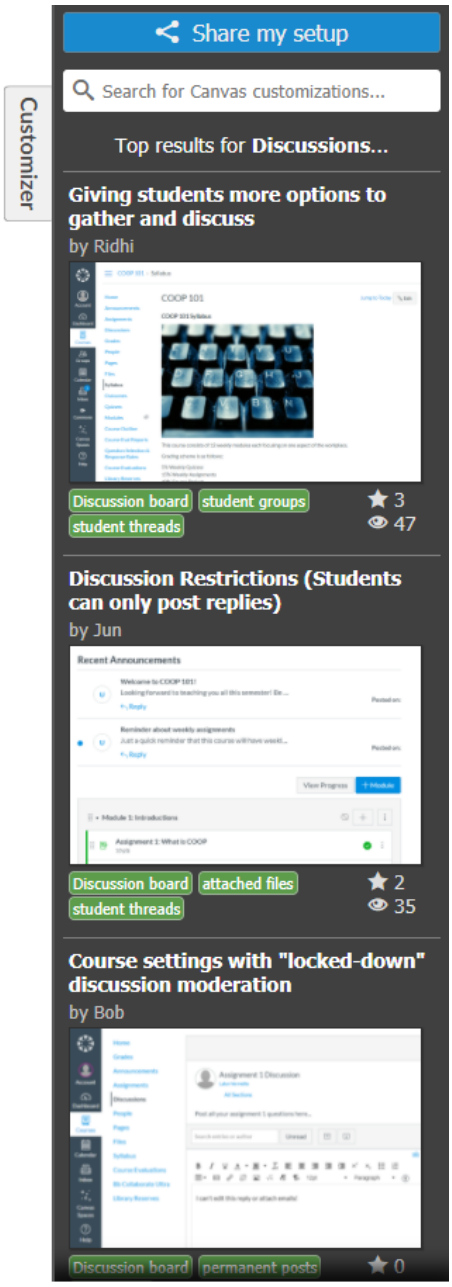

Figure 6.1: The Customizer sidebar, recommending a list of shared customizations on the Discussion Board page in Canvas. Instructors can click any of these items to open more details (such as the author's full written rationale) in a larger dialog. By clicking the blue button at the top, instructors can analyze and share customizations from their own courses.

Customizer includes an authoring interface that can automatically analyze any of the user's current Canvas courses to generate a list of their customizations (e.g., settings, UI changes). For example, Customizer could detect that an instructor had configured their homepage to show recent announcements and upcoming assignments, had set certain course pages to be student-editable, or had installed a course plugin to more easily embed videos. Instructors can review all of their past changes, write in rationale for each of their customizations, and share these customizations with others who can then view, try, and import them.

6.3.2 New extensions to Customizer's design

We describe the larger-scale changes we performed to make the system more amenable to long-term field usage scenarios within instructors' own environments. The majority of these changes were intended to enable this in-situ investigation of our main research question and provide the necessary social interactions, building upon key design implications about scaling the example-based sharing approach identified in prior work [202].

Adding community-based social features

To allow instructors to interact and support one another, we attached a Q&A thread to each individual customization for further discussion at this focused level of granularity, such as to ask or provide clarification (Fig. 6.2). To facilitate the larger corpus of shared customizations planned for the deployment, we also allowed authors to "tag" customizations with keywords to improve the relevance of recommendations, and added a "My Favorites" collection where instructors can bookmark useful customizations for later. Each customization was also augmented with indicators for the number of times it had been viewed, favorited, or imported by instructors, to provide a sense of which customizations are most popular with colleagues or perhaps worth exploring further.

Further encouraging discovery and exploration of unfamiliar LMS features

Not every possible customization to Canvas "in the wild" is amenable to Customizer's automatic course analysis or Try It environments. Thus, we included a facility for showing

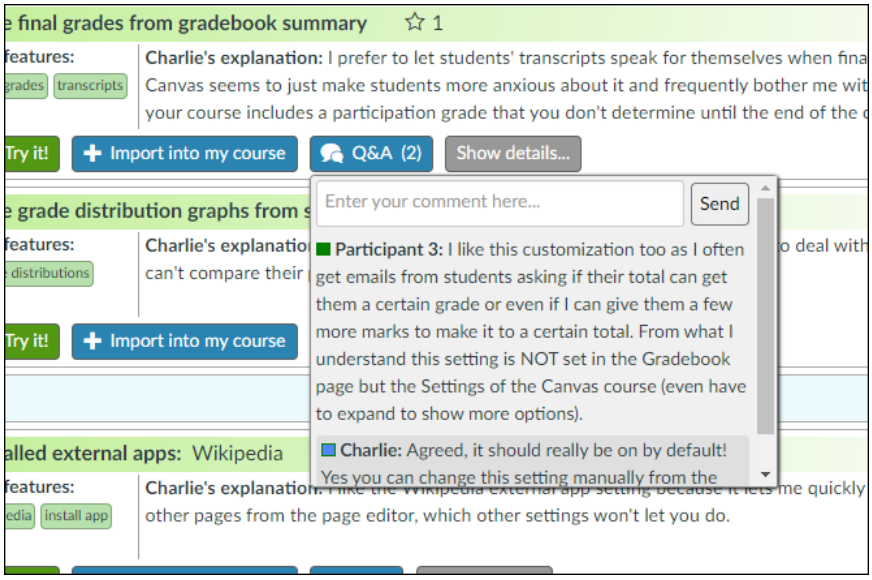

Figure 6.2: The new Q&A thread attached to a customization, showing a comment left by one of the participants.

customization tips that simply link to useful features in Canvas that instructors can explore further. These tips still include the author's explanation and rationale, allowing Customizer serve as a directory of shared knowledge even in cases that lie beyond the capabilities of its implementation (e.g., for more complex external tool integrations), enabling instructors to share and discover a wider variety of content than would otherwise be possible.

Since instructors regularly have to customize student-facing aspects of the LMS, we also integrated the Try It feature with Canvas' built-in *Student View* mode, which previews how a course will appear to students by letting the instructor become the "Test Student" temporarily. For any customizations that are compatible with the Try It feature and primarily alter the *student* perspective (rather than instructors' own interface), Customizer will automatically open the exploratory mode with Student View enabled so that instructors can more clearly see how the changes might impact students. They can then leave or re-enter Student View as needed.

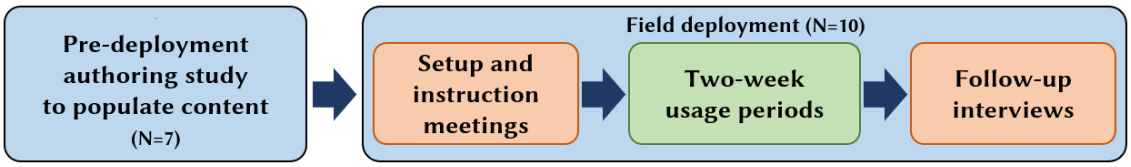

Figure 6.3: Overview of our multi-step field study method.

6.4 Method: Field study of example-based customization sharing

We conducted a field deployment using our extended version of Customizer, taking a case study approach [208] and observing individual interactions with the system. Our goal was to examine different ways instructors could make use of example-based customization sharing in their day-to-day course management workflows. Accordingly, a large North American university offering a range of subjects to undergraduate and graduate students served as our research site. We deployed Customizer to 10 instructors to use it on their own time for two weeks. In preparation for this deployment, we first populated Customizer with real-world content by conducting a study of Customizer's authoring tools with 7 people in teaching roles (see Fig. 6.3).

6.4.1 Pre-deployment authoring study to populate Customizer

Customizer's design is meant to rely on a community of instructors sharing details and explanations about how they have customized their LMS. To attain more ecologically valid results for our deployment, we pre-populated the system with 46 customizations authored by 7 people (1 professor and 6 teaching assistants) who had prior experience using the Canvas LMS.

During individual one-hour video calls, each of these 7 participants installed the Customizer browser extension on their machines, and were asked to complete a series of course customization tasks in a Canvas course provided by the research team. Their screens and think-aloud audio were captured with permission. The six tasks were open-ended, giving the freedom to complete each task in various ways depending on what settings or features they preferred or were familiar with. For example, one task provided participants with a short

list of freely-available Canvas plugins (LTI apps) and asked them to choose one or more to add to the course and try to use. Another task encouraged participants to visit a real course they had taught in Canvas, use Customizer's automatic course analysis to view a list of any customizations made to it, and share one or more of those customizations if they were comfortable doing so.

Each task prompted participants to include a brief written explanation describing their customizations and why other instructors might find them useful. Since the main goal of this authoring study was to have the participants populate Customizer with content, they were allowed to search online or ask the researchers for guidance if they were stuck on any of the tasks, so long as they independently chose and explained the customizations in their own words. After finishing the tasks (or after 55 minutes), participants were asked to complete a questionnaire rating the usability of Customizer's authoring tools. They were offered a $20 gift card in gratitude for their participation.

The 46 customizations produced by participants also included 42 of their written explanations (some participants provided a single explanation for a group of two or more closely-related customizations). One research team member later made minor edits to some of these explanations to correct spelling/grammar errors, remove personal identifiers, and create a pseudonym for each author. To supplement the authored customizations, two members of the research team shared 35 additional customizations of their own into the system, for a total of 81 customizations.

6.4.2 Two-week field deployment methodology

After populating content in Customizer, we began recruiting instructors to take part in the two-week field deployment. We conducted this recruitment by posting to teaching-focused mailing lists and discussion boards at a single university, as well as via word-of-mouth.

We asked each participant to complete a questionnaire about demographics and their existing perceptions of the Canvas LMS as an instructor. The lead researcher then held a 20-30 minute video call with each participant to guide them through installing the Customizer extension, show a brief demo of Customizer's main features, and provide instructions for the next two weeks.

Recognizing that not every participant had an ongoing course with imminent customization needs during the two weeks of the study, we provided each participant with access to a separate temporary Canvas course where they could make changes if needed. A different temporary course was provided to each individual participant, and these were otherwise only accessible to the research team. Furthermore, to provide participants with some motivation to customize, we prepared seven suggested tasks that involved performing customizations in a Canvas course. These were largely open-ended and encouraged participants to explore different options for customizing certain areas of the LMS, allowing them to individually decide when they were satisfied with the result of their efforts. For example, one task suggested that they explore some ways to customize the Canvas discussion board (a built-in forum) to simplify moderation or encourage student participation. The final task also encouraged participants to analyze and share any of their own customizations through Customizer.

Our instructions asked participants to treat the tasks as though they were part of an overarching scenario in which their department is asking them to set up online components for a course they would be teaching next term. The tasks served mainly as prompts, giving instructors opportunities for customizing within this scenario, since not all participants were teaching during the term when the deployment took place. Consequently, task completion was not formally measured. Additionally, all participants had the option of freely using Customizer with any courses they were currently teaching or had taught in the past.

Immediately following their first video call, we emailed each participant a document containing the first four customization tasks, which began their two-week usage period. After one week, the remaining three customization tasks were emailed in a separate document, though participants could request these earlier if they had already completed the first week's tasks. Throughout these two weeks, we collected automated usage logs describing how participants were interacting with Customizer. Participants also had access to a short feedback form where they could provide details about their recent Customizer usage and how they felt about it. We sent reminder emails to participants 2-3 times per week, encouraging them to complete the tasks and to respond to the feedback survey. We did recognize that instructors' busy schedules may limit how regularly they could find the time to complete

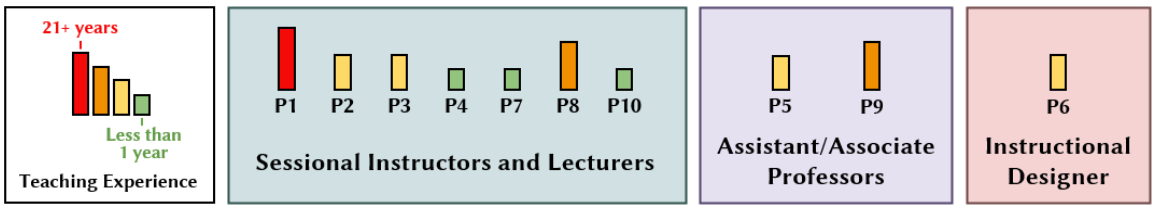

Figure 6.4: The roles and teaching experience of the 10 deployment participants

these steps. Due to scheduling constraints, the participants' individual two-week usage periods were staggered over three months rather than held simultaneously.

After their two-week usage period ended, each participant completed a questionnaire about their perceptions of Customizer, then returned for a semi-structured follow-up interview (via a second video call). We asked them to reflect on their existing Canvas workflows and how they had made use of Customizer's in-context customization sharing features within these workflows. Other questions probed into their thought processes and mental models around exploring and authoring shared customizations, asking about potential advantages and drawbacks of having these features available, and invited participants to envision how they might use an example-based customization sharing platform in the long term assuming it were actively used by many instructors at their school.

In appreciation of their time, participants were given the option of either (a) receiving a $50 gift card or (b) receiving one hour of Canvas tech support and consulting from the lead researcher at any point in the following four months. Two participants chose the latter option.

Deployment participants

As shown in Fig. 6.4, the ten participants (6F, 4M) represented a variety of different roles and levels of teaching experience. They ranged in age from 19-60 and taught across several different subject areas, including Computer Science, UX, Game Design, Business, Marketing, Writing, and Education. All participants were instructors at a single post-secondary institution who were either currently teaching (P3, P5, P7, P10) or had previously taught (P1, P2, P4, P6, P8, P9) a course that made use of the Canvas LMS, which is in widespread use at their institution. These participants taught courses with a range of student enrollments (10–50

for graduate courses, 50–300 for undergraduate). Every participant had taught a course using Canvas within the past year, with the single exception of P6, an instructional designer who regularly teaches Canvas workshops and offers consulting to other instructors building their courses. Despite being from the same institution, the participants in the study did not necessarily know each other, and were only identified in Customizer by their participant IDs, not their real names.

Data analysis

From our questionnaires and automated usage logs, we tallied up participants' sentiments about the usefulness of different aspects of Customizer, and the degree to which they had used particular features during their usage sessions. We were able to cross-reference some of their usage data with their feedback surveys and interview responses to gain a clearer understanding of what each participant was trying to accomplish during each usage session. We transcribed the audio from our post-deployment interviews, and adopted a thematic analysis approach to analyze our data [14]. Two researchers open-coded the interview transcripts as they became available, to extract participants' sentiments and perceptions, and had regular discussions with the full research team to discuss the evolving themes. This was interspersed with affinity diagramming to cluster our emerging findings and surface the key themes. Although each participant had unique perspectives and insights to offer, we found that many of the themes were recurring as we approached 10 participants.

6.5 Overall usage and perceptions of example-based customization sharing

To present our findings from the deployment study, we begin by describing overall statistics of how participants interacted with the customization sharing features. We highlight several key variations in how individual participants approached these features, as well as their differing views on the usefulness of these features. In later sections, we explore how participants felt customization sharing would fit into their course-building and help-sharing workflows.

