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# Youths' Usage of an Informal Chatting Tool in an After-school 3D Print Shop

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Digital technological advancements have been a driving force in the continued evolution of the modern workplace. One notable change is an increased reliance on informal chatting tools in support of both distributed and co-located work. However, while researchers have recognized the growing prominence of these tools in work, little is known about how to best support youth who have grown up with access to interconnected technologies in acquiring and practicing the relevant skills needed to effectively communicate using these tools. In this study, we studied youth's utilization of Slack, a popular workplace chatting tool, in an after-school 3D print shop. Using in-depth semi-structured interviews, we uncovered the factors that supported or hindered youth employees' Slack use in a technical work context. This work offers implications for how to design youth workplace communication and coordination protocols that support the needs of this population.

CCS Concepts: • **Human-centered computing** → **Empirical studies in collaborative and social computing**.

Additional Key Words and Phrases: youth, after-school employment, chatting tools, Slack

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## 1 INTRODUCTION

Technological advances are making it easier for people to cooperate on complex projects regardless of location [36, 52, 54]. In the context of work, these projects can be accomplished using a variety of digital tools including file-sharing services, video and data conferencing solutions, and chatting applications such as Slack<sup>1</sup> and Microsoft Teams<sup>2</sup> [19, 53]. However, despite the widespread availability of these technologies, prior work has noted that there are many barriers preventing their successful implementation and use [24]. Additionally, as new jobs are created in response to the changing landscape of work, there is an increasing need to re-skill and up-skill our existing workforce [40, 56]. In the face of shifting workplace conditions and requirements, it is crucial to consider ways to better equip the workforce of the future for success in the modern workplace. One

<sup>1</sup><https://slack.com/>

<sup>2</sup><https://products.office.com/en-us/microsoft-teams/group-chat-software>

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such opportunity is to further investigate how youth learn to adopt coordination and collaboration tools intended for the workplace.

Unlike much of the existing adult workforce, many youth in the United States have spent most of their lives with access to inter-networked technologies [44]. According to a 2018 report, as much as 95 percent of youth in the United States own or have access to a smart phone and 45 percent say that they are online almost constantly throughout the day – often as a way to remain connected to others [2]. Furthermore, estimates suggest that as much as 97 percent of youth use at least one social network [2], but many actually manage a presence on multiple sites [3]. Although these numbers do not reflect the disparities in access due to socioeconomic factors (e.g., the cost of broadband Internet), they indicate a high degree of connectivity. While there exists a narrative which has likened youth to “native speakers” of the digital language of computers, video games and the Internet” who simply possess technical skills and literacies that adults do not [44], critics have suggested that this stance lacks nuance, over-emphasizes a divide between generations [5, 50], and that there is no correlation between technical proficiency and age [28]. Towards this end, we seek to better understand what factors support or hinder youths’ learning and effective use of communication technologies in work training environments, and how we can better position them for success in further developing these skills that are widely considered to be valuable for the 21st century workplace [13, 28].

In this interview study, we investigated the factors that support or limit the effective use of Slack by youth employees in the context of an after-school 3D print shop located at the Digital Harbor Foundation (DHF), an educational non-profit in Baltimore City, a mid-sized city in the Eastern United States. Slack is a widely-used communication and coordination tool that has been gaining adoption in a range of workplaces [17, 57]. The context we studied is similar to many modern workplaces that combine online and offline activities, requiring employees to initiate and maintain face-to-face and virtual communication to successfully complete job tasks [16, 53]. This work is guided by the following research question: What are the factors that support or limit youth’s effective use of Slack in an employment training context? Investigating this question can inform the design of future youth job training programs that support the development of skills necessary for effective electronic communication in the workplace.

We conducted eleven in-depth semi-structured interviews with two cohorts of print shop employees, each of whom worked together for approximately 18 months. Our findings show that while the youth were motivated to use Slack for coordinating print jobs and troubleshooting, they also faced a number of challenges preventing them from substantially and consistently using the tool. These results provide insights into the experience of youth with digital communication and coordination tools in the workplace and contribute to a better understanding of how to design more effective training programs and tools for this populations.

## 2 RELATED WORK

Work is inherently social in nature [47]. As human beings, we face both physical and mental limitations to what we can accomplish independently. To move beyond these constraints and get more done, we are motivated to cooperate with others [47]. Given this, a long-standing focus of scholars in the computer-supported cooperative work (CSCW) community has been to explore ways to design and implement new technologies that support cooperative work environments (e.g., [27, 31, 37, 48]). However, despite this need, prior work has noted that there are many challenges associated with introducing new collaborative technologies to teams and organizations – these factors include potential disparities between the additional work required to use the new tool and the benefits received, failing to obtain critical mass within an organization, and tools that are unable to accommodate for a wider variety of activities [24]. Furthermore, prior work has found

that coordination technologies cannot be too rigid, and should be modifiable to fit the work at hand [48]. Organizational elements – such as policies, norms and reward systems – and people's technological frames (i.e., mental models) are also important factors which influence how new tools will be used [43]. Additionally, in many work contexts, it is important for workers to be able to maintain awareness of individual and group activities during cooperative work [15]. However, once the limits of transparency afforded by a tool are reached, workers begin communicating with each other [11]. In order to cooperate, workers regularly leverage a variety of productivity and communication tools – these include not only custom-built systems, but also mainstream solutions such as email, blogs, social media services, and informal chatting tools [12, 19, 53]. Due to the complexity of work processes, these tools are often appropriated to fill specific roles based on their strengths and weaknesses [19, 53]. In this paper, we examine the usage of Slack, a popular work-oriented chatting tool in a youth-staffed 3D print shop.

## 2.1 Chatting In the Workplace

In recent years, chatting tools have become increasingly common in workplaces [10, 26, 57]. Prior work has examined the design, usage and adoption of these tools in numerous contexts including with workers at telecommunication and internet companies [42], researchers [55], nurses [30], and software developers [26]. Chatting tools are often characterized by the informal nature of conversations carried out over them, compared to other traditional communication media such as email [42, 53]. Their design also allows for more immediacy than other media – users can quickly compose messages and receive responses almost instantly if the recipient is available [18, 53]. Some prior work has noted that the instantaneous nature of chatting tools may lead to potential distractions for workers [53] while others have identified ways that workers are able to leverage these tools to more effectively manage their disruptions [18, 42]. Prior work has also identified several limitations associated with the design of chatting tools including the inability to easily share detailed or large amounts of information (especially for technical work), establish common ground, maintain awareness, coordinate discussion, and pick up on important social cues such as body language [53, 55]. Efforts have also been made to extend the basic functionality of chatting tools to address these shortcomings [51, 57]. For example, in a 2018 study, Zhang and Cranshaw developed Tilda, a tool designed to support Slack users with sensemaking [57]. To highlight important information in conversation threads, this tool enabled users to collaboratively add notes to messages while in the process of conversing, or tags to already existing messages [57]. These tags and notes were then used by the system to create and deliver structured summaries of conversations to users [57].

There is also work that has examined strategies and barriers to successful adoption of chatting tools in the workplace. For example, Herbsleb et al. reported on their experiences introducing the Rear View Mirror (RVM) chatting tool to a multi-site software development team [26]. Despite offering one hour training sessions, the authors found that this tool was only being used by 10% of its potential user base. Some participants considered chatting to be a superfluous activity and not really part of work, while others had concerns about sharing sensitive information over chat, wanting to limit interactions with certain colleagues from other teams, or privacy concerns about their availability being broadcast to others [26]. In a study on the Babble chatting tool, Bradner et al. noted that waylaying behaviors (or to lie in wait for others to come online), enabled by the tool's awareness and visibility features allowed users to seek out help when needed, but also made it easier for managers to assign additional work, which inhibited usage [7]. A longitudinal study by Muller et al. found that users of the Lotus Sametime chatting tool began to make use of similar awareness and visibility features as they became more experienced [41]. Scholars have also documented instances where personal chatting tools have become embedded in the workplace.

