A Quantitative Study of Youth Employees' Use of an Informal Chatting Tool at a Workforce Training Program

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Abstract—**Understanding the uptake and use of digital co-ordination and communication tools by youth trainees would inform the creation of effective technical training approaches for preparing the next generation of the future workforce that often need to draw on these skills to do their jobs in hybrid working contexts. Despite growing research on the use of informal communication methods, such as chatting, in the workplace, little is known about how youth who have grown up with access to interconnected technologies encounter them in workplace training contexts and how they can be supported in using them effectively. In this study, we investigated youth employees' use of Slack, a popular workplace chatting tool, in an after-school 3D print shop. Using primarily quantitative data from workplace chat logs and participant and direct observations, we looked into youth employees' Slack adoption and use in a technical training context. Our findings show that while the youth used Slack for coordinating print jobs and troubleshooting, they faced a number of challenges preventing them from substantially and consistently using the tool. Furthermore, the youth initially had difficulty using the communication tool consistently. However, over time and with increased experience and structure, their uptake of the technology improved, and in particular, senior employees and the later cohort were able to communicate more consistently and effectively at work.**

Index Terms—**chatting tools, Slack, youth, after-school employment**

I. INTRODUCTION

The importance of developing learners' ability for team-work, online and offline communication, and awareness of others are well-recognized in the literature on both formal and informal learning contexts [9], [30], [45]. Understanding how youth trainees in professional training experiences, such as service learning programs [9], [45], afterschool "earn and learn" programs [13], [14], [16], [28], and others, experience the uptake and use of digital coordination and communication tools would inform the creation of effective future technical training programs. Understanding youth experiences in these contexts is also relevant to the increasingly hybrid nature of today's work contexts. Deepening this understanding has gained more urgency in the aftermath of the COVID-19 pandemic and the increasing move to hybrid work experiences that combine in-person and virtual work.

Emerging digital technological advances have been a driving force in the evolution of the modern workplace [8], [47]. In response, considerable research efforts are focusing on better understanding the sociotechnical changes taking place in the context of work and their impact on the workforce of the future [22], [44]. Research in this space has uncovered the dynamics of how, when, and where work takes place in the increasingly networked and connected workplace and what skills, knowledge, and attitudes are needed by the workers of the future. Workplace trends that are increasingly becoming dominant include different forms of remote work, including freelancing and gig economy [10], [40], and the prevalence of workplace automation powered by machine learning and artificial intelligence [17]. The number of workers who will be or are already impacted by these trends is astounding: estimates suggest that as much as 47 percent of jobs in the United States are potentially automatable, freeing up workers to perform different types of jobs [17]. In 2017, as many as 57.3 million people in the United States participated at least part-time in the freelance economy [33]. This trend is expected to continue – estimates suggest that half of the workforce in the United States will freelance by 2027 [43]. In the face of these shifts, future workers need to acquire and practice technologically-enhanced skills, chief among them are the effective and efficient use of coordination and collaboration tools. Technological advances are making it easier for workers to cooperate on complex projects regardless of location [32], [41], [44]. They accomplish this using a variety of digital tools, including file-sharing services, video and data conferencing solutions, and chatting applications such as Slack[1] and Microsoft Teams[2] [18], [42]. However, despite the widespread availability of these technologies, there are many barriers preventing their successful implementation and use [21]. Despite growing research on the use of informal communication methods, such as chatting, in the workplace, little is known about how youth who have grown up with access to interconnected technologies encounter them in workplace training contexts and how they

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[1]https://slack.com/
[2]https://products.office.com/en-us/microsoft-teams/group-chat-software

can be supported in using them effectively.

In this case study, we investigated the use of Slack by youth employees in the context of an after-school 3D print shop. Slack is a widely-used workplace communication and coordination tool that has been gaining adoption in a range of workplaces [15], [48]. 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 [13], [42].

We conducted participant observations of the print shop's offline and online activities with two cohorts of print shop employees and analyzed 36 months of chat message rates from the print shop's public Slack channels. Our findings show that while the youth used Slack for coordinating print jobs and troubleshooting, they faced a number of challenges preventing them from substantially and consistently using the tool. In particular, there were significant disparities in how youth with different levels of experience used the tool.