Table 6.1: Usage statistics for the major features of Customizer during participants' two-week usage periods

Feature	Total uses (all 10 participants)	Median uses
Opening a set of shared customizations	310	31.5
Opening "More details" for a customization	63	5.5
Entering a search query	62	5
Using Try It (exploratory mode)	112	11
Importing a customization	56	6
Opening the Q&A for a customization	35	2
Sharing one or more customizations	7	0

6.5.1 Overall usage of Customizer

Every participant used Customizer during their two-week usage period, though there were differences in usage patterns between individuals. Each participant had on average 4.6 usage sessions in which they actively interacted with Customizer (at a minimum this involved clicking on or searching for a customization), with at least 10 minutes of inactivity in between sessions. On average, participants spent 19.9 minutes in each usage session, ranging in length from 59 seconds to 80 minutes. Five participants spread their usage out across 3 or more days, while the remaining five only used Customizer on 1 or 2 days. Two participants in the latter group (P9 and P10) used Customizer only during a 1–2 hour window on their final day.

Table 6.1 provides a breakdown of the usage of Customizer's main features across all participants.

6.5.2 Overall usability and usefulness of Customizer

Participants largely found Customizer easy and enjoyable to use, though two participants (P2 and P8) also found it to be slightly confusing. Most participants indicated that they would like to use Customizer for building their future courses (all but P3 and P8), or sharing their own customizations (all but P7), and would recommend Customizer to other instructors (only P8 felt neutral on this). Overall, participants found Customizer to be useful along multiple different dimensions summarized in Fig. 6.5.

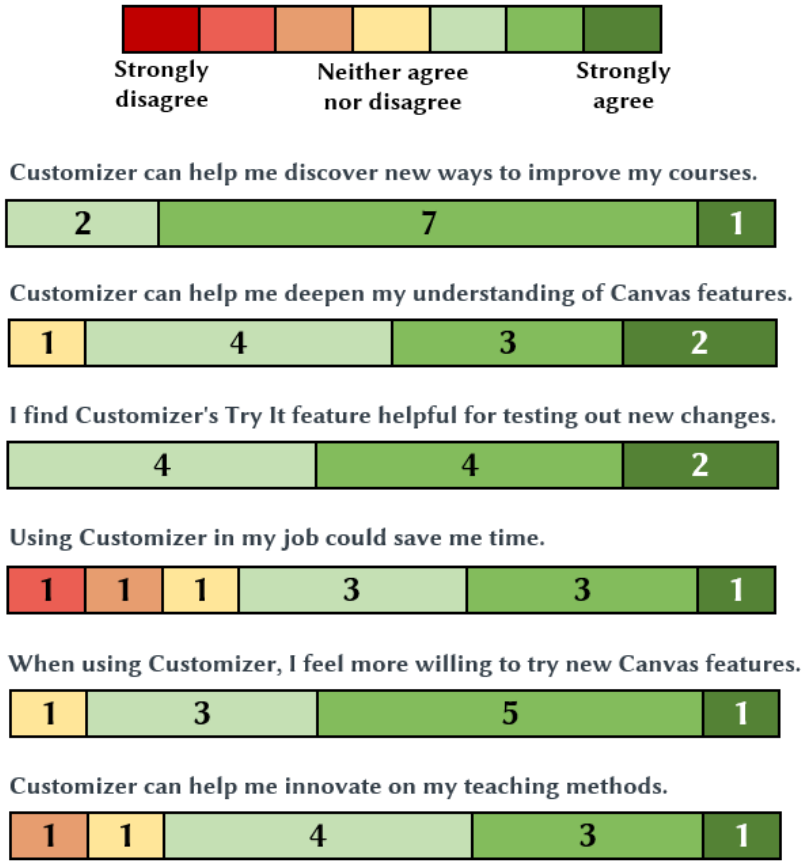

Figure 6.5: Questionnaire results for several aspects of Customizer's usefulness to participants (7-point Likert scale) (N=10).

Participants' opinions varied on how Customizer compared to existing modes of online help. While online guides and forums are resources that instructors frequently turn to for help [166]), several participants noted how Customizer serves a complementary role to these resources. P5 saw a clear difference in how she might use the two: *"I don't have the time to just go, you know, just read [external] tutorials for fun. So it's like an as-needed basis when you're trying to find solutions. [...] But here I like the fact that I could just explore things on the side and like, open it up and see what other people have available, not just what I need to do or what I might have searched based on my previous experiences or biases." (P5)*

Similarly, P7 described how, compared to official guides and Q&A resources, Customizer's sharing model was better equipped to help her encounter new ideas and gain confidence: *"There are some websites like [Canvas] Community, but it's not a systematic manual. [...] Currently I think I'm doing my Canvas page well, but again, I don't know if there is a better way. From [Customizer], I can see how other instructors use Canvas [...] and sometimes they list their experience about 'after I do this what results will I achieve?' So I think this type of thing gives me more confidence that if I adopt that customization, I can also have that result." (P7)*

P3 felt that Customizer's presence within the LMS and in-context recommendations could serve to improve novice users' feature awareness: *"The good thing about Customizer — and I think the person who's using Customizer really needs to know — is that it's very contextual. So if you are on the homepage, for example, then the things that Customizer actually has populated are in relation to what they're seeing right now. So for a newcomer I think it's very good to use Customizer to know what's out there." (P3)*

This feeling of improved feature awareness was widespread among the participants — before the deployment, only two people (P6 and P7) indicated that they felt aware of what Canvas features their colleagues are using, but after using Customizer, every participant agreed or slightly agreed that they had increased this awareness. Moreover, all but one participant (P8) indicated that Customizer made it easier to leverage their colleagues' experience with Canvas. P8, an experienced Canvas user, felt that Customizer could be

improved in this respect by providing "more transparency about the lower level changes" that a colleague's shared customizations will make to her course when imported.

In the remaining findings, we provide further insight into how participants integrated customization sharing into their on-the-job workflows and their main considerations for authoring and sharing example customizations.

6.6 How example-based customization sharing influenced instructors' workflows

We begin by summarizing our participants' current diverse workflows for building and customizing their Canvas courses, especially when teaching remotely (Section 6.6.1). This provides context for how the presence of a customization sharing platform influenced them. Then we describe the variety of different ways participants reported that example-based customization sharing tools could fit into their workflows in the long term (Sections 6.6.2 - 6.6.5). Finally, we provide some additional context for how participants' expertise with Canvas influenced their intended uses for Customizer and how they perceived the discoverability of content aimed at either novices or experts (Section 6.6.6).

6.6.1 Instructors had diverse approaches to course management in remote learning contexts

With the shift to online teaching due to the COVID-19 pandemic, instructors faced an upheaval of their usual teaching workflows, and in many cases were forced to adapt to new methods and tools on short notice. To better understand how this process affected different people, we asked participants how the switch to online teaching had affected their use of classroom software and their approach to LMSs as a hub for their course materials and student interactions.

Two instructors (P9, P10) who had usually used Canvas only minimally (e.g., to post grades) both noted that the shift to online teaching caused them to rely on it more than before, mainly due to the need to stream their lectures through it. However, they otherwise relied on a different website or LMS as the main hub for their courses. Two others (P1, P2) who had split their course materials or activities more evenly across two or more platforms

both felt that the shift online had been a less substantial hurdle for them than for others, due to having many online teaching tools already set up or finding online course delivery easier than in-person.

The remaining instructors (aside from the instructional designer P6) relied on Canvas for the majority of their course communication and activities. While some of these instructors taught their first courses during the pandemic, they all described additional hurdles brought on by the need to learn unfamiliar LMS features, reconfigure their course settings (e.g., to enable online exams), and ease the transition for students. P7, for instance, lamented the difficulty her students now face in connecting with their group members in online settings, so she had to learn how to include additional opportunities for students to communicate and collaborate through the LMS.

6.6.2 Providing a safe environment to test out new features

Our deployment study revealed wide diversity in how the Try It feature could impact instructors' workflows in their usual contexts. While the possibility of an exploratory mode has been suggested in prior work [114, 136] and has seen some preliminary evaluation in lab settings [202], we sought to determine how instructors could use and perceive this feature during their routine software usage and tasks. Notably, in our questionnaire, all ten participants agreed to some extent that the Try It feature was helpful, and their interview responses highlight several reasons why they felt this way.

Try It streamlines existing workflows for testing changes.

Two participants (P2 and P8) described how their usual usage of Canvas entails creating "sandbox" courses separate from their real ones. In P2's case, these courses serve as a preliminary staging ground where he constructs parts of his courses before copying and publishing them to students. Consequently, he appreciated Try It enabling him to more directly see any changes in his existing course: *"I find [Try It] very helpful actually, so I would try everything. [...] I can see how [a customization] would apply, and how it would change what I have, and if I want that incorporated in my course or not." (P2)*

For P8, sandbox courses already serve as a testbed for experimenting with any changes she needs to make to her course, ensuring that they work as expected and do not have unintended effects. As a result, the exploratory mode served to streamline her existing process: *"It's good to be able to try things out without affecting your course. That's what I have to do when I try to change something in my courses myself anyway, if I have to set something up that's hidden from students [...] and see how it affects things before I release that change later on." (P8)*

Try It helps to overcome customization hesitancy

For several other participants, the Try It feature made them feel less hesitant to experiment with customizing their courses or more confident in doing so. For instance, P7 compared it to mechanisms for previewing changes to her blog before making them public, highlighting how it works around her usual reluctance to customize: *"If I import [a customization], it will make a real change. And actually that's scary. I don't know what it will look like, and what will be affected in my course. And every student can see that. [...] My first time using Try It, it was so useful. It helped me to preview and gain confidence if I should adopt this customization or not." (P7)*

6.6.3 Supporting self-sufficiency in learning and customizing the LMS

Several participants felt that the ready-to-adopt availability of shared example customizations afforded them greater self-sufficiency and the ability to self-direct their learning, incurring fewer social costs than asking someone for help directly: *"I think a major advantage is you can learn entirely by yourself. You do not have to rely on anyone. And especially for someone who is introverted like me, [...] we normally need to [make an] effort to seek help. But with Customizer there are no concerns about being rejected by someone who rejects [providing] you help." (P7)*

Additionally, the ability to actualize off-hand tips from other instructors and test out whether they make sense in one's own contexts allowed participants to explore ideas further on their own: *"[A colleague] just briefly told me 'Oh this is how I did it [automatic grade weighting]'. So I knew it existed but I didn't know the details. But Customizer gave me the*

opportunity to try things out and look it up at my own pace. [...] The person that I was talking to, they might not have time, or I might have just heard it from a talk and didn't have the chance to actually try it out and see if it works for me." (P3)

P6, an instructional designer, described how she regularly consulted with instructors who were reluctant to customize. She felt that Customizer's support for more self-sufficient learning processes could help to alleviate this: *"It's giving instructors more opportunities to try things out in a way that they might feel more comfortable doing. Like if they want to make a change, [...] they probably end up coming to us so that we can do the testing and reassure them. [...] I think ultimately what we need is to get people the confidence to do things on their own. Just meeting with faculty, we find out a lot of them just, they're afraid they're going to screw something up." (P6)*

6.6.4 Encouraging serendipitous learning, consistent practices, and comparing perspectives

While many participants saw value in the ability to quickly browse example customizations to discover new ideas, two participants in particular (P2 and P7) noted that this could substantially change how they approach learning LMS features. P2 pointed out that this felt like a different style of learning built around curiosity and exploring new ideas, rather than the goal-oriented nature of searching for help online: *"It kind of affords exploration. [...] You can easily go 'Is there anything that somebody has suggested about this page?' [...] You might not need anything, but maybe if you're just curious, you can just kind of scroll through like, 'Oh, this is something nice that I've never thought of.'" (P2)*

Similarly, P7 appreciated how she could glance at other customizations adjacent to her goal and learn by serendipity, something not afforded by asking a colleague: *"When I just ask someone, I only get an answer to my specific question. But with Customizer, probably when I look for the answer to one question, I'll also learn something else new. [...] Like, when I see this [customization], I can also see how they do the other ones and probably I can have some new findings." (P7)*

Serendipitous learning from colleagues' collective wisdom could naturally, over time, result in greater consistency across courses at the same institution. This was called out

explicitly by some participants who mentioned using the shared examples as a means to ensure their courses have a consistent look-and-feel with other instructors in their department. Their primary motivation here was to create courses that resemble what their students are already used to: *"Looking at other instructors, you can make sure that everything is in the right place so your students will not be confused, and your Canvas [course] just looks similar to other people. [...] Especially if you're instructing a course for the very first time, I think that's very crucial to see what's happening for the more advanced, more experienced instructors to make sure you're not odd." (P4)*

Others similarly pointed out that they could turn to online search engines to find tips on setting up their Canvas course, but that this might lead them to customizations that aren't possible at their institution's Canvas instance or *"might not fit with how things work in [their] department" (P3)*. Some, like P9, appreciated the ability to browse customizations authored by their own colleagues as a way to avoid dealing with these consistency issues: *"The help that I would find on Canvas forums wasn't necessarily relevant to the installation that we had. And so that was inconvenient. [...] If you're seeing examples of something that someone you know is using on [Customizer], you can have a higher belief that it's actually working on the version of things that you've got, which is nice." (P9)*

6.6.5 Streamlining workflows for sharing knowledge with colleagues

P1, our most experienced participant with Canvas, described his primary use case being the ability to share particularly useful or hard-to-find customizations with colleagues: *"Because I've used Canvas so much, it's more likely I'd be sharing out versus learning things by looking at the examples. [...] I'd like to share this [customization] because I think a lot of other instructors [...] could find that of value, but they'd never find it normally. So I really like it that way and as someone more experienced, I'd get into trying to share out a few things." (P1)*

P6 similarly described knowledge-sharing as her main mode of participation, since she was already familiar with many Canvas features and her role as an instructional designer was well-suited for providing help to other instructors through shared examples and advice on best practices. Additionally, she felt that this database of example customizations could

serve as a resource that expert users like herself can direct novices toward when they're seeking help or inspiration: *"I can totally see Customizer being like the starting point for instructors. [...] Very common is, once you're past being a beginner, [asking things] like 'I don't like my front page being modules, I want something more interesting. Can you show me what other people have done?' And so in that case, I could just tell them, 'Hey, you know, go to the Customizer system, take a look and see what other people have done.' That would be a perfect use case for that." (P6)*

Even some less experienced instructors felt that their knowledge-sharing routines were greatly simplified by the example-based customization sharing model: *"In the past, if I need to help someone with Canvas, especially online, either I need to set up a Zoom meeting [...] and share my screen, or if there is no meeting, I screenshot everything, every step. And compared with that, definitely the share function [...] is much more simple." (P7).*

6.6.6 Supporting instructors broadly will require useful content for a variety of experience levels

Ideally, a system like Customizer could support the workflows of instructors with a range of abilities. However, two of the more experienced Canvas users (P1, P8) noted that they weren't finding the existing shared content particularly useful for themselves, highlighting that, as advanced users, they were already familiar with most of the customizations they saw in the system. Consequently, they felt they would be more likely to use such a system as a means to share their own experience rather than to learn new things.

As a potential improvement, some participants suggested that different content should be shown to users with different levels of experience: *"[Beginners] really want a template, or basically someone to tell them 'Okay how do I build my course, what do I do, do I just have to put things in there?'. They don't want any extraneous information. [...] So maybe if it were easier as a beginner user to find the basic stuff that you need without getting muddled down. [...] A rating system could say 'Okay yeah, this is the beginner kind of stuff, this is intermediate, this is an advanced kind of thing.'" (P6)* While a customization sharing system may naturally accumulate advanced content in the long term (due to instructional designers and other experts contributing), this highlighted the key challenge of keeping the system

useful to more experienced users while still remaining optimized for novice users who need to learn the basics quickly.