Karusula et al. examined the adoption of chatting tools by hospital workers as an organizational phenomenon – despite not being endorsed as an official tool, nurses frequently used WhatsApp to engage in work-related interactions as a form of invisible work, even in their personal time [30].

Beyond studying how to introduce chatting tools, research has also sought to describe and understand how these tools are used in different work contexts. In an ethnographic study on 20 workers' usage of chatting tools, Nardi et al. found participants used messaging to receive answers to quick questions, and that they often engaged in intermittent communication over longer periods of time, as a preamble to negotiate availability for more intense work conversations (e.g., scheduling a phone call or face-to-face meeting), and to maintain social connections to others [42]. Handel and Herbsleb analyzed chat logs from three organizations based on content and identified five main categories of use – negotiating availability, non-work topics (e.g., personal interests), work, greetings, and humor [25]. In another study, McGregor et al. conducted an ethnographic study of how chatting platforms are incorporated into six workplaces in India and Kenya [39]. They found that chat platforms were integrated with the existing organizational structures and work practices already in place at each site. The use of chat platforms provided moderate gains in direct communication and awareness between staff.

Finally, studies in this space have sought to understand patterns of use. Isaacs et al. analyzed over 61,000 instant messages and found that frequent users engaged in more rapid interactions than infrequent users and that pairs who frequently messaged each other had longer threads of interaction [29]. Avrahami and Hudson analyzed over 90,000 instant messages from 16 users and found that there were significant differences in how people communicated for work and personal purposes – people communicated for longer periods for personal conversations, but replied more quickly in conversations related to work [4]. While the adoption and use of chatting tools in the workplace is a well-studied area, this body of work largely focuses on the adult workforce. Less is known about how youth may adapt to using chatting tools in professional work environments. However, given that effective communication, collaboration, and usage of information and communication technologies are widely considered to be valuable skills for the 21st century workplace, [13, 28] the DHF 3D print shop offers a valuable opportunity to explore this research gap.

## 2.2 Youth Chatting at Home, School, and Work

There is a large body of work which has examined youths' usage of chatting tools (i.e., instant messaging [22], texting [20, 21] and video chatting [9]) at home and at school. Factors potentially motivating youths' usage of chatting tools include perceived usefulness (in completing work tasks), social usefulness, and media richness [1]. Prior work has noted that youth commonly use these tools as a direct and immediate way to socialize with others, plan events, or collaborate on school work [22, 46]. Grinter and Palen found that youth often build social groups on these technologies that mirror their real life relationships (e.g., friends at school) [22]. Additionally, while chatting enables youth to remain connected with others at times when social interactions would traditionally not be permitted, their usage at home is highly responsive to expectations associated with domestic schedules (e.g., performing chores in the evening) [22]. In an extension of this work, they found that chatting tools served as a means of liberation for youth who would regularly engage in strategies such as muting their devices to maintain control over who was aware of their actions (e.g., not allowing parents to see that they are messaging someone) [23]. Grinter and Palen also found that youth regularly equate an "online" status with conversational availability, and like adults, engage in waylaying behaviors to maximize their interaction time with others [23]. Finally, in a study of young adults, Sarjonaja et al. found that users frequently posted repetitious or mundane "small talk" status updates on Facebook to appear active on the social network to increase social capital and enact social cohesiveness [45].

There are also studies that have examined youths' usage of chatting tools in contexts outside of the the home, such as school or the library. Studies on the use of instant messaging tools in the classroom have found that they can potentially have a positive impact on student engagement [49]. In a 2014 study, Bouhnik et al. examined communication between high school students and their teachers over WhatsApp [6]. They identified several benefits including increased opportunities for teachers to get to know their students and an improved ability share course materials – however, one challenge associated with increased access to teachers was a student expectation that they would be able to reach their teachers 24 hours a day [6]. In a more recent study, Magee et al. identified several factors that contribute to youth's technology use across multiple contexts, including local policies and access, affective factors, life stage and future goals and relationships [35].

In previous studies on youth-staffed print shops, Easley et al. observed the strategies used by youth employees during critical handoff incidents, where employees had to coordinate their work asynchronously [16]. During jobs where unsuccessful handoffs occurred, coordination technology such as Slack were often used minimally, if at all. This lack of coordination often resulted in wasted resources, missed deadlines or lost business. In a follow-up study, they found that the print shop's managers felt that the youth were not using Slack as often as they could and would regularly make efforts to encourage them to become more proactive in posting and more responsive to the messages sent by others. However, one factor which may have partially contributed to the youths' low activity levels was a steep learning curve associated with this tool [17]. These findings motivated our study, which examined the reflection of youth employees from two cohorts on how and why they used or did not use Slack in the print shop and broadened the scope of the study to workplace communication beyond handoffs. To date, very limited prior research has examined how youth use chatting tools in workplace and technical training contexts. Building on prior work and closing the knowledge gap on youths' communication practices in work environments, motivated our current study of youth Slack use at the DHF 3D Print Shop.

### 3 THE DIGITAL HARBOR FOUNDATION (DHF) 3D PRINT SHOP



Fig. 1. The workspace at the DHF Print Shop.

Our research took place at the The Digital Harbor Foundation (DHF) youth-staffed 3D print shop. DHF is a nationally-recognized educational non-profit and youth makerspace in a major city in the Eastern United States. Each year, DHF serves over 1,400 youth from diverse socio-economic backgrounds through after-school and summer educational courses, hackathons, and field trips. In collaboration with a local university, DHF received funding to expand their offerings to include a 3D print shop that employs high school aged youth after school. The print shop opened in January 2017, was located on DHF's premises (Figure 1) and, was managed by DHF's adult staff members. In addition to serving both as an employment opportunity and workforce training program, a goal

of this collaboration was to better understand the impacts of technical employment opportunities on youth through research. Towards this end, members of our research team were granted access to regularly visit DHF's site. While this paper focuses on one impact — youths' adoption and usage of informal chatting tools — studied through interviews, we have sought to understand other topics ranging from how to better support youths' coordination during handoffs to youths' perceptions of privacy in the workplace as part of this collaboration.

### 3.1 Work in the Print Shop

The print shop offers a variety of services to clients including 3D printing, 3D scanning, and 3D design. Youth employees are paid hourly and much of the shop's business comes from clients in the local community (e.g., schools, religious institutions, local businesses, internal requests from DHF). Completed work has ranged from printing giveaways for public events (Figure 2: rings), to collaborating with physical therapy students to develop custom assistive devices for individuals with disabilities (Figure 2: assistive device). Each job request can vary significantly in complexity (e.g., how many things need to be made, how much design work is needed) and difficulty (e.g., how hard something is to fabricate and assemble). Work is completed using a variety of consumer-grade technical resources including twelve 3D printers, a laser cutter, and a 3D scanner — most of these pieces of equipment requiring specialized pieces of software to control. While on site, DHF provided youth with access to necessary tools (e.g., to repair printers), materials (e.g., printer filaments), software (e.g., computer-aided design software), and computing equipment (i.e., personal laptops and a more powerful desktop computer) to complete this work. All print shop employees owned personal smartphones (with access to cellular data and WiFi), on which they installed Slack.