II. RELATED WORK

Previous research has emphasized the importance of understanding how to develop learners' ability for teamwork and communication [9], [30], [45]. However, this area is understudied, and more research is needed to understand the experience of learners in general, and youth in particular, with digital communication technologies, such as chatting. Investigating this area is even more important now in the face of the increase in remote and hybrid learning experiences that have come about in the aftermath of the COVID-19 pandemic and how research has overwhelmingly shown that inequities in accessing and participating in remote learning experiences persist [27], [31], [35].

There is a large body of literature examining youths' usage of chatting tools in contexts other than professional training and informal learning. Prior work suggests that youth are motivated to use these tools in their everyday lives because of their perceived usefulness (in completing work tasks), social usefulness, and media richness [1]. Youth commonly use chatting tools as a direct and immediate way to socialize with others, plan events, or collaborate on school work [19], [37]. Grinter and Palen found that they often build social groups on these technologies that mirror their real-life relationships (e.g., chatting with friends at school) [19]. Additionally, while these tools enable this population to remain connected with others during times when social interactions would traditionally not be permitted (e.g., late in the evening), their usage at home is highly responsive to expectations associated with domestic schedules (e.g., performing chores in the evening) [19]. However, despite outside influences impacting their usage, access to chatting tools can serve as a means of liberation – this population regularly engages in strategies such as muting their devices to maintain control over who is aware of their actions (e.g., not allowing parents to see that they are messaging someone) [20]. The literature also suggests that youth, like adult workers, make use of the awareness features in chatting tools (i.e., equating an "online" status with conversational availability) and engage in waylaying behaviors to maximize their interaction time with others [20].

There are also studies that have examined youths' usage of chatting tools in contexts outside of 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 [38]. In a 2014 study, Bouhnik et al. examined communication between high school students and their teachers over WhatsApp [5]. They identified several benefits, including increased opportunities for teachers to get to know their students and an improved ability to 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 [5].

There is limited prior research on how youth use chatting tools in professional workplace contexts. A 2015 study with 49 college students and recent graduates by Choi et al. found that college students' use of technology changes when moving from college to a first job [7]. They identified shifting human networks, a desire to create a professional persona, and the volume of communication required at work as factors influencing this population's communication technology choices and usage patterns [7]. In a previous study at a youth-staffed print shop, Easley et al. observed the strategies used by youth employees during critical handoff incidents, where employees had to coordinate their work asynchronously [13]. During jobs where unsuccessful handoffs occurred, Slack and Google spreadsheet 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 [15]. This work documented concerns from the print shop's management team over a lack of communication between youth working during cohort 1 [13], [15] leading to multiple machine operators working on the same job; as such, employees must maintain awareness of what their co-workers have done [13].

To our knowledge, research has not used a quantitative approach to study youth's chatting behavior. However, research on the communication patterns of adults in work and life contexts has shown differences among groups in frequency and length of messages. For example, 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 [2]. While the adop-

tion 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, [11], [26] the DHF print shop offers a unique opportunity to explore this research gap. These findings motivated our current study, which more examines youth employees' adoption and usage of Slack within the print shop using a quantitative longitudinal approach.

III. RESEARCH CONTEXT

A. The 3D Print Shop

Our research took place at a youth-staffed 3D print shop (Figure 1) housed at, the Digital Harbor Foundation (DHF), a center for afterschool technology-rich learning and professional training. DHF is an educational non-profit and youth makerspace in a mid-sized East Coast American City. At the time of the study, DHF served over 1,400 youth from diverse socio-economic backgrounds through after-school and summer educational courses, hackathons, and field trips. In January 2017, the 3D print shop opened at DHF as a technical employment opportunity and workforce training program for local youth. The shop was in operation until the beginning of the COVID-19 pandemic which resulted in its closure. During its operation (and the course of our study) the 3D print shop offered a variety of services to clients including 3D printing, 3D scanning, and 3D design. Youth employees were paid hourly to complete various tasks, ranging from printing giveaways for public events to collaborating with physical therapy students to develop custom assistive devices for individuals with disabilities [13], [24]. 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 was completed using a variety of consumer-grade technical resources including 12 3D printers, and 3D scanner – most of these pieces of equipment required different specialized pieces of software to control.

B. Participants

Over the course of its operation, the print shop employed 12 youth from diverse backgrounds across two cohorts (Table I). 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 16 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 to participate in other extracurricular activities or upon graduation from high school.