6.7 Instructors' key considerations for authoring and sharing customizations

In addition to assessing how example-based customization sharing was perceived by instructors, another key research focus was to understand instructors' perspectives around authoring and sharing customizations. In this section, we detail the range of example customizations our participants authored, their perceptions of the authoring process, and potential opportunities and barriers that arose during the authoring process.

Past research on social-sharing systems suggests that most users are consumers rather than content creators who actively contribute [149]. Accordingly, we expected that most of our participants would only rely on existing customizations rather than author new ones. It is then somewhat encouraging to see that 4 of our 10 participants used the system to willingly share one or more of their customizations during the deployment period.

We saw some variation in the types of customizations that our participants created, ranging from narrower feature-specific examples to broader course-wide changes. For instance, two participants (P3 and P8) shared multiple gradebook customizations, each exemplifying their unique approaches to grade-keeping (which they both noted as a key difficulty in Canvas), and P7 shared suggestions for improving the look-and-feel of a course's homepage. P6, in contrast, shared wide-reaching customizations to facilitate student navigation and two little-known Canvas feature options to improve course accessibility and deter cheating on quizzes (Fig. 6.6). Both P1 and P7 had further customizations that they wished to share during the deployment, but which fell outside the scope of what Customizer's implementation supported (e.g., P7 described an involved process for managing her online exams that relied on features Customizer could not access).

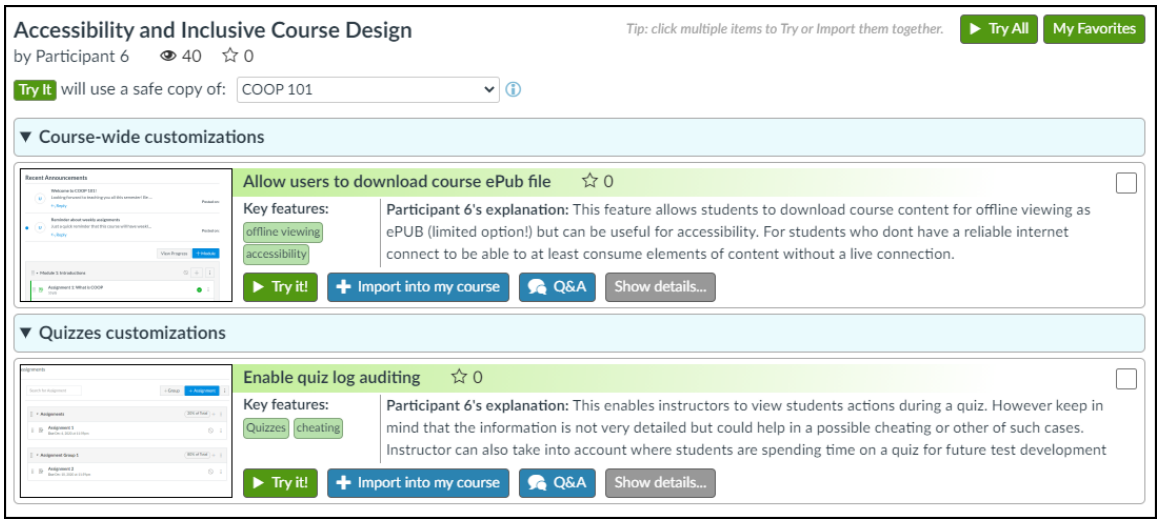

Figure 6.6: Two example Canvas customizations shared by P6, shown here within Customizer's expanded dialog just as users would encounter them.

6.7.1 Impact of privacy considerations when sharing example-based customizations

Among the participants who refrained from sharing any customizations, some were concerned about data privacy issues. These concerns surfaced despite all participants having been briefed that Customizer only shares high-level LMS setting changes without any sensitive data or page content attached. P2 remained unsure of the scope of information that would be included: *"When something gets shared, what exactly goes there, or how much? So if I shared, like, on my homepage, would everything on that page be shared? So that's why I was a little bit hesitant" (P2)*. He later noted that with a better understanding of the scope and limitations with regard to sensitive data, he may be more open to contributing.

On the other hand, P6 felt that if instructors could share willingly through a system like Customizer, it would help to bypass a data privacy hurdle that she and her colleagues (instructional designers) face, particularly when instructors ask them questions like: *"'Can you send us an example of what other people do?' [...] Your system's advantage is that here instructors are willingly sharing, whereas for us, we have to get authorization every time we share something." (P6)*

6.7.2 Differing views on how to communicate about an example-based customization

Many participants found writing a rationale for their customizations was often more challenging than the act of customization itself, and were somewhat split over what types of rationale were most useful to them personally. While many participants found the authored customizations largely helpful (e.g., P3, P4, P7), others were concerned about whether the explanations made it sufficiently clear why a customization was relevant or what precise settings were being changed: *"I can see myself sharing some knowledge, but I would want to do it with a bit more information. I felt like all of the customization bits, they were not describing enough for me what's going on. [...] I'm very thorough and precise. [...] I would have liked to have some kind of how-to steps." (P8).*

P9 similarly felt that he would prefer to have more explanation about how to maintain or troubleshoot the customization after importing it, in addition to the rationale: *"There are 'next steps' in some cases, like 'oh, after you apply this template you'll want to do X, Y, and Z'. And I felt like that was missing." (P9)*

In contrast, P6 believed strongly that the crucial detail in each customization's rationale is to highlight why it is useful in a given context, so others can consider whether it is actually relevant to their own teaching needs: *"[If] someone maybe saw something in Customizer, and they're like 'Oh, I should have five announcements on my front page'. But maybe it doesn't make sense for their course [...] So that's where the WHY really is important, [...] 'is this my situation? Does it work for my situation?'" (P6).*

6.7.3 Sharing only vetted "best practices" versus a wider range of perspectives

Participants differed on what types of content should be shared into a system like Customizer. P6 felt that content should be vetted and moderated by a school's Canvas experts to ensure that it is high-quality and consistent with best practices. Several others felt that if too many people were sharing their own practices, the system might become overly cluttered with low-quality content, making it harder for novice users to navigate and find key information.

On the other hand, P1 and P10 both felt that more informal, idiosyncratic customization examples highlighting different perspectives and varied use cases would be a major strength of the system: *"One of the biggest things for me was just seeing like, not just what the Canvas help page has, but actually seeing lots of different ways that people have applied these settings in their classes. It was more realistic and hands-on. [...] That kind of context is what's important." (P10)*

6.7.4 Less experienced instructors felt more comfortable building upon existing content

Unsurprisingly, participants who were *more* experienced Canvas users were largely open to sharing their knowledge in the form of example customizations. As noted earlier, P1, P6, and P8 were all confident that they would use such a tool to introduce their colleagues to LMS features they had found helpful themselves. On the other hand, while most of the *less* experienced Canvas users were more hesitant about sharing their own customizations, they did describe some scenarios in which they would feel more willing to share.

Similar to findings from related work [79], these participants identified concerns that the content they knew well enough to share may not be interesting enough for others, would be "too basic", or would only clutter the system with duplicate content. As an alternative, they described how having the ability to extend someone else's existing customizations with their own variations might mitigate these concerns and give them more opportunities to contribute: *"If I can build upon somebody else's set up, [...] add another interesting thing to it, I will feel more confident to share it with other people. Because I know that it was something that another person shared, so it was worth sharing. [...] [Then] I will feel confident that it can be helpful for other people." (P4)*

Although this approach of extending existing content was not a part of Customizer's design, two participants (P3 and P10) used the Q&A threads attached to each customization to accomplish a similar goal of adding their own perspectives. Their Q&A comments on existing customizations either added additional information about the customization (e.g., how or where to use it), or asked others for clarification about details they felt were missing.

Table 6.2: Key takeaways from our qualitative findings.

How example-based customization sharing influenced instructors' workflows	*(1) Provided a safe environment to test out new features* *(2) Supported self-sufficiency in learning and customizing* *(3) Encouraged serendipitous learning and consistent practices* *(4) Streamlined workflows for sharing knowledge with colleagues*
Instructors' major considerations for authoring and sharing customizations	*(1) Concerns about data privacy in shared customizations* *(2) Challenges in writing a good rationale and deciding what to include in a shared customization* *(3) Sharing vetted "best practices" versus a wider range of perspectives* *(4) Preferences for building upon existing content with new variations versus adding completely new customizations*

Some others also felt that they might benefit from indicators to help them identify which of their customizations were unique or underrepresented enough to be worth sharing: *"I think, if Customizer can tell me you know like, 'We do not have this setting, or this customization in our database', then I think it will be more likely for me to spend even a little more time in explaining what it is doing, and be more likely to contribute it" (P3).*

6.8 Discussion

Our results provide an empirical understanding of the diverse ways that an example-based customization sharing system can impact instructors' workflows and attitudes toward customizing their LMS (summarized in Table 6.2). We now reflect on these findings and some important tradeoffs around clarity and quality of shared customizations to explore connections to other lines of HCI research and potential future work.

6.8.1 Improving self-reliance to avoid the social costs of seeking and providing help

As several participants noted, one of the biggest challenges for new instructors is the overwhelming process of discovering and learning many new features in a short time with little support. Although asking colleagues for guidance can help, newcomers may not yet have many social connections, and (as per P7) they may need to overcome social barriers

(e.g., embarrassment, saving face) to access this help in person. Compounding this, it can be difficult in general for novices to even know where to start or what to ask about [143].

It is promising that our participants saw example-based customization sharing features as providing an alternative means for novice LMS users to access social help from colleagues without facing many of these obstacles. Most instructors in our study appeared readily able to augment their learning processes by finding relevant suggestions shared within Customizer. To some extent, this mitigates the need to directly ask colleagues for assistance. A potential downside is that instructors may have fewer opportunities to ask follow-up questions or engage in over-the-shoulder learning [194]. However, the lack of these in-person interactions is at least partially balanced by the opportunities that participants found for serendipitous/incidental learning [51].

Moreover, past work has found tech-savvy instructors often serve as "hubs of knowledge" within their schools, which can result in them being overburdened by dealing with many help requests from colleagues [201]. Our findings shed light on how example-based customization sharing may help to reduce this burden by streamlining the way expert users share certain types of software help (e.g., by encouraging re-use of shared examples as help artifacts). One should, however, remain wary of shifting too much of this burden back to help-seeking novices.

6.8.2 Unclear trust and privacy boundaries with in-application customization sharing

Past research has highlighted the importance of understanding the nuances around users' trust in shared customizations and the ecosystems in which they are shared [41,79]. Unsurprisingly, instructors in our study largely indicated greater trust for customizations shared internally by their colleagues. However, more unexpectedly, some participants were concerned about the privacy implications of *sharing* their course customizations in the first place. Thus, it is worth considering how a system like Customizer might blur privacy boundaries, especially in educational environments where data privacy is paramount. In more traditional online help-giving and help-seeking (such as on a Q&A forum), the act of posting details about one's course setup entails the author's strictly *intentional* determination of what is included or

revealed in their post. While Customizer's focus on high-level course settings is designed *not* to capture or transmit any sensitive information about a course (such as student data or an instructor's own teaching materials), the ease with which Customizer enables in-application sharing can nonetheless create the perception of a privacy risk due to incomplete knowledge about what exactly is being shared.

The current mitigation is to present a summary of the settings to be shared and to ask the user to confirm any sharing actions. However, we could take inspiration from research on chatbots and other adaptive agents, which suggests that users gain trust by having the ability to peek under the hood of otherwise opaque systems to understand their internal workings [70, 108]. For example, privacy-conscious instructors may benefit from having a way to review a more comprehensive breakdown of the content to be shared. While this could take place within the application itself, power users may even wish to export their customizations into a more transparent format that they can inspect and send to others (e.g., via email or forums), and which a system like Customizer could recognize and import as it does currently.

6.8.3 Making customization "too easy" may create potential for mistakes

While most instructors found it convenient to be able to import a wide range of customizations into their course with a single button press (and a confirmation dialog), some noted that this might make it too easy to modify their courses without fully understanding the changes they are making. As suggested in prior work [162, 202], there is some tradeoff in having a more centralized system for a wide range of customizations, as opposed to keeping those customizable settings closer to their point of effect. An optimistic assumption is that instructors will remain somewhat cautious about making untested changes and will rely on the ready availability of author explanations and the Try It feature to ensure they understand what they are changing and thereby avoid problems. However, the possibility remains that in-context customization sharing systems may lower the barriers to making purposeful changes to such an extent that they reduce productive friction between the user and the system and accidental and unintended changes could result.

6.8.4 Potential value in expertise-based content filtering

As multiple participants pointed out, it could be valuable for a system like Customizer to suggest different examples to different instructors according to their level of expertise with the underlying LMS. In a sense, this would serve to work around the tradeoff between offering more advanced examples yet still being simple for novice users to navigate and find the basics. Other systems to support more general help-seeking, like Social CheatSheet [200], have experimented with asking users to self-identify their expertise with an application (e.g., as a first-time user, novice, or expert) to prioritize recommending help resources that are more likely to benefit someone at that stage in the learning process. Furthermore, additional factors such as certain teaching methods (e.g., flipped classrooms [11]) or the subject and grade being taught could be accounted for with collaborative filtering techniques [168] to more prominently suggest example customizations that have proven useful for others in similar teaching situations. A remaining question is how to incentivize users to share both advanced customizations and more basic ones in order to cater to a wider range of instructors.

6.8.5 Considerations for supporting customization sharing in the long term

Our findings revealed that both newer and more experienced instructors found ways to integrate customization sharing features into their LMS usage, whether relying on the contributions of their colleagues or making those contributions themselves. Given that research has shown a high prevalence of non-contributing users in social sharing systems [149], it is promising that several of our instructors highlighted their willingness to share knowledge about their most useful course customizations. As with in-person classroom scenarios [201], it is likely that a small, motivated subset of instructors (and instructional designers) making these contributions could provide a substantial boost to their colleagues' ability to discover and implement software customizations that support different pedagogical approaches. Furthermore, when instructors have greater knowledge about their LMS features, the benefits are likely to extend to their students in the form of more positive learning experiences [27].

However, our participants' perceptions differed on the level of content standardization needed in a customization sharing system. For instance, a key issue was to ensure that instructors have access to crucial information about institutional best practices, while still surfacing a wider range of instructor perspectives and insights from individual use cases. This highlights the possibility that customization sharing platforms for instructors might benefit from a two-level approach, separately presenting (1) "priority" or "verified" customizations that have been vetted by experts at a given school, and (2) other examples that demonstrate how instructors are actually applying different LMS customizations "on the front lines". Appropriate filters could allow instructors to seek either type of example as they see fit for their needs. An institution's LMS experts could broadcast institution-specific tips and example customizations to serve as a self-directed starting point for novice LMS users, and more adventurous instructors would still have a means to experiment with a broader range of alternatives.

Moreover, given the relevance and extent of customization-related Q&A on existing forums [166], there could be wide-ranging benefits in connecting customization sharing systems with this valuable Q&A information. With this tighter integration, a customization sharing system could serve as a broader in-context hub, supplying both interactive in-application examples and branching out to these external resources for additional help and learning where needed.