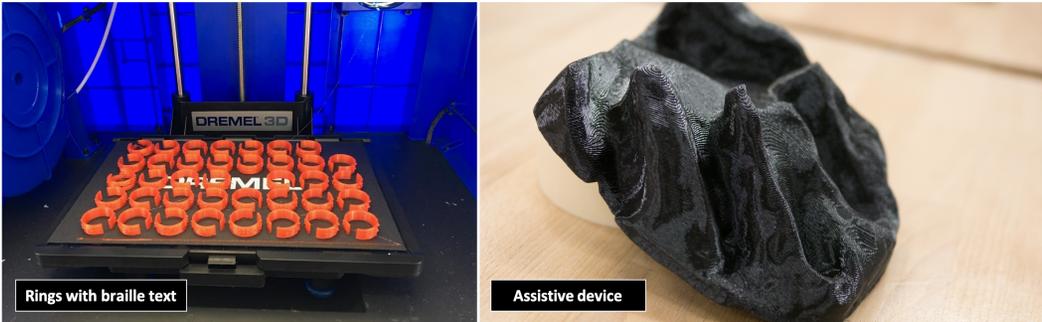


Fig. 2. Two examples of 3D printing jobs completed in the print shop. On the left are 3D printed rings with text written in Braille and on the right is a custom assistive device for an individual with limited hand dexterity.

### 3.2 Youth Employees

The print shop employed twelve youth from diverse backgrounds across two cohorts (Table 1). Employees were recruited and hired by the print shop's managers who were full-time staff members at DHF. Openings were advertised through flyers posted within DHF's space and recruitment emails sent to youth participating in DHF's after-school programs and their parents. To be hired, youth had to be at least 14 years of age (to obtain a work permit), complete a job application, and participate in a hiring interview. After approximately 18 months of employment, cohort one, with the exception of P2 and P6, were transitioned out of the print shop and a new group of employees were hired. P2 and P6 were retained as senior employees who could help mentor their new co-workers. While most employees worked in the shop for at least one year, there was an expectation that some may

transition out of their roles sooner in order to participate in other extracurricular activities or upon graduation from high school. This was the case during our study – some participants were employed for shorter periods of time than their peers in the same cohort.

Cohort	ID	Age	Gender	Months Worked
Cohort 1/2 (Senior)	P2	17	M	35 months
	P6	15	F	35 months
Cohort 1 (Standard)	P1	18	F	7 months
	P3	17	M	18 months
	P4	16	M	12 months
	P5	16	M	15 months
	P7	15	F	18 months
	P8	15	F	18 months
Cohort 2 (Standard)	P9	16	M	18 months
	P10	15	F	18 months
	P11	15	M	8 months
	P12	14	F	18 months

Table 1. An overview of youth employees enrolled in our study. Note that P2 and P6 were hired with cohort 1 and remained as senior employees during cohort 2.

All youth hired to work in the print shop were informed about our research during their onboarding process. It was explained to them that participation in our study was optional and that the choice to participate – or not to participate – would have no impact on their employment status at DHF. Prior to beginning data collection, we received both youth assent and parental consent from all participants. During the informed consent process, participants were made aware of data that would be collected and shared between DHF and members of our research team. They were also informed that published results from this study would not be linked back to their names. This study was approved by our university's Institutional Review Board (IRB) prior to data collection.

### 3.3 Job-related Coordination in the DHF 3D Print Shop

Work involving consumer-grade 3D printers can be time-consuming, complicated, and error prone [8, 14, 16]. Many steps in the printing process, such as determining whether a file is printable or monitoring an object as it prints, are invisible work which is performed by machine operators [14]. Prior work on print shops has noted that it is common for multiple machine operators to work on the same job; as such it is necessary for employees to maintain awareness of what their co-workers have done [16]. At DHF, work shifts typically occur after-school from 4-6 PM. As a result, many tasks, including printing, are left in-process at the end of each day. In order for job requests to be completed in a timely manner, youth working in the print shop must regularly coordinate with their peers who work in different shifts.

The shop relied on three primary tools to support this coordination – Slack (the focus of this study), email, and a Google spreadsheet used for documentation. Slack was used organization-wide by all adult employees at DHF – this included program assistants who taught after-school courses, and members of DHF's executive leadership team. From the beginning of the print shop's founding, its managers decided that it would be valuable to also train employees in the use of this widely-used platform. This decision was made both to ensure youth employees acquire digital

communication skills that the management saw as an important component of workforce training, and to immerse youth employees deeply in the broader DHF's professional culture and work practice. As a result, the first channel, *Staff-3D Printshop*, was created as a place for employees to have general work-related conversations. After several instances where deadlines were missed due to a lack of coordination and awareness between shifts, the print shop's managers instituted a new policy where employees would provide "standup" updates (i.e., short progress reports) at the end of each work shift. A second channel, *Print-Shop Standup* was created to facilitate this process. Employees submitted their standup by responding to several pre-defined questions about what they worked on (e.g., jobs worked on, prints left running), which were then shared in the channel. At first, this process was facilitated by an app called Geekbot<sup>3</sup>, which would prompt each employee to complete their standup at a specified time (e.g., 6 PM). However, this method was not always effective due to the learning curve associated with configuring Slack client applications – as such, it was common for standups to be submitted late or missed entirely. The print shop eventually replaced Geekbot with a Google Form which employees would navigate to, and fill out on their own. A third and final channel, *Printer-Health*, was later created as a specific place for employees to share updates about the operational status of printers. All three channels were made private (invite only) within DHF's Slack workspace to ensure that only people affiliated with the print shop would access them. Youth received no formal training on how to use Slack, but were encouraged to install the client application on their personal phones in order to more easily receive, and respond to notifications.

## 4 RESEARCH METHODS

We conducted eleven semi-structured interviews with youth employees from both cohorts, thus, the two set of interviews were conducted approximately 1.5 years apart. Interviews with Cohort 1 included P2, P3, P5, P6, P7 and P8, and interviews with Cohort 2 included P2, P6, P9, P10, and P12. P2 and P6 participated in both interviews as they were employed in the print shop for both cohorts.

### 4.1 Cohort 1 Exit Interviews

The first round of interviews (n=6) were conducted after the completion of cohort 1's employment experience at DHF. These interviews covered a variety of topics including asking youth to reflect on their career interests, skills developed while working in the print shop, and challenges and experiences collaborating at work. To better understand their perceptions of how collaborative tools should be used in the workplace, we asked participants to describe the ecosystem of collaborative tools used by them, define the purpose of each tool, and also to reflect on their personal usage and that of their peers and managers. In addition to this, participants were also asked to reflect on whether these tools were effective in promoting awareness in the print shop. Each interview lasted between one hour and one hour and 12 minutes. All interviews were conducted on-site at DHF, and each participant received \$20 for their time.

### 4.2 Cohort 2 Check-in Interviews

Approximately 18 months into their employment experience, we conducted a second round of interviews (n=5) to check-in with the youth currently working in DHF's second cohort of print shop employees. The gap between the two set of interviews were due to several factors, including an approximately 3 month break from print shop operations in DHF between completion of work by cohort 1 and recruitment of cohort 2, and our plan to interview as many of the employees as possible after they completed work for approximately a year at the print shop, so that their

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<sup>3</sup><https://geekbot.com/>

perspectives are comparable to each other. Two youth employees (P1 and P11) joined the cohorts later than others making their work experience shorter but we decided to also interview them. While much of the protocol for this round of data collection was identical to the one used previously, later sections of the interview guide were revised to place a larger emphasis on chatting tools in the workplace. In our revised protocol, we explicitly asked participants to talk about their prior experiences with Slack and similar tools, to share how often they actually used it, and reflect on the barriers and/or motivating factors to use and strategies for acclimating to this tool. Interviews were conducted on-site at DHF during employees' regularly scheduled shift. Participants did not receive additional compensation for taking part in these interviews, but they did take place during paid work time.

