

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

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## ABSTRACT

Although modern classrooms are increasingly moving towards digital immersion and personalized learning, we have few insights into K-12 teachers' current practices, motivations, and barriers in setting up their digital classroom ecosystems. We interviewed 20 teachers on their process of discovering and integrating a vast range of productivity software and educational platforms in their classrooms, with a particular focus on how they personalize the UI and content of these tools (e.g., with plugins, templates, or option menus). We found that teachers largely depended on their own experimentation and professional circles to find, personalize, and troubleshoot software tools to support student needs or their own preferences. Teachers were often hesitant to attempt more advanced personalizations due to concerns over student confusion and increased troubleshooting load. We derive several design implications for HCI to better support teachers in sharing their personalized setups and helping their students benefit from digital immersion.

## CCS CONCEPTS

- Human-centered computing → Empirical studies in HCI.

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## KEYWORDS

Digital classroom tools, Educational technology, Personalization

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## 1 INTRODUCTION

Digital tools used in the classroom are part of a rapidly growing multibillion-dollar educational technology market [65], with millions of students and teachers signing up as the barriers to entry drop [12]. 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 [42, 64]. This spans 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 [47, 63]. 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 [63].

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 [8, 25, 57]. 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 [7, 31], 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 paper, 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.

## 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.

### 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 [50, 58], educational beliefs and attitudes relating to technology [15, 26, 32, 35, 48, 54, 62], and skills or experience with technology in general [15, 32, 48, 50, 53]. 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 [3, 21, 65] and if their colleagues and administrators promote a supportive school culture that rewards pushing the boundaries [65]. However, other research casts doubt on the idea that this improved access to technology is enough to meaningfully change existing teaching practices [11]. It is also well-known that teachers are routinely pressed for time, which negatively impacts their ability to integrate new technology [3, 21, 32, 54] and to properly vet and adapt new tools and resources to meet curriculum or privacy standards [17, 38, 44, 52, 53].

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.

### 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 [14]. Informal workplace learning is commonly facilitated through interactions with colleagues [18]. Studies of teachers and teacher education have already explored informal on-the-job learning strategies from the perspective of both new and experienced teachers [27, 28, 37]. 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 [64]. Teachers value communities of practice for exchanging curriculum-related details [13], improving pedagogy, and reflecting back on policies and education strategies [56]. Increasingly, these communities are not just within a particular school or school district, but also moving online [29], 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.

### Design of Digital Classroom Tools

There is another body of literature evaluating novel digital classroom tools against student learning outcomes [30, 59, 60], but comparatively little that considers the teacher's own experience [22], especially with regard to learning and troubleshooting these tools. Recent innovations aim to alleviate teachers' cognitive burden by supporting them in managing the "flow" of their classroom [10] or by leveraging principles like peripheral interaction and ambient displays to address the distracting, multitasked nature of their job [1, 2, 4, 5]. However, research in this space focuses on evaluating specific tools, providing few insights into the broader classroom integration perspective, 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 [9], adding further complications to teachers' support loads.

Our study, by contrast, seeks to provide a broader picture. As we describe, it is rarely smooth sailing after the decision to adopt new software, and these studies typically do not address the high-level challenges that arise day-to-day in digital classrooms.

### 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 [6, 45], or changes to the layout and access points to features [19]. Other work focuses on the mechanism for making adaptations to the interface, in order to facilitate making customizations in the first place [55]. At a broader level, research has looked at the extensibility of a software tool in terms of the functionality it offers [23] or interoperation of several software tools [41].

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

[33] and general usability [45], much of the work focuses on improving efficiency in terms of providing faster access to used features [16, 63], sometimes for users with special needs [20], and to make the software more useful [23].

From a different angle, there has been research that characterizes the individuals performing the customization and their approaches. For example, the "translators" [39] and "tinkerers" [41] capture dimensions such as a user's motivation and level of expertise. Upfront vs. as-you-go approaches [46] capture the timing in individual customization strategies. Others have looked at the relationships between customization and an individual's sense of control and identity [43], and the role of customization authors in customization sharing ecosystems, online spaces through which customization authors can host and share them with others [24].

There is no agreed-upon definition for customization [24]. 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 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.

### 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

**Table 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

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 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.

### 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.

### 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 [61] 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.

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

### **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 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.

**Table 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

*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)*

### **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.

### 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.

As shown in Table 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... [students] 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*

**Table 3: Examples of the most widespread varieties of customization**

Customization Type	Teachers (/20)	Example
<b>UI Customizations</b>		
Changing UI preferences/options	9	<i>"I'm still figuring out some of the privacy options on Teams... can the kids comment on one another?" (P14)</i>
Installing software plugins	9	<i>"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)</i>
Changing visual layout	5	<i>"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)</i>
Cosmetic theme/color changes	5	<i>"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)</i>
<b>Content customizations</b>		
Creating reusable template content	8	<i>"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)</i>
Adapting/individualizing content/subject difficulty	4	<i>"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)</i>
<b>UI + Content customizations</b>		
Meticulous organization of content structure or setup	12	<i>"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)</i>

*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.

### 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... T-here'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)*

## 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.

### 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 [32, 35, 50], 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 [36, 49, 51], 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.

### 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 [41]. 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 [55] 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 [39] 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.

### 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 [40]. 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., [34]) 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 [9], 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.

### 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.

## 6 CONCLUSIONS

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. 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.

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