6.8.6 Tradeoffs in pursuing ecological validity through field deployment studies

A major goal of this work was to gain insight into how instructors use an example-based customization sharing system in the context of their job, rather than in a lab-based setting. For this reason, we needed to both: (1) build a complete system that could robustly support several weeks of independent, unexpected usage by multiple users; and (2) design a study that would give instructors the freedom to use Customizer as they saw fit within their own workflows, but also try our core features for supporting example-based sharing. To provide participants with motivation to customize despite the lack of long term benefits (known to be a key challenge in customization studies [8]), we gave them a scenario and

a separate template course that they could freely change. This was intended to serve as a compromise between a fully-realistic lens into how they might customize an actual course and the practical consideration that they should not feel limited by only the immediate needs of their ongoing courses. Our approach of leaving the task objectives open-ended seemed to successfully result in most participants attempting a range of customizations according to their own needs and experience, which may not have been the case had we provided more concrete, specific tasks. On the flip side, had we provided no tasks at all, we may have seen low customization activity from more participants altogether.

Customizer allows instructors to experiment with customizations in a temporary copy of their course at any time using the Try It feature. In retrospect, a potential improvement to the study design could have been to create a more permanent copy of a past or current course from each participant, in place of the identical scenario and template course given to them. Although this would result in less consistency between participants' starting points, such an approach would likely have been more ecologically valid; participants may have noticed more natural opportunities to customize the course due to their existing familiarity with it. However, a further consideration is that they may already have implemented some customizations they find useful in their past courses, which could have limited their perceived need for discovering new features in Customizer — though these customizations may also stand out as worthwhile to share with colleagues.

6.8.7 Limitations

Although we gained rich insights into how instructors might realistically use a system like Customizer from their two weeks of usage, studies spanning a longer time period may be needed to get a more complete picture. Depending on the instructor, most of their customization might take place only in short bursts around the beginning of a new teaching term (when they may be too busy to participate in a study). Furthermore, the Canvas LMS is used by instructors worldwide, while our case study approach was limited to 10 instructors at a single North American university — broader studies would have the potential to uncover regional differences in how instructors approach customization sharing.

Finally, because this study was conducted during a time when instructors were forced to teach fully online, it is possible that some of our findings may not fully generalize to more normal circumstances with in-person teaching. As many of our participants began using Canvas more than usual during this shift online, their approach to sharing customizations might differ if they become less reliant on an LMS when returning to in-person teaching.

6.9 Conclusion

We have presented a wide range of empirical insights showcasing the diversity of instructors' perceptions and approaches to example-based customization sharing within an LMS. Additionally, we have demonstrated the potential for an in-application customization sharing platform to facilitate instructors' workflows for managing their courses, learning new LMS features, and sharing knowledge with their colleagues in real-world settings. Our findings provide several promising considerations for future work to further investigate customization sharing practices and perceptions across different domains and levels of expertise.

Chapter 7

Reflections, implications, and future work

7.1 Key takeaways

In this dissertation, I have presented study results that demonstrate Customizer's design to be a usable and useful approach that lowers the barriers for educators to discover, try, appropriate, and share their software customizations. Customizer's example-based customization sharing approach presents a promising way forward to help educators customize their classroom software. In particular, participants found that Customizer afforded them greater self-sufficiency in how they learn and customize their LMS, enabling new opportunities for them to learn by serendipity and improve their LMS feature awareness.

Additionally, the empirical understanding gained from formative studies in Chapters 3 and 4 have contributed much-needed insights into the diversity of educators' approaches to software customization, as well as their challenges with learning and seeking help with customization tasks. While these insights were crucial for informing the design of Customizer, they are also of wider importance in emphasizing the role of software customization in educators' practices and struggles on the job while navigating the increasingly complex world of educational technology.

In this chapter, I will reflect on some broader implications and impacts of this research as a whole, discuss some potential improvements and tradeoffs in Customizer's design, and explore connections to other lines of HCI research that relate to my study findings.

7.2 Implications and promising directions for future work

7.2.1 Extending customizations for power users

Customizer was intentionally designed to provide an easy entry point for novice users to begin customizing, but it is worth considering how these ideas might be extended to better serve power users too. Some participants in the deployment study noted that after importing certain customizations, they wanted to go and fiddle with the new changes to set them up exactly how they wanted or to better understand the available options. While the manual approach of finding and exploring the relevant settings page can be instructive, a system like Customizer could further facilitate making these sorts of smaller-scale tweaks to a shared customization prior to importing.

One possibility is by allowing some customizations to have further configuration options available when browsing and discovering shared customizations. Different aspects of each customization would then be adjustable so that users could explore the full range of options before deciding whether they would like to import. For instance, one might be able to modify not just the *presence* of a custom grading scheme, but also tweak the letter grade conversions therein before importing it. Furthermore, these different options could be tried within an exploratory mode as before, without having to track them down within settings pages after the fact. In this way, advanced users may find it valuable having further means to explore and adapt shared customizations to better meet their own needs. To avoid confusing or burdening novice users with further cognitive load, these configuration tools could perhaps be accessed through an "advanced options" menu.

7.2.2 Targeted personalization of shared customizations

In my studies I found that many instructors are supportive of the idea that customization-sharing systems could provide them with more relevant recommendations based on factors like their experience level with the LMS and the subjects they are teaching. A promising approach, then, could be that a system like Customizer might overcome the difficulty of filtering through the many available customizations that an instructor might not need, to discover the most relevant ones for their current teaching situation. Further facets of

personalization might be based on which customizations they are already using in their courses (or have used in the past), and which customization authors from whom they have frequently tried or imported content. Collaborative filtering methods [168] could be applied to compare an instructor's own characteristics and customization history to others, determine statistical similarities between them, and suggest customizations with a greater likelihood of proving worthwhile to each individual. A remaining question is how to better encourage users to share both advanced customizations and more basic ones so that the content caters to a wider range of instructors.

7.2.3 Incentivizing users to share their customizations

In my deployment study of Customizer, nearly half of the participants shared customizations they had created or found useful in the past, and included their own explanations. This was somewhat surprising, given long-standing evidence in past research that indicates the vast majority of users of online sharing systems tend to be exclusively consumers of other users' content and who are reluctant to author and contribute their own content [149]. It is possible that some of our participants were more willing to contribute content for the sake of the research study than they would be in more natural contexts. Since the authoring and sharing features in Customizer were not as widely used as the other features for discovery and exploration, this raises the important question of whether a system like Customizer could be reliably sustained by only a small number of content creators.

Promisingly, the study in Chapter 3 showed that communities of teachers often rely primarily on a small handful of tech-savvy colleagues for much of their tech support and troubleshooting needs. These tech-savvy teachers might conceivably be willing to take the lead on authoring and sharing useful customizations for their peers. Not only would this benefit all of the instructors who have access to the resulting knowledge base of example course customizations, but it could also help to reduce some of the burden facing the tech-savvy teachers themselves by offloading some of their ongoing support duties to Customizer's persistent sharing tools. Future work might find promise in investigating the impact of providing additional incentives for instructors to share their customized setups as examples for others, perhaps resembling the reputation-based incentive structures employed by large

online Q&A hubs like StackExchange [186]. Recent work has begun to explore the impact that strategies like gamification [198] and contributor rankings [204] can have on users' motivation to share their knowledge in these online environments, and systems like Customizer may provide a fruitful environment for further study into designing effective knowledge-sharing communities based around altruism toward colleagues.

7.2.4 Extending the exploratory mode concept and design

One of the original design goals underlying Customizer was to highlight customizations with visual cues, realized in part by its Try It feature highlighting interface elements related to each customization. While changes that affect the LMS's visual presentation are easily represented through these highlights, customizations that mainly change the *functionality* of the application do not always have an obvious corresponding visual referent. In these cases, Customizer instead highlights an element that is closely related to the change in functionality where possible, with the attached help badge providing context for what was customized. However, there remain possibilities for exploring other methods to demonstrate customized functionality in a way that users can more readily understand. For instance, a future extension to the exploratory mode might offer more tutorial-style comparisons of how the application reacts differently to the user's actions with or without a certain customization applied.

More generally, the Try It feature's design presents opportunities for improving the learnability of a wide range of customizable software, beyond LMSs. In demonstrating the usability benefits of an exploratory mode for letting software users freely experiment with user interface customizations, this dissertation provides a basis for software designers and researchers to introduce similar features into their user-facing systems across a variety of domains (which are expanded on further in Section 8.1.1). While many feature-rich applications do offer some form of "preview" feature for changes made to application *content*, an exploratory mode can provide an entirely new level of capabilities for interactively previewing *user interface changes* and their application-wide effects. Furthermore, participants' positive reception to Customizer's exploratory mode indicates that further extensions to this design concept are worth examining in future research. As potential directions, McGrenere originally

suggested that an exploratory mode could incorporate expertise-tailored help snippets and usage examples for the UI features and customizations being explored, or even suggest which features can be used to achieve end results similar to a piece of example/reference content [136]. Some further details about how Customizer's exploratory mode contributes to the broader literature are included in Section 8.1.4.

7.3 Limitations of the research methodology

While my findings captured a broad range of educators' experiences and my designs were meant to be widely generalizable, it is worth considering some potential shortcomings of my study methods and how complementary perspectives could further improve this research.

First, all of the research in this dissertation was conducted at North American schools (both K-12 and universities), but there can be important regional differences in how educators approach classroom software use depending on the resources available to them and differing uses or attitudes toward educational technology (e.g., [28, 197]). Going forward, it would be valuable to consider a more global perspective on educators' customization needs, since a one-size-fits-all solution is unlikely to address all of the widely-varying needs of educators throughout the world.

Additionally, the COVID-19 pandemic has had substantial impacts on how instructors at all levels approach educational technology [109, 167]. While some of these impacts may bring about long-lasting changes to instructors' teaching methods, others may eventually have little bearing on instructors' day-to-day workflows for fully in-person teaching. The final leg of this research was conducted within the context of that pandemic, so the generalizability of the findings to more ordinary teaching circumstances may be limited as a result. However, the rapid shift to online teaching also exposed many educators to technologies that they might not have considered using in their classes before (whether due to not knowing about them, or not feeling compelled to use them). When considering that there are many educators who are averse to adopting and integrating classroom technology [84, 201], this shift online has provided a valuable lens into the challenges they face in adapting to changing teaching technology and the pitfalls of current educational software design. Consequently, this research

provides designers with a deeper understanding of educators' needs and struggles when customizing classroom software, and evaluates promising user-centered design ideas for smoothing that learning curve going forward.

Chapter 8

Conclusion

The overarching goal of this dissertation was to discover and evaluate novel methods to better support educators with customizing their classroom software. By building and evaluating Customizer through a user-centered design process, I demonstrated that an in-context example-based approach to customization sharing in an LMS empowers educators with a usable means to discover and vet unfamiliar features within their daily workflows. In particular, my initial usability studies showed that Customizer's design is intuitive for instructors to learn and use, and provided early insight into the variety of use cases instructors foresaw for the design concept (Chapter 5). Building upon this promising start, my deployment study of Customizer in real-world situations provided crucial insights into the ways that instructors are quick to harness example-based customization sharing to gain self-sufficiency in how they discover and learn LMS features, to feel comfortable testing out new ideas on the fly, and to ensure consistency with their colleagues (Chapter 6). Finally, the design of Customizer is strongly supported and motivated by my exploratory work that provides an empirical understanding of the diversity in educators' customization needs, attitudes, and practices, including the types of customizations they commonly employ, variations in how proactively they approach customization, and the difficulties they face in providing and receiving help (Chapters 3 & 4).

In this chapter, I conclude the dissertation by reflecting on my research contributions and how they can support further advances both in the design of educational technology and for more general classes of software.

8.1 Core research contributions

8.1.1 Broadly-applicable design concepts for in-context social sharing of customizations

My studies of Customizer have established a variety of usability benefits attainable by incorporating example-based customization sharing tools and an exploratory mode within an application. Customizer's model of overlaying its features atop an existing interface served to provide a ready testing ground for these ideas, but this need not be the final iteration of the design. Indeed, a key contribution of this dissertation to the HCI community is in laying the foundation for broader design standards built upon these primitives: peeking at part of a colleague's software environment (as if participating in digital over-the-shoulder learning [194]), and trying out or adopting a colleague's changes within the familiar context of one's own software setup. These features, if applied in wider contexts, have the potential to introduce a shift in how the customizability of software is approached by both user interface designers and end users. For instance, one might imagine similar features being used to help novice users understand the range of ways they can customize the functionality of their email client, experiment with privacy-enhancing features in their web browser, or borrow game mods that their friends play with.

While the designs presented in this dissertation have focused mainly on educational applications, there is clear promise in imagining how an example-based customization sharing approach could be further generalized to benefit other domains as well. Tools for sharing customizations have previously shown potential in other contexts, such as letting users collaboratively tailor their word processors [106] and helping programmers configure their IDEs [12, 41]. Many modern IDEs already include a high degree of customizability as one of their key selling points [68, 140], and may even feature built-in mechanisms for downloading popular plugins [139], indicating considerable potential for improved example-based customization sharing features to make an impact in this space. Moreover, several of the study participants who tried Customizer expressed enthusiasm for the possibility of using similar platforms atop other feature-rich applications that they use as well — among those mentioned were image/video editors, website builders, live-streaming software. Since

these types of software tend to be highly customizable with steep learning curves, the ability to discover and share peer-driven insights about useful customizations could greatly benefit both novice and expert users of these applications.

Furthermore, the social sharing aspect of the design is crucial for offering easy access not just to information provided by the application developers (as in many existing in-application help systems), but also to rich social artifacts recommended by trusted colleagues with shared context. This stands in contrast to other means of seeking help online, such as Q&A forums, where it can be challenging to get help that is tailored to one's own unique circumstances. Software ecosystems and policies can differ greatly between different schools and school districts, a fact which extends also to different workplaces and teams in domains outside education. In these workplace scenarios, a standard means of sharing knowledge about common or useful software customizations can help with both onboarding new colleagues and supporting longer-term collaborative software usage. Indeed, as some participants in my deployment noted, a major advantage of this design is the ability to independently compare their own software setup with those of their colleagues and maintain consistency with them. While this consistency was important to educators for their students' sake, it can be similarly valuable in other domains — for instance, a team of software developers may want to share a basic set of IDE functionality customizations with one another that ensure a consistent build process for testing. In these types of scenarios, the ability to quickly peek at and import elements from a colleague's software setup could become a natural approach to software customization more generally.

8.1.2 Empirical insights into how educators approach software customization and their unique difficulties

An overarching theme throughout this work has been gaining an improved understanding of how to make software customization easier for educators. To this end, my formative studies into how both K-12 teachers and post-secondary instructors customize classroom software yielded rich insights about educators' widely-varied practices and pain points. In particular, these studies revealed the extent to which they rely upon a social fabric of friends and peers to discover and troubleshoot software customizations, and especially their inclination to learn

from examples of their colleagues' customizations where possible. However, these studies also highlighted educators' hesitance to customize due to the challenge of experimenting in classroom environments where unintended software changes could interfere with lesson plans or have a negative impact on students' learning experiences. Moreover, instructors' focus on customizing not only their own software environments but also those of their students leads to a number of other unique challenges, such as those arising from inconsistencies across a range of student devices and the need to ensure student data privacy.

These insights ultimately formed the basis for the design goals underlying Customizer and several of its key features. In the long term, these findings are well-positioned to provide a solid foundation for further design research or advances in educational technology that aim to streamline software customization experiences for educators.