### 4.3 Analysis

The first author of this paper conducted all interviews with participants. During each session, they took notes and made an audio recording with the consent of each participant. Audio recordings from all interviews were fully transcribed. To identify common themes in the data, transcripts were open and axially coded through an iterative process with two coders. To ensure consistency between both coders, one interview was independently analyzed by both coders. They then met to reconcile differences in their coding approach and develop a shared list of codes. Both coders then independently analyzed a second interview using the shared code list and met a second time to reconcile any remaining differences before independently analyzing the remaining interview transcripts. Using this approach to ensure reliability between coders is common in the HCI community [38]. While these interviews covered several topics, we focus primarily on themes pertaining to the usage of chatting tools in the workplace.

## 5 FINDINGS

### 5.1 Youth Reflections on Using Slack in the Workplace

During our interviews, youth provided insight into the types of content they shared over Slack, who they communicated with, and how often they checked their notifications and posted. Both senior employees talked about their experiences working in both cohorts and shared their observations regarding disparities in how both groups communicated.

*5.1.1 Types of Content Shared.* Youth described using the public channels on Slack to share job information (e.g., files, updates, follow-up questions), information about whether printers were working, resources (e.g., links to websites), and jokes. They regularly communicated with their managers, co-workers, and occasionally, other staff members working at DHF. In contrast, youth explained that their managers would use Slack to share announcements, let staff know about and recruit volunteers for upcoming events, and send follow-up questions about on-going work. Our observations of messages are consistent with this characterization. We note that much of the content described by youth aligns with the intended purpose of the printshop-standup and printer-health channels. While jokes were occasionally shared in the staff-3dprintshop channel, they were a relatively rare occurrence.

During cohort 2 interviews, we explicitly asked participants to reflect on how they used Slack's direct messaging feature since we did not have access to this data. They described communicating through direct messages for similar purposes, and also for personal communications with coworkers they were friends with. Some youth, like P9, explained that they made decisions over whether to send a message publicly or privately based on who might find the information relevant.

*"I guess if I want multiple people to be known about it, if the printer's not working or something, then I'll post to there.."* (P9, Cohort 2)

All participants in cohort 2 interviews indicated that they were more active in direct messaging than posting publicly.

**5.1.2 Checking Notifications.** While it was a regular occurrence for youth to go an entire shift without posting in either the staff or printer health channels, all five participants in cohort 2 shared that they logged in to check Slack on a regular basis. Both senior employees explicitly mentioned being available to receive messages 24 hours a day – P2 remained logged in on their home computer, while P6 received notifications on their mobile phone. P9 and P12 described logging in to Slack as an initial task to perform upon arriving to work, while P10 explained that “*making sure to just check in at least once a day for me is good.*”

During the course of this study, we observed that while youth were encouraged to make themselves available over Slack, no specific requirements or guidelines were set by management. These varying approaches to checking notifications show that the youth employees brought with them, or developed, diverse expectations for how to incorporate a new workplace tool into their existing ecosystem of communication technologies. This evidence also helps to provide insight into a potential contributing factor to the lack of responsiveness previously observed by Easley et al. [16, 17]. However, as noted in prior literature, it is important to acknowledge that youth choosing to remain connected to work 24 hours a day, like P2, and P6, may contribute to unhealthy work-life decisions [17].

**5.1.3 Disparity in Usage Between Cohorts.** Both senior youth employees expressed their belief that there was a significant disparity between how cohorts 1 and 2 adopted and used Slack. During their interviews and subsequent interactions with our research team, both suggested that the slow uptake during cohort 1 may have been influenced by an initial lack of effort. Speaking of cohort 1, P2 stated:

*“[Communicating on Slack involved] a lot of ghosting... Everybody would either say it in person or never say anything ever. The only answer or the only Slack message I have with [another co-worker] is ‘Hey, do you know where you put the [object] that was on the scanner?’ 2017, December 20-something. Never got a response back.” (P2)*

In another example, P2 explained that despite being encouraged to do so, some youth in cohort 1 never installed the Slack client on their phones, preventing them from seeing any messages in a timely manner. They later explained how communication within cohort 2 was much improved, and attributed this to the fact that the use of Slack was heavily encouraged from day one. P6, similarly felt that communication in cohort 2 was improved because each of the print shop’s channels already had clearly defined roles, reflecting the fact that the printshop-standup, and printer-health channels were created several months into cohort 1’s employment experience.

**5.1.4 Strategies for Acclimating to Chatting in the Workplace.** We asked youth in cohort 2 about their process of becoming acclimated to using Slack in the workplace. P9 and P10 described having an easier experience adapting given their prior experience with other instant messaging tools: “*I don’t know [how I learned to use Slack]. It just came kind of natural to me, I guess, because it was just like a instant messaging kind of thing*” (P9, Cohort 2). This “natural” transition was not the case for all participants however. P2, P6, P10, and P12 described their learning experience as part of a trial-and-error process. P2, P6, and P12 described receiving help and guidance from managers and senior employees during shifts and all-employee meetings.

*“I think just the experience [helps you learn how to use Slack]. If you send the wrong thing, someone could say, ‘hey, you know this doesn’t go here’. This should go through here. Or having the [all-employee] meeting, like we did that one time... It’s usually senior coworkers, so like [P6 or P2 who offer guidance]. I think [one of the managers] said something once*

*or twice, but it was usually your coworkers that caught it first since you were right there with them.” (P12, Cohort 2)*

Finally, P2 and P10 described watching and modeling their communication behaviors after more experienced workers like their manager. This is reminiscent of legitimate peripheral participation, which describes how individuals naturally transition from being newcomers to experienced members of a community through participating in socio-cultural practices [34].

## 5.2 Factors Motivating Slack Use

**5.2.1 Understanding the Value of Effective Communication.** Youth frequently mentioned that they were motivated to use Slack because they were aware of the importance of effective communication and the impact that it could have on job success. P9 described motivation for being proactive in sending messages not only when things went wrong but also when there were positive status updates. He explained that he shared information about the operating status of printers so that his peers would not have to deal with unexpected problems upon starting their shifts.

*“I guess just if a printer starts working again that hasn’t worked for a while, I’ll let people know that now it’s working. Or if a printer has been working for a while, and isn’t working now, then I’ll let people know. That way, it’s not a shock at the people that were expecting to use it.” (P9, Cohort 2)*

To further drive this point home, youth often described instances where a lack of communication lead to challenges or breakdowns in work. In the following quote, P7 talks about the challenge of coming into work and trying to identify a print left behind by a previous shift.

*“There was a print on the printer and no one said anything... I would try and double check and see if anyone left a message in Slack or if there’s a note left around or anything. Like I said usually wasn’t a thing...” (P7, Cohort 1)*

When asked to elaborate on how they worked through situations like this, P7 explained that they would typically resort to searching through digital 3D models in order to match them to the tangible artifacts (completed prints) left behind by previous shifts. This supports findings from Easley et al., which found that youth employees would often resort to performing additional work in situations where communication with their peers was lacking [16]. P10, similarly, shared that they gradually recognized the importance of effective communication by learning from mistakes. These experiences helped make them more proactive in ensuring that they provided their peers with the information needed to complete their jobs. These descriptions of gradually transitioning into more effective members of a team (often through trial-and-error) are reminiscent of literature on the experiential learning theory which also views learning as a process [32, 33].

**5.2.2 Familiarity With Channel Structure.** Several participants mentioned that Slack’s channel structure made it easier to learn how to use. P2, P9 and P12 compared Slack’s channel-based structure to that of Discord,<sup>4</sup> a popular application targeted towards gamers which offers Voice over IP (VoIP) and text chatting functionality. They drew parallels between the instantaneous nature of messages, the one-to-many nature of posting messages in channels, and the the ability to share files such as images. Participants also noted that one of the biggest differences between the two tools is the level of formality. We note that adjusting to the cultural norms of a workplace present an additional set of challenges.

*“Discord, it’s like the nonprofessional Slack. It’s set up the same way. So you have your main, I guess, chat or workplace. In Slack’s case you’ll have kind of like subcategories for that chat, if that makes sense... it was pretty much set up the same as Slack and it was all*

<sup>4</sup><https://discordapp.com/>

*on the left side too where you can click on all the categories and you have the different bots too that you can put in.” (P12, Cohort 2)*

**5.2.3 Encouragement and Incentives.** Both P2 and P6 felt that employees in cohort 1 initially did not put much effort into communicating effectively with each other. In her second set of interviews, P6 explained that encouragement from her managers in combination with other extrinsic motivators helped to promote Slack usage. In the following quote, she describes their reaction after another employee received a cash bonus for being proactive in communicating with his peers during a period of time when their manager was unavailable to help.

*“When [our managers] were actually pushing us to have better communication... like ‘yeah guys, you need to communicate with each other’ and one of our staff members, he actually started picking up and started responding to Slack. We all kind of made an effort, but he really put in the effort, and he got a [cash bonus]. Everybody knows who that is. Yeah, after that, we all really stepped up our game, communication wise.” (P6, Cohort 2)*

**5.2.4 Slack as a Requirement for Work.** Finally, P9 and P10 mentioned that they were motivated to use Slack because it was universally adopted within the organization.

### 5.3 Factors Preventing Slack Use

**5.3.1 Fear and Shyness.** P2 and P6 both discussed how feeling shy sometimes prevented them from being more active on Slack. For example, during the first set of interviews, P2 shared how he initially felt apprehensive about posting in public channels because he did not always feel that had something valuable to contribute to the open conversation.

*“...you don’t want to put your voice out there, I guess, but I got used to it after a while... [posting] seems too important for something that you have to say, but then yeah... [it’s becoming] comfortable with the idea that what you have to say is actually important when it comes to Slack.” (P2, Cohort 1)*

This topic re-emerged in the second set of interviews a year later. When asked to talk about how his co-workers were using Slack, P2 noted that communication in public channels was very limited – he further suggested that power disparities between users may have been one factor contributing to this hesitation.

*“[Communication was] very sparse when it came to communication with everyone, especially when it became with multiple youth employees or higher ups in general... I’m not sure if it’s fear or something or it was like them being afraid to speak to someone who’s higher up, but that’s from what I saw. Because that’s why I didn’t do it.” (P2, Cohort 2)*

Later in the same interview, P2 again broached this topic, mentioning that some youth may face another challenge in determining what level of formality is appropriate when chatting in the workplace. This insight from P2 offers a very valuable and unique perspective given his time spent working in the shop and his experiences transitioning into a senior role where he regularly helped other youth. This feedback also highlights to the importance of remaining aware of power disparities in work environments staffed by youth, and how they may influence the ways in which this population interacts with others.

**5.3.2 Having Relevant Content to Share and Respond to.** Participants explained that a willingness to post was contingent on having appropriate content to share. P6 mentioned that while they would often read articles shared by others, they did not always have content to share themselves.

*“[For most] public channels, I don’t really see what kind of posts I would post, because I don’t do a lot of outside research as far as 3D printing and finding particularly interesting*

*articles. So because of that I don't really post much. But I do read when other people post. And sometimes that's interesting."* (P6, Cohort 2)

This willingness to post was similarly impacted by a lack of relevant content to respond to. P9 shared that they did not feel the need to frequently check their messages because only a limited amount of information being posted was relevant to them.

*"Nothing ever really gets posted in them much. Usually, it's just kind of status things that don't really pertain to me. So I don't really ever check them. And if there is something that pertains to me, I get an @ notification<sup>5</sup>, like @printshop."* (P9, Cohort 2)

**5.3.3 Comfort Level With Chatting Tools.** In contrast to youth who felt more comfortable using Slack due to its functional similarities to Discord, P8 explained that she felt as if she was *"really bad at Slack"* compared to her co-workers. She later explained that she preferred to use email whenever possible due to her existing familiarity with it. While this sentiment was unique among our participants, this finding is important to share because it provides further evidence that much like other demographic groups, not all youth will enter the workforce with high levels of experience or comfort with workplace chatting tools.

*"I'll admit I didn't message people a lot. I kind of would always forget... I wan't very talkative in the print shop... I use email a lot more [than] Slack... [If] I couldn't come to work and that kind of stuff, I would email... I was more used to it..."* (P8, Cohort 1)

**5.3.4 Technical Problems.** Finally, consistent with earlier findings from Easley et al., we found that some youth encountered difficulties receiving notifications for messages [17]. The results in this study show that these challenges, which are likely associated with correctly configuring the Slack client application [17], were encountered by youth in both cohorts. Not receiving notifications may be a contributing factor to the previously mentioned lack of responsiveness.

*"Weirdly enough, Slack doesn't send me straight up notifications on my phone. So not all the time I'll see something."* (P10, Cohort 2)

## 6 DISCUSSION

The findings in this paper show that our youth participants, despite having prior exposure with interconnected technologies, faced numerous barriers, technical or otherwise, when starting to use workplace digital communication tools. We even saw that one employee, P8, expressed a preference towards using email over Slack – a viewpoint that contrasted with those of her peers. All of these factors may have contributed to our participants' varying degrees of uptake of Slack. In considering these results, it is important to recognize that challenges introducing new collaborative technologies to the workplace, such as getting workers to buy-in to reach critical mass, are not unique to the print shop context or youth employees (e.g., [24, 26]). Towards this end, we offer lessons learned from this study on steps that can be taken by those involved in running or designing future workplace training programs for youth.

### 6.1 Accounting for Youths' Diverse Experiences with Technology

Despite belonging to a demographic group which is regularly associated with being experts on social technologies [44], each participant brought with them their own unique set of experiences and preferences with respect to digital communication. While several of our participants found that their transition to using Slack was supported by their prior experience using similarly structured technologies, this experience was not universal. Therefore, we agree with the sentiment that it is

<sup>5</sup>Slack users can bring specific posts to the attention of others by directly mentioning them (e.g., @username)

unwise to assume that youth will automatically become “*effective users of technology*” given their presumed level of experience [28]. P8’s reluctance to switch over from email to Slack mirrors the experiences of many other workers after being introduced to a new tool (e.g., [26, 43]). Given that prior work has shown that training users on the features of a new communication tool alone may not be enough to spur successful adoption, [26], it is reasonable to expect that many youth will still benefit from opportunities for experiential learning. Additionally, our findings point to the potential of instituting reward structures and incentives at the organizational level, like the cash bonus described by P6, to encourage adoption [43].

## 6.2 Importance of Clear Organizational Communication Culture and Expectations

While youth encountered some technical challenges using Slack, their most significant learning curve was in adapting to the workplace culture and expectations for communicating with others. The results of this study highlight some key differences in how youth from cohorts 1 and 2 used Slack, and also in how their communication behaviors were received within the organization. Prior work from Easley et al. documented concerns from a print shop’s management team over a lack of communication between the youth [16, 17]. In the study presented here, those concerns in cohort 1 still held and we saw similar concerns over a lack of communication held by the senior employees (P2, and P6). In contrast, youth working in cohort 2 were generally perceived by the senior employees as being more effective communicators over Slack (Section 5.1.3).

Interview data from the senior employees suggests that youth in cohort 2 were more active in sending and responding to direct messages than their peers from cohort 1. These differences in communication behaviors, along with corresponding responses from the shop’s management team point to tensions between youths’ expectations for communicating in the workplace and the print shop’s organizational values and priorities. Based on the results of this study, and our understanding of the print shop’s information needs [16], we conclude that cohort 2 was more effective in ensuring that essential information needed to complete jobs was communicated.