8.1.3 Design of a novel example-based customization sharing platform

The most significant contribution of this dissertation is the design and full implementation of the Customizer platform for example-based customization sharing. Through successive iterations of refinement and interviews with instructors, I derived four main design goals:

DG1: Encourage exploration

DG2: Facilitate discovery of relevant examples

DG3: Highlight customizations with visual cues

DG4: Enhance customizations with rationale and context

I used these goals to inform the design of Customizer and ensure that it supported the use cases I had identified as most meaningful to educators' ability to customize on-the-job. In particular, Customizer included a lightweight means to discover examples of colleagues' existing customizations and rationale, and the capacity for fully-interactive risk-free experimentation. My usability studies provided evidence that this design demonstrated considerable improvements over instructors' existing means of customizing their LMS.

While my implementation of Customizer was built to support the Canvas LMS, its design concept should be generalizable not only to other LMSs, but to a broad range

of other feature-rich classroom software, such as "teacher dashboards" that provide a customizable array of tools for student analytics, grade keeping, and general classroom management [4]. Moreover, there is little reason these design ideas could not be extended to improve customization support beyond educational applications — several participants in our studies were enthusiastic about the possibility of harnessing example-based customization sharing in other aspects of their software usage, such as with complex image and video editing applications. Given the importance of online customization sharing ecosystems in other domains such as coding [12, 41], personal productivity [79], and gaming [39, 79], it is possible that Customizer's in-context example-based approach could have a considerable impact on how a wide range of more general software users conceptualize and engage in customization activities.

8.1.4 Implementation and evaluation of an exploratory mode to facilitate exploratory learning

One of the core features I included in Customizer's design was *Try It*, which realizes the concept of an exploratory mode [136] in which users are free to learn by making experimental changes to any application settings, safe in the knowledge that those changes will be automatically reverted unless they choose to keep them. Although this idea has been touched upon in some past designs (e.g., [114]), to my knowledge this is the first time the exploratory mode concept has been fully designed, implemented, and evaluated in a real application. Furthermore, the usability studies and deployment both revealed that instructors overwhelmingly find this capability useful, both as a means to test potential changes without the usual risk of accidental student-facing consequences, and for simply comparing the impacts of different customizations to confirm their intuition.

Given the success of the exploratory mode concept in educational contexts, there is little doubt that it could prove valuable in broader classes of feature-rich software. Although educators have shown a particularly widespread hesitance to customize due to perceived student-facing risks, there is evidence that similar worries about unintended consequences may present a barrier to customization activity for more general software users as well [124]. Exploratory modes like the one in Customizer present a promising approach to mitigate

these concerns and place the power of software customization within reach for a larger class of users with diverse levels of technical expertise. With the scope and complexity of feature-rich software growing each day in domains ranging from

8.1.5 Empirical insights into how educators incorporate example-based customization sharing into their daily workflows

My deployment study evaluated Customizer's design in practice and how instructors integrated it into their day-to-day course management workflows, with the goal of maximizing ecological validity. Through this evaluation I demonstrated that instructors readily adopt Customizer's features to streamline their workflows in a variety of ways. Their diverse range of use cases included serendipitous discovery of useful LMS features (to complement other learning methods), quickly previewing the impacts of potential changes to their course settings, and disseminating best practices to help less experienced colleagues overcome the steep LMS learning curve. Overall, almost all deployment participants felt positively about Customizer's usefulness in supporting their common LMS customization needs.

The deployment study unlocked valuable insights into the surprisingly varied use cases that instructors found Customizer could support. Beyond just offering a means to browse example customizations, instructors found Customizer's in-context recommendations afforded ample opportunities for serendipitous learning and discovery of unfamiliar features in the course of their usual Canvas usage. Moreover, they described how Customizer enabled a more self-sufficient approach to learning about the LMS due to the asynchronous nature of trying and importing shared examples, which offers greater convenience and independence than asking around among colleagues or seeking help online. On the other hand, instructors with an abundance of LMS experience largely found that Customizer supported their ability to share knowledge with one another, a process that my earlier studies found to be time-consuming and stress-inducing for many help-givers who felt that offering technical advice to their colleagues sometimes detracted from their teaching role. These findings confirmed the usefulness of Customizer for many common teaching scenarios, and have paved the way for further research into how educators might benefit from having such customization sharing tools at their disposal over longer periods of time.

8.2 Secondary contributions

8.2.1 Empirical insights about the challenges educators face in seeking Q&A-style help online

Through our analysis of the Canvas Community Q&A website, we contributed a breakdown of the different types of questions (e.g., "where is this feature?") and question themes (e.g., facilitating shared experiences between students) underlying the LMS-related discussions that take place on these forums. In this analysis, we also identified the difficulties that educators encounter when seeking help for questions about LMS customization that are more complex or idiosyncratic in nature. Beyond the design of Customizer, these insights would be valuable to researchers and practitioners designing help-seeking experiences for educators, or even for further attempts to provide help with customization more generally. Finally, our analysis offered a unique perspective on the impacts of the COVID-19 pandemic on educators' software customization needs due to the widespread adoption of remote teaching methods within a short time frame.

8.2.2 Broader insights into K-12 teachers' digital classroom ecosystems and barriers to software integration in schools

By interviewing many K-12 teachers, I uncovered an abundance of insights not only about their customization practices and needs, but also about their more general approaches to software use, learning, and troubleshooting on the job. These interviews revealed a surprising range and diversity in the types of software applications teachers use in class, and highlighted frequent challenges they encounter in vetting and supporting such a broad array of applications — especially in scenarios where students are bringing their own varied computing devices to class. Moreover, I found that teachers often rely on a small number of tech-savvy colleagues for help with setting up and troubleshooting their classroom software throughout the school day. Since these tech-savvy teachers are often offering this ad hoc support in an informal capacity, it can present a significant strain on their already-busy teaching roles.

Importantly, I found in these interviews that many teachers combined the strengths of multiple software applications to try to accomplish complex workflows in a way that was

best characterized as customizing their *digital classroom ecosystems*. This insight enabled a more complete illustration of how teachers' approaches to software customization often transcend the more widely-recognized types of small-scale changes to individual applications. This new lens may prove beneficial in informing future research that examines the nuances of teachers' software choices, workflows, and customization needs.

8.3 Closing remarks

This dissertation explored multiple angles of understanding how educators of varying backgrounds experience the process of discovering, integrating, troubleshooting, and customizing their classroom software. Reflecting on these formative insights led to concrete design goals that culminated in the design, implementation, and evaluation of Customizer, a novel in-context platform to facilitate example-based customization sharing among educators. Customizer's features and design present a promising way forward for helping educators learn and customize their classroom software by building upon the collective wisdom of their colleagues. I believe that these designs and insights are well-positioned to underpin future efforts by HCI researchers and practitioners that aim to better understand and support educators with navigating the increasingly-complex world of customizing educational technology.

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Appendix A

Study materials

In this appendix, I include study instruments and related documents that were used to recruit and collect data from participants in my studies.

A.1 Study materials for Chapter 3

A.1.1 Consent form

Investigating How Teachers Learn and Customize Digital Classroom Tools

Consent Form

The overall goal of this research is to characterize the motivations and interests of teachers using digital classroom tools in classes from kindergarten to Grade 12. In this research, we will first be carrying out an interview study with teachers to better understand what types of digital classroom tools they use, their strategies for finding and implementing these tools, and their approach to customizing and personalizing these tools.

Who is conducting this study?

- Laton Vermette (Principal Investigator) [redacted]
- Parmit Chilana (Faculty Supervisor) [redacted]
- Joanna McGrenere (Collaborator, UBC) [redacted]

We are researchers from the Human Computer Interaction (HCI) Lab at Simon Fraser University, the University of British Columbia, and the Microsoft Canada Excellence Centre (MCEC). Participants in this study will have signed up for it through Microsoft Canada.

Who is funding this study?

This study is funded by the NSERC Strategic Partnership Grant "Making It Personal: Tools and Techniques for Fostering Effective User Interaction with Feature-Rich Software" as well as Mitacs Accelerate internship funding.

Why are we doing this study?

You are being invited as a K-12 teacher to take part in this research study, which will help us learn about how digital classroom tools are currently being used and customized by teachers in school environments. Our purpose is to better understand teachers' goals and strategies for implementing and customizing digital classroom environments, as well as their individual and social means of learning about these tools, in order to develop design goals and prototypes showing the potential of these tools and sharing customizations for them.

Where will this study take place?

This study will take place over video chat (e.g., Skype) or in person at a mutually agreed upon location. We would be happy to meet you in person in a quiet room at your school if possible. Alternatively, you are welcome to come to our lab at Simon Fraser University in Burnaby, BC.

Your participation is voluntary

You have the right to refuse to participate in this study. If you decide to participate, you may still choose to withdraw your participation from this study at any time. If you do not want to continue, you can simply let the interviewer know, and your answers will not be recorded. There will be no negative consequences for withdrawing your participation.

What happens if you say "Yes, I want to be in the study"?

If you say "yes", here is how we will do the study:

- At the beginning of the study, we will ask you to fill a form with some basic information about your age, gender, educational background and experience as a teacher. You can use as much time as you need to fill the form and your responses are optional. We will not be using this demographic data in any way to create stereotyping of groups, etc. It will mainly be used as an aggregate to give an overview of our participant pool.
- We will be using a semi-structured interview approach, asking you a series of questions about your usage of and experience with digital classroom tools and customizations thereof.
- There are no right or wrong answers. You may decline to answer any of the questions if you so wish. Further, you may decide to withdraw from this study at any time without any negative consequences by advising the researcher.
- With your permission, the interview will be audio recorded to facilitate collection of information, and later transcribed and de-identified for analysis. We will delete the audio file after we receive successful transcription. Only those participants who give their consent to be audio recorded will be recorded, and you may choose to opt out of audio recording.
- With your permission, we may also ask you for screen captures of any digital learning tools or other digital environments that you show to us during the interview. You may choose to decline to provide a screen capture for any reason. Screen captures will only be taken with your express consent, and all attempts will be made to de-identify any screen captures we collect.
- Overall, it will likely take **at most 60 minutes** to finish the interview.

Is there any way being in this study could be bad for you?

There are no foreseeable risks to you in participating in this study.

Will being in this study help you in any way?

We do not think taking part in this study will directly help you. However, in the future, others may benefit from what we learn about your use of digital classroom tools.

Will you be paid for your time?

You will be given a $20 Starbucks gift card for your participation in this study.

How will your privacy be maintained?

Your confidentiality will be respected. All records will be stored in a secure server at Simon Fraser University accessible only by the investigators. We retain the data for three years and will destroy all the records afterwards. All the electronic data will be deleted from the storage disk. All the paper data (including transcripts/notes, questionnaires, consent forms, etc.) will be shredded by a crosscut shredder.

This study is being conducted in partnership with Microsoft Canada, and researchers from Microsoft will have access to the de-identified study data, although they will not be directly involved in the data analysis or writing publications that result from this.

If you choose to contact the investigators about this study, we will not share your personal information, including your email address, with anyone. We will make our best effort to maintain the confidentiality of your communication with us, but be aware that email is not a secure means to share confidential information.

How will the study results be used?

The results of this study may be reported in a PhD dissertation and may also be published in conference or journal papers. Please note that the names of participants will not appear in any dissertation or publication resulting from this study. However, we may select extracts of quotations to use as supporting evidence for our study, labelled only with a participant number and no personally identifiable information. When we have the study results published, you will be able to download the relevant publications from our research group's website (hci.cs.sfu.ca).

Who can you contact if you have questions or concerns about the study?

If you have questions related to the study, please contact the researchers listed at the top of this consent form.

If you have any concerns about your rights as a research participant and/or your experiences while participating in this study, you may contact Dr. Jeffrey Toward, Director, Office of Research Ethics ([redacted] or [redacted])

Taking part in this study is entirely up to you. You have the right to refuse to participate in this study. By continuing to answer the questions you are consenting to participate in this research study. You may print this page for your records.

PRINT NAME _____

SIGNATURE _____

DATE (YYYY/MM/DD) _____

A.1.2 Recruitment email

Dear <Name>,

You are invited to participate in an interview study about the use and customization of digital classroom tools among teachers, which is being run by researchers in Canada from Microsoft, Simon Fraser University, and the University of British Columbia. We will be conducting interviews over Skype throughout the next 2-4 weeks, each lasting 45-60 minutes. If you choose to participate, you will be given a $20 Starbucks gift card in appreciation of your time.

The purpose of this study is to learn how K-12 teachers experience the process of customizing digital classroom tools, such as Microsoft OneNote (Class Notebooks), Microsoft Teams, and Microsoft Excel. The findings from this study will be kept **completely anonymous** and will be used to improve the design of these tools. Our goal is to evaluate the effectiveness of these tools and how well they support customization, not to evaluate you. This study has been reviewed and received ethics approval through Research Ethics Boards at [redacted] School District, Simon Fraser University, and the University of British Columbia.

If you would like to sign up for an interview, or have any questions about the study, please contact me by replying to this email ([redacted]). Please include your preferred dates and times for the interview (between **Nov 27, 2017 and Feb 16, 2018**) – we will try our best to accommodate your schedule (e.g., before or after school) and find a time that is convenient for you.

Thank you,

Laton Vermette
PhD Student, Simon Fraser University
Research Intern, Microsoft

A.1.3 Pre-interview questionnaire

TEACHER USE & CUSTOMIZATION OF DIGITAL CLASSROOM TOOLS

PRE-QUESTIONNAIRE

1. How old are you?

a. 19-30
b. 31-40
c. 41-50
d. 51-60
e. 61+

2. What is your gender?

a. Male
b. Female
c. Prefer not to say

3. What is your **highest** educational background?

a. High school
b. Bachelor's degree (Major: _____)
c. Master's degree (Major: _____)
d. PhD (Major: _____)
e. Other (Please specify: _____)

4. How many years have you been teaching in a classroom setting?

a. < 1 year
b. 1-5 years
c. 6-10 years
d. 11-15 years
e. 16-20 years
f. 21+ years

5. What grade(s) do you currently teach?

_____

_____

6. How often do you use the following software in your classroom?

   Microsoft Teams (circle one):
   Every day | Few Times a Week | Few Times a Month | Few Times a Year | Never

   Microsoft OneNote:
   Every day | Few Times a Week | Few Times a Month | Few Times a Year | Never

   Microsoft OneNote Class Notebook:
   Every day | Few Times a Week | Few Times a Month | Few Times a Year | Never

   Microsoft Excel:
   Every day | Few Times a Week | Few Times a Month | Few Times a Year | Never

7. What other kinds of software, hardware, or other technology do you currently use in your classroom? Please list the tools you use most frequently:

   _____
   _____
   _____

8. Roughly when did you start incorporating digital classroom tools into your teaching, if at all?

   _____
   _____

9. What kinds of social events or communities at your school have you attended that were related to learning, setting up, or customizing digital classroom tools? Circle all that apply.
   a. Professional development workshops
   b. Presentations or learning sessions led by other teachers
   c. Presentations or learning sessions led by IT staff
   d. Other: _____

A.1.4 Interview questions

This document reflects the general outline of the questions we asked participants during interviews. Being a semi-structured interview, the exact subjects, wording, and ordering of questions differed according to each participant's unique responses.

INTERVIEW QUESTIONS

General Warm-up

- Study overview, consent form, and pre-questionnaire

1. Describe a typical day in your classroom, and in particular, how you incorporate technology into that typical day – just a high level overview.
    a. Lessons? Group/individual work?
    b. How do students access the technology – BYOD? Classroom computers?