Standups were valued in the print shop and considered mandatory because they helped incoming shifts orient themselves with the status of ongoing work. We note that this practice did not exist when cohort 1 started working – instead it was later created as a mechanism to help prevent missed deadlines by ensuring that important information was shared between shifts. We note that standup practices were new to our participants and that their value became increasingly apparent after breakdowns in communication helped highlight the interdependence of their work (Section 5.2.1). It is possible that these practices may have been initially viewed by youth in cohort 1 as a cost, rather than a benefit to their work (i.e., [24]).

Given that chatting tools are well-suited for sending and replying to quick questions [42], replying to direct messages was valued in the print shop because it could potentially prevent work from stalling or being repeated. For example, if an employee was trying to complete a job by printing an object that was already 3D scanned but could not find the file, they could message the employee who last worked on this job. With a quick response, this work could proceed as expected. However, with no response, the object needed to be either re-scanned, requiring hours of additional work, or potentially halted until the other employee returned to work. However, despite the potential value offered to the organization, P2 noted that not all employees in cohort 1 had installed the Slack client on their phones, reducing their ability to receive or respond to messages.

As mentioned by both senior employees in Section 5.1.3, youth in cohort 2 may have benefited by having an established organizational culture of communication already in place, rather than having to adapt after becoming accustomed to their work. With this culture already in place, managers were able to place a clearer emphasis on completing standups and being available to answer questions on days off. These findings are consistent with prior work which has found that providing employees

with a clearer understanding of the rationale for a new technology towards the goals of the worker may help them to use it in more effective ways [24, 43]. In contexts like the print shop, where the constant evolution of communication practices is expected, it may be valuable for managers and employees to come together to discuss what the organization's values and needs are and then work together to clearly define a set of expectations for communication and availability. Establishing these expectations explicitly can be an effective on-boarding strategy for this population given their many other non-professional communication practices and responsibilities [22]. When discussing availability, it is important for employers to be mindful of how workplace policies may impact youths' development of healthy work-life boundaries [17]. Towards this end, we believe it is valuable to consider ways in which healthy and effective communication behaviors can be modeled for new employees.

### 6.3 Navigating Power Structures in the Workplace

Another consideration is the impact of power dynamics on youths' willingness to communicate openly in public channels. Unlike in their personal lives where they exercise a certain degree of agency in forming social groups and managing communication with them [22], youth working at the print shop had limited control over who can read their public communications on Slack. When posting in the staff-3dprintshop channel, for example, youth were willingly sharing information with everyone from their peers, to adult staff (who may hold senior roles or have previously instructed), to their managers, to members of our research team. We recognize that youth in this position may feel additional pressure to say the right things and that these power dynamics may impact each employee differently.

We also recognize that this research context is unique and that DHF makes efforts to minimize the impacts of power differences between adults and youth working in the the shop. These specific characteristics are important because, as previous research has shown, the use of chat and other communication mechanisms can interact with existing offline work practices and reflect and amplify them [39]. Among our participants, DHF is considered to be a friendly and safe learning environment where mistakes are welcomed (even when they run contrary to the goal of making a profit), and youth are treated with trust from their first day. We note that kind of treatment is not universal for youth – hierarchical relationships with adults still exist at home with family, at school with teachers, and at other organizations offering part-time employment. As such, it is important for those offering workplace training programs to remain vigilant of whether, and how, power dynamics might be impact youths' experiences and behaviors. An important workplace skill of the future may be how to navigate both online and offline workplace power structures skillfully and professionally.

We would like to also acknowledge another complex dimension of our study. While the youth employees were operating in a professional context, where they had to complete tasks and communicate effectively to accomplish their tasks, working in the print shop has also the explicit and often-emphasized purpose of providing technical training to the youth. This characteristic makes the youth operate with multiple identities (i.e., trainee and employee), different aspects of which might also impact their Slack use and communication priorities. While many technical jobs involve a training phase, in the print shop getting trained was the job, making it different from the majority of other technical employment experiences. While our study design did not involve a comparison of experiences between youth employees and adult professionals at other sites, future research can explore the differences and similarities that might exist in these contexts, especially in relation to communication norms and practices.

#### 6.4 Recommendations for Designing Future Youth Employment Training Programs

We would like to offer several recommendations based on our findings to inform future youth technical employment training programs. At a high-level, we recommend developing and including specific training modules in youth training programs that focus on effective workplace communication and coordination tools and protocols. Our work has shown that despite previous experience with digital technologies, youth need support in professional communication and coordination skills. Following, we will unpack this recommendation by describing what our findings point to with respect to the format and content of these future training modules. Needless to say, depending on the specific characteristics and goals of a given youth training program or employment opportunity, the training modules need to be customized.

First, training needs to outline and make explicit what coordination and communication tools and protocols are expected to be used by youth employees and what are the management's expectations of youth practices with respect to content, format, and frequency of communications. For example, in the context of our study providing a comprehensive overview of how Slack, email, and text should be used to coordinate tasks and hand-offs would be needed. Additionally, the purpose of each Slack channel, as well as, private messages should be outlined in detail and with examples of what effective communication would look like using these platforms. While the coordination needs of youth employees in our context might be different from those of youth in other contexts, completing technical work tasks often and increasingly requires synchronous and asynchronous digital communication and ensuring that youth are on the same page with each other, their managers, and other stakeholders, on when and how to use these can contribute to their success both during training and beyond.

Second, we recommend including explicit opportunities for reflection and discussion among youth employees and managers on the privacy and data sharing best practices when using the communication and coordination tools in the workplace. In our case, in addition to internal communication, youth sometimes worked directly with clients or other youth at the center, and having specific instructions on what information and data needs to be shared with each stakeholder can contribute to their professional training.

Finally, we highly encourage that future youth workplace training programs provide opportunities for dialogue and discussion among youth employees, managers, and educators/trainers to clarify communication expectations, periodically offer and receive feedback and suggestions on tools and protocols, and include all stakeholders in making design decisions pertaining to their workplace practices. These measures can both support youth in developing both their communication skills and also sense of workplace empowerment and self-efficacy.

### 7 CONCLUSION AND FUTURE WORK

The dynamic and rapidly changing nature of work and technical employment is well-studied in the CSCW research communities. In the face of technological, logistical and cultural shifts in the workplace, it is essential to study the communication and information needs of the workers of the future and how they may be supported through training programs and resources. Among the key skills needed are those that enable effective professional communication; these are increasingly important as many workplaces are adopting hybrid or entirely virtual remote work practices.

We investigated how two cohorts of youth employed in a 3D print shop used the Slack workplace communication tool over 36 months. Our findings show that youth initially had some difficulty in forming a clear understanding of the organizational communication culture and expectations that impacted their performance. Additionally, they were aware of the power structures present in the workplace, which impacted their online activity and sharing. Finally, we found that despite their

prior experience with digital communication tools outside of the workplace, the youth still faced challenges in adopting Slack and needed time and support to develop skills for using it effectively.

Findings from this work point to new directions for how to design technical workplace training programs for youth that take into account the need to incorporate effective workplace communication and coordination technologies. Furthermore, it shows an important aspect of learning how to use these technologies in the workplace relate to the capacity to understand and successfully navigate workplace power structures and hierarchies.

This study can be expanded in several directions in the future. First, in our study, we didn't have access youth's private Slack messages or work email or text message content. Future studies that include this data can provide a more comprehensive picture of employee communication and coordination methods. These studies would also require careful consideration of participants' privacy. Second, our study can be replicated in other youth technical employment training programs that require the use of chatting platforms to compare and contrast the impact of various environmental and organizational factors on technology use. Given the specificity of the DHF print shop, results may not generalize to all contexts, although we expect them to transfer to similar youth employment training programs. Finally, while our current study did not focus on the specific affordances of Slack that may have impacted youth's experience with it, future research can explore what helpful interface affordances are present in popular mainstream chatting tools and what is lacking and may be helpful to implement in the future to support youths' adoption of work-oriented tools.

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## REFERENCES

- [1] Murugan Anandarajan, Maliha Zaman, Qizhi Dai, and Bay Arinze. 2010. Generation Y adoption of instant messaging: An examination of the impact of social usefulness and media richness on use richness. *IEEE Transactions on Professional Communication* 53, 2 (2010), 132–143.
- [2] Monica Anderson and Jingjing Jiang. 2018. Teens, Social Media & Technology 2018. <http://www.pewinternet.org/2018/05/31/teens-social-media-technology-2018/>
- [3] Monica Anderson and Jingjing Jiang. 2018. Teens' Social Media Habits and Experiences. <http://www.pewinternet.org/2018/11/28/teens-social-media-habits-and-experiences/>
- [4] Daniel Avrahami and Scott E Hudson. 2006. Communication characteristics of instant messaging: effects and predictions of interpersonal relationships. In *Proceedings of the 2006 20th anniversary conference on Computer supported cooperative work*. ACM, 505–514.
- [5] Siân Bayne and Jen Ross. 2011. 'Digital native' and 'digital immigrant' discourses: a critique. In *Digital difference*. Brill Sense, 159–169.
- [6] Dan Bouhnik and Mor Deshen. 2014. WhatsApp goes to school: Mobile instant messaging between teachers and students. *Journal of Information Technology Education: Research* 13, 1 (2014), 217–231.
- [7] Erin Bradner, Wendy A. Kellogg, and Thomas Erickson. 1999. The Adoption and Use of "BABBLE": A Field Study of Chat in the Workplace. In *Proceedings of the Sixth European Conference on Computer Supported Cooperative Work* (Copenhagen, Denmark). Kluwer Academic Publishers, USA, 139–158.
- [8] Erin Buehler, William Easley, Samantha McDonald, Niara Comrie, and Amy Hurst. 2015. Inclusion and Education: 3D Printing for Integrated Classrooms. In *Proceedings of the 17th International ACM SIGACCESS Conference on Computers & Accessibility - ASSETS '15*. ACM Press, New York, New York, USA, 281–290. <https://doi.org/10.1145/2700648.2809844>
- [9] Erin Buehler, Shaun K Kane, and Amy Hurst. 2014. ABC and 3D: opportunities and obstacles to 3D printing in special education environments. In *Proceedings of the 16th international ACM SIGACCESS conference on Computers & accessibility*. ACM, 107–114.

- [10] Ann Frances Cameron and Jane Webster. 2005. Unintended consequences of emerging communication technologies: Instant messaging in the workplace. *Computers in Human behavior* 21, 1 (2005), 85–103.
- [11] Laura Dabbish, Colleen Stuart, Jason Tsay, and Jim Herbsleb. 2012. Social Coding in GitHub: Transparency and Collaboration in an Open Software Repository. In *Proceedings of the ACM 2012 Conference on Computer Supported Cooperative Work* (Seattle, Washington, USA) (CSCW '12). ACM, New York, NY, USA, 1277–1286. <https://doi.org/10.1145/2145204.2145396>
- [12] Robert M Davison, Carol XJ Ou, Maris G Martinsons, Angela Y Zhao, and Rong Du. 2014. The communicative ecology of Web 2.0 at work: Social networking in the workspace. *Journal of the Association for Information Science and Technology* 65, 10 (2014), 2035–2047.
- [13] Chris Dede. 2010. Comparing frameworks for 21st century skills. *21st century skills: Rethinking how students learn* 20, 2010 (2010), 51–76.
- [14] Kristin N Dew, Sophie Landwehr-Sydow, Daniela K Rosner, Alex Thayer, and Martin Jonsson. 2019. Producing Printability: Articulation Work and Alignment in 3D Printing. *Human-Computer Interaction* (2019), 1–37.
- [15] Paul Dourish and Victoria Bellotti. 1992. Awareness and Coordination in Shared Workspaces. *Proc. Intl. Conf. on Computer-Supported Cooperative Work* November (1992), 107–114. arXiv:0812.1045v1
- [16] William Easley, Foad Hamidi, Wayne G. Lutters, and Amy Hurst. 2018. Shifting Expectations: Understanding Youth Employees' Handoffs in a 3D Print Shop. *Proc. ACM Hum.-Comput. Interact.* 2, CSCW, Article 47 (Nov. 2018), 23 pages. <https://doi.org/10.1145/3274316>
- [17] William Easley, Darius McCoy, Shawn Grimes, Steph Grimes, Foad Hamidi, Wayne G. Lutters, and Amy Hurst. 2018. Understanding How Youth Employees Use Slack. In *Companion of the 2018 ACM Conference on Computer Supported Cooperative Work and Social Computing* (Jersey City, NJ, USA) (CSCW '18). Association for Computing Machinery, New York, NY, USA, 221–224. <https://doi.org/10.1145/3272973.3274060>
- [18] R Kelly Garrett and James N Danziger. 2007. IM= Interruption management? Instant messaging and disruption in the workplace. *Journal of Computer-Mediated Communication* 13, 1 (2007), 23–42.
- [19] Joseph A. Gonzales, Casey Fiesler, and Amy Bruckman. 2015. Towards an Appropriable CSCW Tool Ecology: Lessons from the Greatest International Scavenger Hunt the World Has Ever Seen. In *Proceedings of the 18th ACM Conference on Computer Supported Cooperative Work & Social Computing* (Vancouver, BC, Canada) (CSCW '15). ACM, New York, NY, USA, 946–957. <https://doi.org/10.1145/2675133.2675240>
- [20] Rebecca E Grinter and Margery Eldridge. 2003. Wan2ilk? Everyday Text Messaging. In *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems* (Ft. Lauderdale, Florida, USA) (CHI '03). Association for Computing Machinery, New York, NY, USA, 441–448. <https://doi.org/10.1145/642611.642688>
- [21] Rebecca E Grinter and Margery A. Eldridge. 2001. Y Do Tngrs Luv 2 Txt Msg?. In *Proceedings of the Seventh Conference on European Conference on Computer Supported Cooperative Work* (Bonn, Germany) (ECSCW'01). Kluwer Academic Publishers, USA, 219–238.
- [22] Rebecca E Grinter and Leysia Palen. 2002. Instant messaging in teen life. In *Proceedings of the 2002 ACM conference on Computer supported cooperative work*. ACM, 21–30.
- [23] Rebecca E Grinter, Leysia Palen, and Margery Eldridge. 2006. Chatting with teenagers: Considering the place of chat technologies in teen life. *ACM Transactions on Computer-Human Interaction (TOCHI)* 13, 4 (2006), 423–447.
- [24] Jonathan Grudin. 1994. Groupware and social dynamics: eight challenges for developers. , 92–105 pages. <https://doi.org/10.1145/175222.175230>
- [25] Mark Handel and James D Herbsleb. 2002. What is chat doing in the workplace?. In *Proceedings of the 2002 ACM conference on Computer supported cooperative work*. ACM, 1–10.
- [26] James D. Herbsleb, David L. Atkins, David G. Boyer, Mark Handel, and Thomas A. Finholt. 2002. Introducing Instant Messaging and Chat in the Workplace. In *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems* (Minneapolis, Minnesota, USA) (CHI '02). ACM, New York, NY, USA, 171–178. <https://doi.org/10.1145/503376.503408>
- [27] James D Herbsleb, Audris Mockus, Thomas A Finholt, and Rebecca E Grinter. 2001. An empirical study of global software development: distance and speed. In *Proceedings of the 23rd international conference on software engineering*. IEEE Computer Society, 81–90.
- [28] Nicky Hockly. 2011. The digital generation. *ELT journal* 65, 3 (2011), 322–325.
- [29] Ellen Isaacs, Candace Kamm, Diane J Schiano, Alan Walendowski, and Steve Whittaker. 2002. Characterizing instant messaging from recorded logs. In *CHI'02 extended abstracts on Human factors in computing systems*. 720–721.
- [30] Naveena Karusala, Ding Wang, and Jacki O'Neill. 2020. Making Chat at Home in the Hospital: Exploring Chat Use by Nurses. In *Proceedings of the 2020 CHI Conference on Human Factors in Computing Systems* (Honolulu, HI, USA) (CHI '20). Association for Computing Machinery, New York, NY, USA, 1–15. <https://doi.org/10.1145/3313831.3376166>
- [31] Sandra L Kogan and Michael J Muller. 2006. Ethnographic study of collaborative knowledge work. *IBM Systems Journal* 45, 4 (2006), 759–771.