Motivations for using digital classroom tools

2. You mentioned in the questionnaire that you use tool X. Could you describe in more detail what you use it for in your classroom? (How do you use tool X to accomplish Y? Is there anything you find particularly challenging about using X in your classroom?)

3. You mention in the questionnaire that you first started incorporating digital classroom tools into your teaching X years ago. How did you first hear about or come across those first digital classroom tools that you used?
    a. What are some of the reasons you chose to adopt these digital tools for your classroom?

4. You mention in the questionnaire that you've learned about digital classroom tools through events such as X. Can you tell me a bit more about what tools you learned about, and the type of things you were learning?
    a. How frequent are these events? How long are they?
    b. How beneficial would you say this format is for learning about new tools?

Customization of digital classroom tools

5. Think back to when you were first getting started with tool X – to the best you can remember, can you show me what you did to get it set up to work the way you wanted for your classroom?

6. What kinds of challenges did you face when getting it set up? How did you resolve them?

7. When you see a need for some sort of new technology in the classroom, or when any kind of technology change is needed, what do you do to solve that?
    a. Who do you go and talk to for help with getting a solution, if anyone?
    b. Do you tend to try modifying an existing application, or look for completely new ones? Why?

    I'm going to ask you a few questions about "customization," which is when you make changes to how an application looks or works beyond the defaults, or change how it presents content. One example of a software customization might be setting up a document template that you aim to re-use multiple times in the future. More advanced examples might be along the lines of changing the application options or preferences to suit your needs better, or installing plug-ins to modify the interface.

8. To what extent have you tried to customize the **content** of these digital classroom tools? Changes related to content, rather than the application's interface, might be things like saving a font style for easy re-use, or creating a template/lesson plan that can be used to set up many different documents. (Show an example?)

    a. Could you describe in more detail the process you followed to implement customization X?

9. To what extent have you tried to customize the **interface** of the digital classroom tools you use? This would involve changes to the way the application itself looks or functions, like changing what buttons appear in a menu or the layout of the ribbon. (Show an example?)
    a. Could you describe what you did in more detail? Try walking me through the process.

10. How *important* is it for you to be able to customize and personalize the software you use in the classroom? Why?

11. How do you usually find these customizations or learn about them in the first place? (e.g. on your own, from colleagues, online…)
    a. Think about a case where you've customized a tool for your classroom. After finding out about that way to customize it, what was your process for implementing it?
    b. (Can probe into online forums, Q&A, and other communities if they bring it up)
        1. (If primarily browsing) Can you describe your browsing habits when searching for customizations or other ways to adapt your software?
        2. If you can recall a specific instance when you were browsing for customizations, could you describe what you searched for, where you searched, why, etc.
        3. Why do you choose/prefer these methods of finding customizations?

12. How often do you share what you've learned about a customization with other people or communities?
    a. How do you usually share them? (Email, online, in-person…) Why this method? Could you walk me through the process?
    b. What are some challenges you've faced while trying to share your customizations?
    c. To what extent does the tool in question support your ability to share your customizations?

13. Of all the applications you use in your class, is there a particular one that you tend to customize more than others? Why or why not?
    a. Or a particular sort of customization that you find most useful?

14. Is there anything else you'd like to share about digital classroom tools, or software customizations?

Some contextual follow-ups:

- (Re Teams use or similar) Do all of your students use Teams together too? Or is it just the teachers? If the former, how much freedom do the students have to form their own groups and collaborate on their own?
- (Re sharing via email) How detailed are your email instructions for customizing? How well does email seem to work for this purpose? Why?

A.2 Study materials for Chapter 5

A.2.1 Consent form

SFU Study Number: 2017s0367

Investigating How Teachers Learn and Customize Digital Classroom Tools

Consent Form

The overall goal of this research is to characterize the motivations and interests of teachers using digital classroom tools in classes from kindergarten to Grade 12 or in postsecondary classes. In this research, we will be carrying out usability studies and interview studies with teachers to better understand what types of digital classroom tools they use, their strategies for finding and implementing these tools, and their approach to customizing and personalizing these tools.

Who is conducting this study?

- Laton Vermette (Principal Investigator) [redacted]
- Parmit Chilana (Faculty Supervisor) [redacted]
- Joanna McGrenere (Collaborator, UBC) [redacted]

We are researchers from the Human Computer Interaction (HCI) Lab at Simon Fraser University, the University of British Columbia, and the Microsoft Canada Excellence Centre (MCEC). Participants in this study who teach kindergarten through Grade 12 will have signed up for it through Microsoft Canada. Participants who teach postsecondary classes will have signed up by contacting the researchers directly via word-of-mouth or email.

Who is funding this study?

This study is funded by the NSERC Strategic Partnership Grant "Making It Personal: Tools and Techniques for Fostering Effective User Interaction with Feature-Rich Software" as well as Mitacs Accelerate internship funding.

Why are we doing this study?

You are being invited as a K-12 or postsecondary teacher to take part in this research study, which will help us learn about how digital classroom tools are currently being used and customized by teachers in school environments. Our purpose is to better understand teachers' goals and strategies for implementing and customizing digital classroom environments, as well as their individual and social means of learning about these tools, in order to develop design goals and prototypes showing the potential of these tools and sharing customizations for them. One such prototype is our Customizer system for exploring Canvas LMS customizations, and we hope to evaluate its design and usability.

Where will this study take place?

This study will take place in person at a mutually agreed upon location. We will be happy to meet you in person in a quiet room at your school. Alternatively, you are welcome to come to our lab at Simon Fraser University in Burnaby BC.

Your participation is voluntary

You have the right to refuse to participate in this study. If you decide to participate, you may still choose to withdraw your participation from this study at any time. If you do not want to continue, you can simply let the interviewer know, and your answers will not be recorded. There will be no negative consequences for withdrawing your participation.

What happens if you say "Yes, I want to be in the study"?

If you say "yes", here is how we will do the study:

- At the beginning of the study, we will ask you to fill a form with some basic information about your age, gender, educational background and experience as a teacher. You can use as much time as you need to fill the form and your responses are optional. We will not be using this demographic data in any way to create stereotyping of groups, etc. It will mainly be used as an aggregate to give an overview of our participant pool.
- We will then provide you with a brief walkthrough of the major features of the Customizer system to introduce you to the design. We will ask you to perform two 15-minute usability tasks within the Canvas LMS using the Customizer system, which adds additional functionality on top of Canvas. The tasks involve finding and changing various settings of a Canvas course. These tasks will be performed on the researcher's computer using the researcher's Canvas account -- your own Canvas courses will not be affected in any way. The researchers will observe during these tasks and you will be asked to "think aloud" by narrating what you are doing and why. There will be software recording the screen while you perform these tasks, to help the researchers better understand your actions. These recordings will be anonymous and not linked to your identity in any way. You may decline to complete any part of the usability tasks if you wish.
- After both tasks, we will ask you to fill out another questionnaire asking how you feel about different aspects of the Customizer system's usability. As before, your responses are optional.
- After this, we will begin a semi-structured interview approach, asking you a series of questions about your experience using Customizer during the usability tasks, as well as your usage of digital classroom tools and customizations thereof.
- There are no right or wrong answers. You may decline to answer any of the questions if you so wish. Further, you may decide to withdraw from this study at any time without any negative consequences by advising the researcher.

- With your permission, the interview will be audio recorded to facilitate collection of information, and later transcribed and de-identified for analysis. We will delete the audio file after we receive successful transcription. Only those participants who give their consent to be audio recorded will be recorded, and you may choose to opt out of audio recording.
- With your permission, we may also ask you for screen captures of any digital learning tools or other digital environments that you show to us during the interview. You may choose to decline to provide a screen capture for any reason. Screen captures will only be taken with your express consent, and all attempts will be made to de-identify any screen captures we collect.
- Overall, it will likely take **at most 60 minutes** to finish the study.

Is there any way being in this study could be bad for you?

There are no foreseeable risks to you in participating in this study.

Will being in this study help you in any way?

We do not think taking part in this study will directly help you. However, in the future, others may benefit from what we learn about your use of digital classroom tools.

Will you be paid for your time?

You will be given a $20 Starbucks gift card for your participation in this study.

How will your privacy be maintained?

Your confidentiality will be respected. All records will be stored in a secure server at Simon Fraser University accessible only by the investigators. We retain the data for three years and will destroy all the records afterwards. All the electronic data will be deleted from the storage disk. All the paper data (including transcripts/notes, questionnaires, consent forms, etc.) will be shredded by a crosscut shredder.

This study is being conducted in partnership with Microsoft Canada, and researchers from Microsoft will have access to the de-identified study data, although they will not be directly involved in the data analysis or writing publications that result from this.

If you choose to contact the investigators about this study, we will not share your personal information, including your email address, with anyone. We will make our best effort to maintain the confidentiality of your communication with us, but be aware that email is not a secure means to share confidential information.

How will the study results be used?

The results of this study may be reported in a PhD dissertation and may also be published in conference or journal papers. Please note that the names of participants will not appear in any dissertation or publication resulting from this study. However, we may select extracts of quotations to use as supporting evidence for our study, labelled only with a participant number and no personally identifiable information. When we have the study results published, you will be able to download the relevant publications from our research group's website (hci.cs.sfu.ca).

Who can you contact if you have questions or concerns about the study?

If you have questions related to the study, please contact the researchers listed at the top of this consent form.

If you have any concerns about your rights as a research participant and/or your experiences while participating in this study, you may contact Dr. Jeffrey Toward, Director, Office of Research Ethics ([redacted] or [redacted])

Taking part in this study is entirely up to you. You have the right to refuse to participate in this study. By continuing to answer the questions you are consenting to participate in this research study. You may print this page for your records.

PRINT NAME _____

SIGNATURE _____

DATE (YYYY/MM/DD) _____

A.2.2 Recruitment email

SFU Study Number: 2017s0367

You are invited to participate in a study about the use and customization of digital classroom tools among instructors, which is being run by researchers in Canada from Microsoft, Simon Fraser University, and the University of British Columbia. We will be conducting studies throughout the next 2-4 weeks, each lasting at most 60 minutes. These studies will take place either at a mutually agreed-upon location or over Skype if that is more convenient for you. We would be happy to host the interview at the HCI Lab (TASC1 9200) or in another quiet room on campus. If you choose to participate, you will be given a $20 Starbucks gift card in appreciation of your time.

The purpose of this study is to learn how K-12 and postsecondary instructors experience the process of customizing digital classroom tools, and especially learning management systems such as Canvas and Moodle. During the study, you will be asked to perform some short tasks in Canvas using a new plugin to facilitate customizing a course setup. The findings from this study will be kept **completely anonymous** and will be used to improve the design of these tools. Our goal is to evaluate the effectiveness of these tools and how well they support customization, not to evaluate you. This study has been reviewed and received ethics approval through Research Ethics Boards at Simon Fraser University and the University of British Columbia.

If you would like to sign up for an interview, or have any questions about the study, please contact me by replying to this email ([redacted]). Please include your preferred dates and times for the interview within the next couple of weeks – we will try our best to accommodate your schedule (e.g., before or after classes) and find a time that is convenient for you.

Thank you,

Laton Vermette
PhD Student, Simon Fraser University
Research Intern, Microsoft

December 18, 2019

A.2.3 Pre-interview questionnaire

SFU SIMON FRASER UNIVERSITY
ENGAGING THE WORLD

Study Number: 2017s0367

INSTRUCTORS' USE & CUSTOMIZATION OF DIGITAL CLASSROOM TOOLS
PRE-QUESTIONNAIRE

1. How old are you?

19-30 31-40 41-50 51-60 61+

2. What is your gender?

Male Female Prefer not to say

3. What is your **highest** educational background? (Circle one or more)

Bachelor's Master's PhD
Other (please specify): _____
What was your major? _____

4. How many years have you been teaching in a classroom setting?

< 1 year 1-5 years 6-10 years
11-15 Years 16-20 years 21+ years

5. What student levels have you taught within the last five years? (Circle one or more)

Undergraduate – 1st/2nd year Undergraduate – 3rd/4th year
Graduate (Masters) Graduate (PhD)
Other (please specify): _____

6. What is your current job title? (Circle one or more)

Teaching Assistant Sessional Instructor Lecturer Senior Lecturer
Assistant Professor Associate Professor Professor Prof. Emer.
Other (please specify): _____

7. What subjects (broadly) have you taught within the last five years?

_____
_____

8. What (if any) learning management systems have you used for your courses, either currently or in the past? (Circle all that apply)

Canvas D2L Blackboard CourSys Moodle
Other (please specify): _____

9. What other digital tools or software do you currently use as part of your classes? Please list the tools you most frequently use:

_____
_____

June 10, 2019

A.2.4 Customizer usability tasks

Usability Task 1 (10 minutes)

You have been asked by your department to set up a new distance-education course for co-op students (COOP 101). It's an urgent task -- the previous instructor had to leave suddenly, and the course starts in a few days, but you are very busy and only have about **10 minutes** to work on this. Luckily, the previous instructor had created the basic Canvas course which you will be using. Most of the early course materials are added already, but the course settings still need to be tweaked.

Your department wants to maintain a similar look & feel across all of their courses, so you should **model your course after what others have done**. Instructors in your department (e.g., Alice and Bob) have shared several of their own courses through the **Customizer** system, where you can peek at examples from their course setups for inspiration and explanations.

You have a few ideas in mind for how the course should be set up:

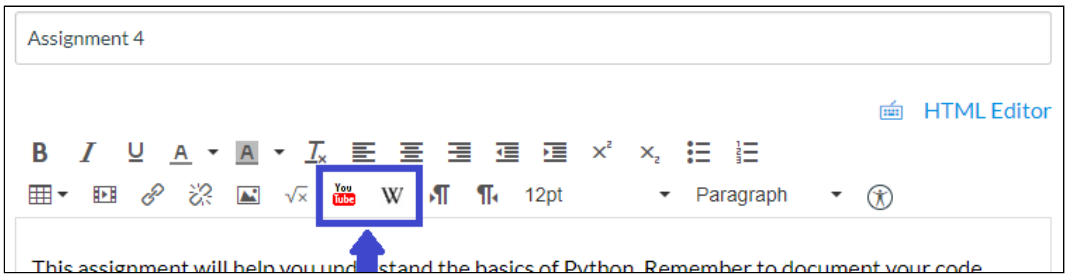
- Student control over the discussion board should be limited. Using Customizer, figure out some ways to lock down the discussion board functionality for students.
- You want to have as much useful information as possible on the home page, such as announcements and upcoming assignments. There are many options to choose from at your discretion, but you want to **see what other instructors have done** first.
- You are planning to use real-time collaboration with students, but aren't very familiar with the features available for that. You have heard good things about both the **Etherpad Collaboration** feature and the **BB Collaborate Ultra** feature from your colleagues, so you want to **compare other instructors' setups/explanations** before making a choice.

Remember that we are not testing your ability to use Canvas -- we are interested in seeing how you interact with Customizer to discover and explore shared customizations.

Usability Task 2 (10 minutes)

It's now one month into the semester. While discussing course material with a colleague, you notice that the **page editor** in their Canvas course has two extra buttons in it: one for **YouTube** and one for **Wikipedia** (see image below). Your colleague says they use these to embed videos and wiki pages into their course pages, but they don't remember how they got those buttons.

You'd like to **figure out how to add these buttons** and experiment a bit to see if it would make a good addition to your own COOP 101 course. Your course is currently being used by students, so avoid making any unnecessary changes to it -- you don't want to break your setup by accident!