- [32] Alice Y Kolb and David A Kolb. 2005. Learning styles and learning spaces: Enhancing experiential learning in higher education. *Academy of management learning & education* 4, 2 (2005), 193–212.
- [33] David A Kolb. 2014. *Experiential learning: Experience as the source of learning and development*. FT press.
- [34] Jean Lave and Etienne Wenger. 1991. *Situated learning: Legitimate peripheral participation*. Cambridge university press.
- [35] Rachel M Magee, Denise E Agosto, and Andrea Forte. 2017. Four factors that regulate teen technology use in everyday life. In *Proceedings of the 2017 ACM Conference on Computer Supported Cooperative Work and Social Computing*. 511–522.
- [36] Gloria Mark and Steven Poltrock. 2001. Diffusion of a collaborative technology cross distance. In *Proceedings of the 2001 International ACM SIGGROUP Conference on Supporting Group Work*. ACM, 232–241.
- [37] Gloria Mark and Steven Poltrock. 2004. Groupware adoption in a distributed organization: Transporting and transforming technology through social worlds. *Information and Organization* 14, 4 (2004), 297–327.
- [38] Nora McDonald, Sarita Schoenebeck, and Andrea Forte. 2019. Reliability and inter-rater reliability in qualitative research: Norms and guidelines for CSCW and HCI practice. *Proceedings of the ACM on Human-Computer Interaction* 3, CSCW (2019), 1–23.
- [39] Moira McGregor, Nicola J. Bidwell, Vidya Sarangapani, Jonathan Appavoo, and Jacki O'Neill. 2019. Talking about Chat at Work in the Global South: An Ethnographic Study of Chat Use in India and Kenya. In *Proceedings of the 2019 CHI Conference on Human Factors in Computing Systems* (Glasgow, Scotland Uk) (CHI '19). Association for Computing Machinery, New York, NY, USA, 1–14. <https://doi.org/10.1145/3290605.3300463>
- [40] Brian Merchant. 2019. The Davos Elite Say the Public Will Have to Pay to Retrain the Workers They Automate Out of Jobs. <https://gizmodo.com/the-davos-elite-say-the-public-will-have-to-pay-to-retr-1831964427>
- [41] Michael J. Muller, Mary Elizabeth Raven, Sandra Kogan, David R. Millen, and Kenneth Carey. 2003. Introducing Chat into Business Organizations: Toward an Instant Messaging Maturity Model. In *Proceedings of the 2003 International ACM SIGGROUP Conference on Supporting Group Work* (Sanibel Island, Florida, USA) (GROUP '03). Association for Computing Machinery, New York, NY, USA, 50–57. <https://doi.org/10.1145/958160.958168>
- [42] Bonnie A. Nardi, Steve Whittaker, and Erin Bradner. 2000. Interaction and Outeraction: Instant Messaging in Action. In *Proceedings of the 2000 ACM Conference on Computer Supported Cooperative Work* (Philadelphia, Pennsylvania, USA) (CSCW '00). ACM, New York, NY, USA, 79–88. <https://doi.org/10.1145/358916.358975>
- [43] Wanda J. Orlikowski. 1992. Learning from Notes: Organizational Issues in Groupware Implementation. In *Proceedings of the 1992 ACM Conference on Computer-supported Cooperative Work* (Toronto, Ontario, Canada) (CSCW '92). ACM, New York, NY, USA, 362–369. <https://doi.org/10.1145/143457.143549>
- [44] Marc Prensky. 2001. Digital natives, digital immigrants part 1. *On the horizon* 9, 5 (2001), 1–6.
- [45] Ari-Heikki Sarjanoja, Minna Isomursu, and Jonna Häkkinen. 2013. Small talk with Facebook: Phatic communication in social media. In *Proceedings of International Conference on Making Sense of Converging Media*. 118–121.
- [46] Diane J Schiano, Coreena P Chen, Ellen Isaacs, Jeremy Ginsberg, Unnur Gretarsdottir, and Megan Huddleston. 2002. Teen use of messaging media. In *CHI'02 extended abstracts on Human factors in computing systems*. 594–595.
- [47] Kjeld Schmidt, J Rasmussen, B Brehmer, and J Leplat. 1991. Cooperative work: A conceptual framework. *Distributed decision making: Cognitive models for cooperative work* (1991), 75–110.
- [48] Kjeld Schmidt and Carla Simonee. 1996. Coordination mechanisms: Towards a conceptual foundation of CSCW systems design. *Computer Supported Cooperative Work (CSCW)* 5, 2-3 (1996), 155–200.
- [49] Eusebio Scornavacca, Sid Huff, and Stephen Marshall. 2009. Mobile phones in the classroom: if you can't beat them, join them. *Commun. ACM* 52, 4 (2009), 142–146.
- [50] Neil Selwyn. 2009. The digital native—myth and reality. In *Aslib proceedings*. Emerald Group Publishing Limited.
- [51] Marc Smith, Jonathan J Cadiz, and Byron Burkhalter. 2000. Conversation trees and threaded chats. In *Proceedings of the 2000 ACM conference on Computer supported cooperative work*. 97–105.
- [52] Anthony M Townsend, Samuel M DeMarie, and Anthony R Hendrickson. 1998. Virtual teams: Technology and the workplace of the future. *Academy of Management Perspectives* 12, 3 (1998), 17–29.
- [53] Thea Turner, Pernilla Qvarfordt, Jacob T. Biehl, Gene Golovchinsky, and Maribeth Back. 2010. Exploring the Workplace Communication Ecology. In *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems* (Atlanta, Georgia, USA) (CHI '10). ACM, New York, NY, USA, 841–850.
- [54] Gregory Valdez. 2018. The workplace of the future. <https://www.wired.com/brandlab/2018/06/the-workplace-of-the-future/>
- [55] Amy Volda, Wendy C. Newstetter, and Elizabeth D. Mynatt. 2002. When Conventions Collide: The Tensions of Instant Messaging Attributed. In *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems* (Minneapolis, Minnesota, USA) (CHI '02). Association for Computing Machinery, New York, NY, USA, 187–194. <https://doi.org/10.1145/503376.503410>
- [56] World Economic Forum. 2018. *The Future of Jobs: Centre for the New Economy and Society*. Number January. 147 pages. <https://doi.org/10.1177/1946756712473437> arXiv:0803.1716

- [57] Amy X. Zhang and Justin Cranshaw. 2018. Making Sense of Group Chat through Collaborative Tagging and Summarization. *Proc. ACM Hum.-Comput. Interact.* 2, CSCW, Article 196 (Nov. 2018), 27 pages. <https://doi.org/10.1145/3274465>

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