You are still very busy, so you will only be able to spend about **10 minutes** exploring these features today. As before, several other course instructors have shared their setups with you through the Customizer system, and may provide insight into how to add these extra buttons.

Usability Task 3 (5 minutes)

The semester is finally coming to a close, and you've learned a great deal about how to customize your course in Canvas. You have about **5 minutes** of spare time, and think it would be useful to "pay it forward" by sharing some customizations from your COOP 101 course so that other instructors can learn from them in the future. Take a few minutes to explore how you can use Customizer to accomplish this, and choose one or more customizations to share.

A.2.5 Customizer post-task usability questionnaire

SFU Study Number: 2017s0367

USABILITY QUESTIONNAIRE

For each of the following statements, rate the extent to which you agree or disagree with it:

1. I found the Customizer system **easy to use**.

1	**2**	**3**	**4**	**5**	**6**	**7**
Strongly disagree						Strongly agree

2. I found the Customizer system **frustrating**.

1	**2**	**3**	**4**	**5**	**6**	**7**
Strongly disagree						Strongly agree

3. I found the Customizer system **confusing**.

1	**2**	**3**	**4**	**5**	**6**	**7**
Strongly disagree						Strongly agree

4. I enjoyed using the Customizer system.

1	**2**	**3**	**4**	**5**	**6**	**7**
Strongly disagree						Strongly agree

5. I would rather build a new Canvas course with Customizer than without it.

1	**2**	**3**	**4**	**5**	**6**	**7**
Strongly disagree						Strongly agree

6. I would like to use the Customizer system **with my real courses**.

1	**2**	**3**	**4**	**5**	**6**	**7**
Strongly disagree						Strongly agree

7. I would like to use a system like Customizer **in other contexts** outside of education.

1	**2**	**3**	**4**	**5**	**6**	**7**
Strongly disagree						Strongly agree

8. I would recommend the Customizer system to a friend or colleague.

1	**2**	**3**	**4**	**5**	**6**	**7**
Strongly disagree						Strongly agree

December 18, 2019

A.3 Study materials for Chapter 6

A.3.1 Consent form

SFU SIMON FRASER UNIVERSITY
ENGAGING THE WORLD

Study Number: 2017s0134

INFORMATION LETTER AND CONSENT FORM

Simon Fraser University

Date

Dear ***(insert participant's name):***

I am a researcher in the area of human-computer interaction in the Department of Computing Science at Simon Fraser University (SFU) and this letter is an invitation to consider participating in a study I am conducting on how course instructors customize their learning management systems (LMS). I would like to provide you with more information about this project and what your involvement would entail if you decide to take part.

The purpose of this study is to investigate common real-world usage patterns in *Customizer,* our new software help system that facilitates discovering, exploring, and sharing LMS customizations. Findings from the field of human-computer interaction and our ongoing studies of software learners indicate that many instructors lack the time and resources to learn in-depth about how to customize feature-rich classroom software like an LMS. With Customizer, instructors can discover how their colleagues have customized their LMS, interactively explore those customizations risk-free in the context of their own courses, and share their own customizations with others.

To evaluate the Customizer system, we are recruiting course instructors and teaching assistants who are actively teaching a course at SFU using the Canvas LMS to participate in a deployment study. The study will be carried out on your own time over the course of two weeks, with the option to continue using Customizer for up to 12 weeks if you wish. You will first meet with the researchers via video-conference (e.g., Zoom) to install the Customizer browser extension in Google Chrome (or another compatible browser) on your machine and receive instructors for doing so. Instructions will also be provided on how to uninstall Customizer at any point if you wish to withdraw from the study. This meeting will include a brief questionnaire (if you have not completed it beforehand) and should take only 10-15 minutes. For the remainder of the study, you will interact with Customizer to any extent you wish during your ordinary usage of the Canvas LMS. This phase of the study will last two weeks. It is suggested that you spend at least 30 minutes per week using Customizer, but ultimately the amount that you use Customizer is at your own discretion. A list of tasks that involve customizing a Canvas course will be provided for you to try completing during the two-week period. You will also be encouraged to record feedback on your interactions with Customizer by writing brief descriptions of your thoughts about your Customizer usage, through an anonymous online survey collected by the researchers throughout the duration of the study. After the completion of this 2-week deployment, you will be invited to meet again (via video-conference) with the researchers to participate in a semi-structured interview about your experience with Customizer. With your permission, this interview will be audio recorded and transcribed.

Following the completion of the 2-week deployment, you will be provided instructions via email for uninstalling the Customizer extension from your browser. However, if you wish to continue using Customizer, you may keep it installed for up to 12 more weeks. During this time, Customizer will continue to collect data on how you interact with it. You are free to uninstall Customizer at any time to conclude your participation in the study.

The findings from this study will only be reported as an aggregate and will not be able to identify you in any way. There is no cost to you for installing Customizer. In appreciation of your participation in the study, you will be offered a choice of **one of the following**:

- A $50 Amazon.ca gift card
- One hour of priority Canvas tech support from a member of the research team with expertise in this area, which you are free to schedule any time during the four months after your initial two-week deployment period. This tech support could include, for example, help with troubleshooting a problem in Canvas, instructions on using particular features, or advice on best practices.

Participation in this study is voluntary. It will involve a time commitment of your own choosing. You may decline to answer or participate in any part of the study. Further, you may decide to withdraw from this study at any time without any negative consequences by advising the researcher. With your permission, we will log the following when you explicitly interact with Customizer:

- Dates and times at which you use Customizer
- The duration of each interaction with Customizer
- The sequence of clicks made or text entered within Customizer
- Which shared customizations you use the Try It or Import features of Customizer on
- Which shared customizations you mark as helpful or add to your favorites
- Metadata about any customizations that you choose to share with others using Customizer, including the type of customization, any written explanation you add to it, and the complexity level you assign to it

Importantly, these logs will not include any information about your course materials, student enrollment, assignment work, or grades in the Canvas courses where Customizer is used. Only interactions within the Customizer system itself are captured, along with the URL of the Canvas page where the interactions took place. The "customizations" that can be shared within Customizer only represent changes to the settings and navigation structure of your Canvas courses, and do not include any information about the course's content or student data.

No data will be collected pertaining to any web pages on which you do not explicitly interact with Customizer. All logged interactions and feedback surveys will be anonymous and saved on a secure server accessible only to the researchers of this study. All information you provide is considered completely confidential. Your name will not appear in publication resulting from this study, however, with your permission anonymous quotations from the collected feedback surveys and interviews may be used. Only researchers associated with this project at SFU and UBC will have access. There are no known or anticipated risks to you as a participant in this study.

When information is transmitted over the Internet, privacy cannot always be guaranteed. The anonymous survey responses will be submitted directly to the researchers' server over a secure connection, with no intermediate external host. If you prefer not to submit your survey and interview responses over the Internet, please contact one of the researchers so you can participate using an alternative method such as through a phone call. The alternate method may decrease anonymity but confidentiality will be maintained.

This study is being undertaken by Laton Vermette in fulfillment of a PhD degree in Computing Science, under the supervision of Dr. Parmit Chilana ([redacted]) and Dr. Joanna McGrenere ([redacted]) at UBC. If you have any questions regarding this study, or would like additional information to assist you in reaching a decision about participation, please contact me by email at [redacted].

I would like to assure you that this study has been reviewed and received ethics clearance through the Office of Research Ethics in Simon Fraser University. However, the final decision about participation is yours.

I hope that the results of this study will be benefit you, and other course instructors around the world.

I very much look forward to speaking with you and thank you in advance for your assistance in this project.

Yours sincerely,

--

Laton Vermette
Department of Computing Science
Simon Fraser University
Burnaby, BC V5A 1S6
Email: [redacted]

CONSENT FORM

By signing this consent form, you are not waiving your legal rights or releasing the investigator(s) or involved institution(s) from their legal and professional responsibilities.

I have read the information presented in the information letter about a study being conducted by Laton Vermette at Simon Fraser University. I have had the opportunity to ask any questions related to this study, to receive satisfactory answers to my questions, and any additional details I wanted.

I am aware that I am giving consent to log the URLs of web pages on which I explicitly interact with Customizer, as well as navigation actions I take in Customizer and the amount of time I spend using features of Customizer, during the course of this study, with the understanding that this data will be anonymous. If I feel uncomfortable, I will let the researcher know in advance.

I am also aware that excerpts from the entries I write in the anonymous feedback survey or say in the interview during this study may be included in the thesis and/or publications to come from this research, with the understanding that the quotations will be anonymous.

I was informed that I may withdraw my consent at any time without penalty by advising the researcher.

With full knowledge of all foregoing, I agree, of my own free will, to participate in this study.

☐YES ☐NO

I agree to have the following recorded during this study: 1) the URLs of web pages on which I explicitly interact with Customizer, 2) any navigation actions I take within Customizer, and 3) the amount of time I spend interacting with the features of Customizer.

☐YES ☐NO

I agree to be interviewed by the researchers following the deployment study, with the understanding that this interview will be audio recorded and transcribed.

☐YES ☐NO

I agree to the use of anonymous quotations in any thesis or publication that comes of this research.

☐YES ☐NO

Participant Name: _____ (Please print)

Participant Signature: _____ Date: _____

A.3.2 Recruitment email

Are you a course instructor using Canvas? Do you wish you could easily experiment with examples of useful Canvas features and customizations suggested by your colleagues? Want to contribute to improving the usability of learning management systems (LMS)? If so, we would like you to participate in our study at Simon Fraser University on evaluating a new example-based approach to customizing an LMS.

What is this study about?
The purpose of this study is to investigate the common usage patterns for *Customizer*, our new software platform that helps educators discover, experiment with, and share LMS customizations. Findings from this study can help to support educators in learning complex classroom software and learning ways to innovate on their online course delivery.

Who's eligible?
We are looking for participants (at least 18 years old) who:

- Are a course instructor or teaching assistant at SFU
- Have taught a course using Canvas, or plan to teach during this year's summer term
- Have access to their own desktop or laptop computer capable of running Google Chrome
- Are available to use Customizer and provide feedback during a two-week period starting between April 29 and May 31, 2021

How long will it take?
Participating in this deployment study involves installing the Customizer browser extension for a **period of two weeks**, during which you will be asked to spend approximately **30 minutes per week** completing certain tasks in a Canvas course (separate from your real courses). However, you are encouraged to try using Customizer with your real courses as well if you would like to. In appreciation of your participation, you will be offered a choice between **a $50 Amazon.ca gift card**, or up to **one hour of priority Canvas tech support** at a time of your choosing during the four months after the end of the study.

I would like to assure you that this study has been reviewed and received ethics clearance through a Simon Fraser University Research Ethics Board. However, the final decision about participation belongs to you.

If you wish to sign up for the study, have any questions, or would like additional information to assist you in reaching a decision about participation, please contact me by email at ([redacted]). This study is being undertaken by Laton Vermette in fulfillment of a PhD degree in Computing Science under the supervision of Dr. Parmit Chilana at SFU ([redacted]) and Dr. Joanna McGrenere at UBC ([redacted]). This email is being sent on the behalf of the researchers.

Yours sincerely,

Laton Vermette
Department of Computing Science
Simon Fraser University
Burnaby, BC V5A 1S6

A.3.3 Scenario and tasks for deployment week 1

Scenario

The next school term is beginning in two weeks, and you have just started setting up a new Canvas course for the class you'll be teaching about basic computer skills (CMPT 9999). The course will be delivered fully online to over 100 first-year students. The department has asked you to **use Customizer** to see how other experienced instructors have customized their courses, and **follow their examples** when setting up your online Canvas course. Ideally, you would like to learn about and use innovative teaching tools that showcase the strengths of the online teaching medium.

Remember that your overall goal in this study is to use Customizer and provide feedback on its features and usability. For most of the tasks, there is no "right answer". The customizations you choose to explore and try are up to you. We are not evaluating your knowledge or skills with Canvas, or how well you perform these tasks.

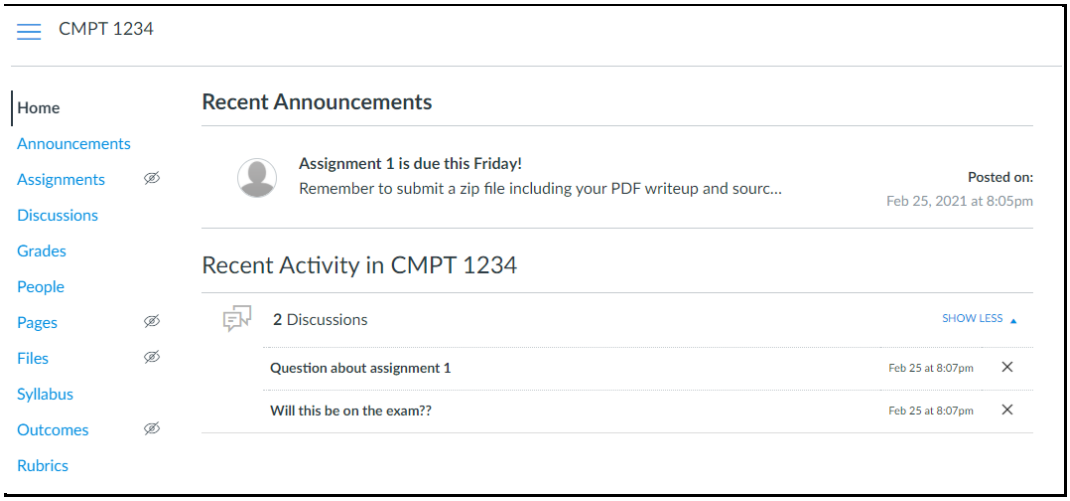
Week 1 Deployment Tasks

Task 1

Because your CMPT 9999 course will be delivered online, you want to make sure your course is organized, easy to navigate, and makes students aware of upcoming deadlines. Your goal is to **explore different ways to customize your course pages** (e.g., Home page, Discussion boards, Announcements) based on what other instructors have shared in Customizer.

You are encouraged to try some of the examples that other instructors have shared using Customizer's Try It feature. We recommend that you try at least a few different customizations for comparison. The customizations you choose are up to you -- there is no "right answer" for this task.

For example, in the image below, an instructor has customized their home page to show some recent announcements, discussions, and other course activity.



Task 2

Your CMPT 9999 course in Canvas includes a discussion board where students can post questions and discuss course material. You're planning to use the discussion board frequently for certain assignments and to encourage students to participate actively. As such, your goal is to explore some examples of how to **customize your course's discussion board** for various purposes like moderation and student engagement. Choose at least one customization to add to your discussion board for CMPT 9999 using the Import feature in Customizer.

As before, there is no "right way" to complete this task. We recommend that you try out a few options based on the examples shared by other instructors in Customizer.

Task 3

For your CMPT 9999 course, you plan to have many assignments, quizzes, and project checkpoints -- placeholders for these have already been provided for you in the course, and you do not need to write any content for them. Rather, you need these items to have their grading weighted according to the syllabus, and it would be cumbersome to calculate all of the weights manually. Instead, you have heard it is possible to **assign weights to entire groups of course material** so that Canvas **automatically re-weights** the individual items as needed.

As specified in the CMPT 9999 syllabus, the project submissions should collectively be worth 50% of the grade, assignments should be worth 30% of the grade, and quizzes 20%. Using Customizer, find examples of how other instructors have accomplished similar goals and apply them to your course. Since grading schemes vary from course to course, you may need to modify what other instructors have done to match your CMPT 9999 weights.

Task 4 **(Open-ended exploration task)**

One of your goals for this new course is to innovate on your teaching practices and try new things. Accordingly, you are looking for inspiration from other instructors on more interesting changes or additions you could make to your course.

Take some time to further **browse and explore what other instructors have shared in Customizer**, and find a customization entirely of your choice that you think would be interesting to use or that you didn't know about before. You are encouraged to use the Try It feature to experiment with different customizations, before importing your favourite one(s) into the CMPT 9999 course.

A.3.4 Tasks for deployment week 2

Week 2 Deployment Tasks

Task 5

You want to hold check-in meetings with project groups halfway through the term. Rather than individually creating an appointment with each team, your goal is to have Canvas **automatically create a group of appointments** within a given timeframe, which students & teams can sign up for.

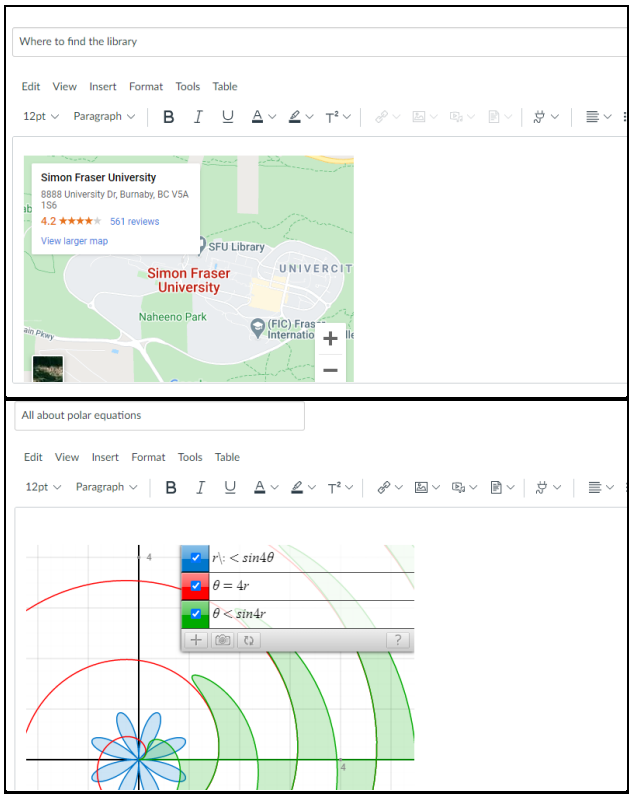
Enrollment for the class is likely to be high, so you will need a group of at least 24 appointments, each 15 minutes long, throughout the day on June 9, 2021. Do not manually create each appointment one-by-one! Instead, use Customizer to see examples of how other instructors have solved this problem efficiently, and apply their methods to your CMPT 9999 course.

Task 6

Some instructors add external tools to their Canvas courses to access useful new features. Your goal is to **try installing a Canvas app into your course** that lets you embed interactive external content into your course pages. For example, some apps let you embed things like **Google maps, interactive graphs (shown in images below), or Twitter feeds** into a course page – this is not an exhaustive list.

You would like to innovate on your teaching practices by trying one or more external apps in your CMPT 9999 course. Using Customizer, find examples of app-related Canvas customizations that have been shared by other instructors, and use the Import feature to install one or more of them into your course. As usual, there is no "right answer" for which apps you choose to import.

After adding the app, you should be able to see and test it by starting to create a new course page. It will appear in the "Apps" menu on the editor toolbar, indicated by a plug icon. (Note: due to Canvas limitations, sometimes it can take 5-10 minutes before a newly-added app shows up in this toolbar.)



Task 7 **(Open-ended authoring task)**

Future instructors could benefit greatly from varied and interesting content being shared through Customizer. Think back to past courses you've taught with Canvas -- were there any customizations you made to course settings or structure in Canvas that you were particularly fond of, or think other instructors would find useful? What are the most helpful features of Canvas you've used in the past?

If so, please take a moment to navigate to one of your past courses, analyze its settings with Customizer, and share any of your past customizations with an explanation of your rationale behind it. You may do this for multiple courses and customizations if you like. Alternatively, if you prefer, you can try recreating these customizations in your CMPT 9999 course, and share them from there.

You are always welcome to get in touch with the researchers if you remember something you would like to share but are having trouble finding or recreating it.

Remember that Customizer does not use or share any sensitive course content such as any student information (e.g., enrollments, grades), or assignment content -- it only analyzes high-level changes to the settings or structure of the course.

A.3.5 Pre-deployment demographics and LMS usability questionnaire

Customizer Study Consent & Pre-Deployment Survey

Demographics

Thank you for joining the Customizer deployment study. Please begin by answering the following demographic questions.

* 5. What is your participant ID?
(You will have received this in the same email that linked you to this survey)

* 6. What is your age?

- ◯ 19-30
- ◯ 31-40
- ◯ 41-50
- ◯ 51-60
- ◯ 61+

* 7. What is your gender?

- ◯ Male
- ◯ Female
- ◯ Prefer not to answer
- ◯ Other (please specify)

* 8. What is the highest level of education you have completed?

- ◯ High school
- ◯ Bachelor's
- ◯ Master's
- ◯ PhD
- ◯ Advanced professional degree (e.g., MD)
- ◯ Other (please specify)

* 9. What are the main subject areas/topics that you teach?

* 10. How many years of experience do you have with classroom teaching?

- ◯ Less than 1 year
- ◯ 1-5 years
- ◯ 6-10 years
- ◯ 11-15 years
- ◯ 16-20 years
- ◯ 21+ years

* 11. What is your current job title?

- [ ] Teaching Assistant
- [ ] Assistant Professor
- [ ] Sessional Instructor
- [ ] Associate Professor
- [ ] Lecturer
- [ ] Professor
- [ ] Senior Lecturer
- [ ] Post-doctoral Fellow
- [ ] Other (please specify)

* 12. During a teaching semester, on how many days each week do you usually use Canvas?

- ◯ Less than 1 day each week
- ◯ 5-6 days
- ◯ 1-2 days
- ◯ Every day
- ◯ 3-4 days

* 13. During a teaching semester, how many hours per week do you usually spend using Canvas?

- ◯ Less than 1 hour per week
- ◯ 7-9 hours
- ◯ 1-3 hours
- ◯ 10+ hours
- ◯ 4-6 hours

* 14. Other than Canvas, what learning management systems (LMS) do you have experience using in a teaching role?

- [ ] Blackboard
- [ ] Google Classroom
- [ ] Moodle
- [ ] Microsoft OneNote (Class Notebook)
- [ ] CourSys
- [ ] Microsoft Teams
- [ ] D2L (Brightspace)
- [ ] Other (please specify)
- [ ] None of the above

15. What other software applications do you regularly use as part of your teaching, if any?

* 16. How do you usually learn about new features in Canvas? (Select all that apply)

- [ ] From other instructors in my department
- [ ] From other instructors outside of my department
- [ ] From technical support staff in my department
- [ ] From technical support staff outside of my department
- [ ] From SFU's IT Service desk (ITS)
- [ ] From online forums or guides about Canvas
- [ ] From blogs or other social media
- [ ] On my own, through trial-and-error or exploration
- [ ] Other (please specify)

- [ ] None of the above

* 17. When you are stuck or need help with something in Canvas, where do you usually seek help? (Select all that apply)

- [ ] From other instructors in my department
- [ ] From other instructors outside of my department
- [ ] From technical support staff in my department
- [ ] From technical support staff outside of my department
- [ ] From SFU's IT Service desk (ITS)
- [ ] From online forums or guides about Canvas
- [ ] From blogs or other social media
- [ ] On my own, through trial-and-error or exploration
- [ ] Other (please specify)

- [ ] None of the above

Usability of the Canvas LMS

This page will ask you to rate your agreement with several statements about your experience with the Canvas LMS. Please answer these questions by making a selection that best represents your opinion.

* 1. What is your participant ID?
(You will have received this in the same email that linked you to this survey)

* 2. Please rate the extent to which you agree or disagree with the following statements.

	Strongly disagree	Disagree	Slightly disagree	Neither agree nor disagree	Slightly agree	Agree	Strongly agree
It is easy to learn how to use Canvas.	◯	◯	◯	◯	◯	◯	◯
I find Canvas to be confusing.	◯	◯	◯	◯	◯	◯	◯
I enjoy using Canvas.	◯	◯	◯	◯	◯	◯	◯
I would like to use Canvas when building my courses in a future term.	◯	◯	◯	◯	◯	◯	◯
I would recommend Canvas to other instructors.	◯	◯	◯	◯	◯	◯	◯

* 3. Please rate the extent to which you agree or disagree with the following statements.

	Strongly disagree	Disagree	Slightly disagree	Neither agree nor disagree	Slightly agree	Agree	Strongly agree
I have control over what happens in my courses on Canvas.	◯	◯	◯	◯	◯	◯	◯
I have the resources necessary to use Canvas effectively.	◯	◯	◯	◯	◯	◯	◯
I have the knowledge necessary to use Canvas effectively.	◯	◯	◯	◯	◯	◯	◯
Canvas is compatible with my way of thinking.	◯	◯	◯	◯	◯	◯	◯
I am able to anticipate what will happen next in response to my actions in Canvas.	◯	◯	◯	◯	◯	◯	◯
Canvas feels responsive to the actions I perform.	◯	◯	◯	◯	◯	◯	◯
My interactions with Canvas feel natural.	◯	◯	◯	◯	◯	◯	◯
I am confident that I can build effective courses in Canvas.	◯	◯	◯	◯	◯	◯	◯

* 4. Please rate the extent to which you agree or disagree with the following statements.

	Strongly disagree	Disagree	Slightly disagree	Neither agree nor disagree	Slightly agree	Agree	Strongly agree
I am aware of what Canvas features my colleagues are using in their courses.	○	○	○	○	○	○	○
I am curious about how my colleagues have customized their courses in Canvas.	○	○	○	○	○	○	○
I feel like I am missing out on potentially useful Canvas features.	○	○	○	○	○	○	○

* 5. Please describe how easy or difficult you find the following.

	Very difficult	Difficult	Slightly difficult	Neither easy nor difficult	Slightly easy	Easy	Very easy
Leveraging my colleagues' experience to improve my Canvas courses is currently...	○	○	○	○	○	○	○

6. Is there anything else you would like to share about your experience using the Canvas LMS?

A.3.6 Mid-deployment feedback form

Customizer Feedback

Please answer the following questions about your recent experiences using Customizer.

* 1. What is your participant number?

* 2. Have you used Customizer recently (within the last 3 days)?

- ◯ Yes (please answer the remaining questions)
- ◯ No (please skip to the end)

3. If you answered yes, to what extent do you agree with the following statement?

	Strongly disagree	Disagree	Slightly disagree	Neither agree nor disagree	Slightly agree	Agree	Strongly agree
I found Customizer **useful** during my recent usage of it.	◯	◯	◯	◯	◯	◯	◯

4. Briefly describe what you have done using Customizer recently.

5. To what extent did you find Customizer **enjoyable** or **frustrating** for the tasks you listed above?

	Strongly disagree	Disagree	Slightly disagree	Neither agree nor disagree	Slightly agree	Agree	Strongly agree
I found Customizer **enjoyable** to use.	◯	◯	◯	◯	◯	◯	◯
I found Customizer **frustrating** to use.	◯	◯	◯	◯	◯	◯	◯

6. If you would like to share more details about what you found enjoyable or frustrating in your recent Customizer usage, please explain here. To upload any screenshots from your recent Customizer usage, please visit this link.

A.3.7 Post-deployment usability questionnaire

Customizer Post-Deployment Questionnaire

Usability of Customizer

This page will ask you to rate your agreement with several statements about your experience **using Customizer on the Canvas LMS**. Please answer these questions by making a selection that best represents your opinion.

* 1. What is your participant ID?

* 2. Please rate the extent to which you agree or disagree with the following statements about Customizer.

	Strongly disagree	Disagree	Slightly disagree	Neither agree nor disagree	Slightly agree	Agree	Strongly agree
It is easy to learn how to use Customizer.	◯	◯	◯	◯	◯	◯	◯
I find Customizer to be confusing.	◯	◯	◯	◯	◯	◯	◯
I enjoy using Customizer.	◯	◯	◯	◯	◯	◯	◯
I would like to use Customizer when building my courses for a future term.	◯	◯	◯	◯	◯	◯	◯
I would like to use Customizer to share my customizations with other instructors.	◯	◯	◯	◯	◯	◯	◯
I would recommend Customizer to other instructors.	◯	◯	◯	◯	◯	◯	◯

* 3. Please rate the extent to which you agree or disagree with the following statements about Customizer.

	Strongly disagree	Disagree	Slightly disagree	Neither agree nor disagree	Slightly agree	Agree	Strongly agree
Customizer can help me discover new ways to improve my courses.	◯	◯	◯	◯	◯	◯	◯
Using Customizer can help me improve or deepen my understanding of Canvas features.	◯	◯	◯	◯	◯	◯	◯
I find Customizer's Try It feature helpful for testing out new changes.	◯	◯	◯	◯	◯	◯	◯
Using Customizer in my job could save me time.	◯	◯	◯	◯	◯	◯	◯
When using Customizer, I feel more willing to try new Canvas features.	◯	◯	◯	◯	◯	◯	◯
Customizer can help me innovate on my teaching methods.	◯	◯	◯	◯	◯	◯	◯

* 4. Please rate the extent to which you agree or disagree with the following statements about Customizer and Canvas.

	Strongly disagree	Disagree	Slightly disagree	Neither agree nor disagree	Slightly agree	Agree	Strongly agree
With Customizer, I have control over what happens in Canvas.	○	○	○	○	○	○	○
With Customizer, I have the resources necessary to use Canvas effectively.	○	○	○	○	○	○	○
With Customizer, I have the knowledge necessary to use Canvas effectively.	○	○	○	○	○	○	○
With Customizer, Canvas is compatible with my way of thinking.	○	○	○	○	○	○	○
With Customizer, I am able to anticipate what will happen next in response to my actions in Canvas.	○	○	○	○	○	○	○
With Customizer, Canvas feels responsive to the actions I perform.	○	○	○	○	○	○	○
With Customizer, my interactions with Canvas feel natural.	○	○	○	○	○	○	○
With Customizer, I am confident that I can build effective courses in Canvas.	○	○	○	○	○	○	○

* 5. Please rate the extent to which you agree or disagree with the following statements.

	Strongly disagree	Disagree	Slightly disagree	Neither agree nor disagree	Slightly agree	Agree	Strongly agree
With Customizer, I am aware of what Canvas features my colleagues are using in their courses.	◯	◯	◯	◯	◯	◯	◯
With Customizer, I feel curious about how my colleagues have customized their courses in Canvas.	◯	◯	◯	◯	◯	◯	◯
With Customizer, I feel like I am missing out on potentially useful Canvas features.	◯	◯	◯	◯	◯	◯	◯

* 6. Please describe how easy or difficult you find the following.

	Very difficult	Difficult	Slightly difficult	Neither easy nor difficult	Slightly easy	Easy	Very easy
With Customizer, leveraging my colleagues' experience to improve my Canvas courses would be...	◯	◯	◯	◯	◯	◯	◯

7. Is there anything else you would like to share about your experience using Customizer?