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
	P9	16	M	18 months
Cohort 2 (Standard)	P10	15	F	18 months
	P11	15	M	8 months
	P12	14	F	18 months

TABLE I

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 on-boarding process. It was explained to them that participation in our study was optional and that their 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. This study was approved by our university's Institutional Review Board (IRB) prior to data collection.

C. Job-related Coordination in the DHF 3D Print Shop

Work involving consumer-grade 3D printers can be time-consuming, complicated, and error-prone [6], [12], [13]. Many steps in the printing process, such as determining whether a file is printable or monitoring an object as it prints, are invisible work that is performed by machine operators [12]. 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 [13]. 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 relies on three primary tools to support this coordination – Slack (the focus of this study), email, and a Google spreadsheet used for documentation. Slack is used organization-wide by all adult employees at DHF – this includes program assistants who teach after-school courses, and members of DHF's executive leadership team. From the very 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. 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, the print shop's managers decided to create a second channel, **Print-Shop Standup**. The goal of this channel was to increase awareness in the shop by facilitating the sharing of status updates between employees.
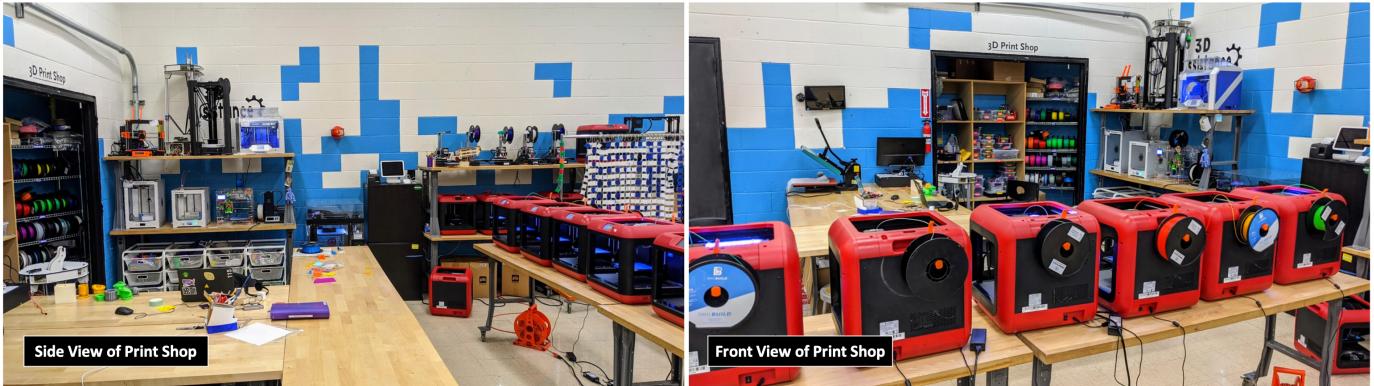
Fig. 1. The workspace at the DHF Print Shop.

At the end of each shift, employees submit their standup by responding to several pre-defined questions about what they worked on, which are then shared in the channel. To ensure that updates were shared on a regular basis, post-shift standups were considered mandatory for all employees. At first, this process was facilitated by an app called Geekbot which would automatically prompt each user 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 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 have to remember to navigate to 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 phones in order to more easily receive, and respond to notifications.

IV. RESEARCH METHODS

We analyzed 36 months of logs exported from the print shop's three Slack channels (staff, standup, and printer health). This data were provided to us by DHF, who administer the organization's workspace. We only received and analyzed messages from the channels and not private messages.

DHF's leadership who had administrative access to Slack provided our research team with an archive of exported .JSON files that we parsed into a mySQL database for analysis. This database initially contained 2,331 messages. We cleaned this data by removing sub-types of messages that were not relevant to our research, including system notifications, which resulted in 2,218 messages remaining in our data set. We then queried and sorted messages in the database by channel name, user ID, and/or the date that messages were sent. For the standup channel where most messages were posted by bots (i.e., Geekbot or Google Sheets) on behalf of users, we used

another approach in which we used the consistent message formats to by sort responses by their message content (i.e., employee names were included at the start of each post).

User Group	# Users
Standard Youth Employees	10
Senior Youth Employees	2
Print Shop Managers	3
Other DHF Staff	9
Research Team	3
Bots (Geekbot and Google Drive)	4

TABLE II
OVERVIEW OF THE SIX USER GROUPS (31 USERS) WITH ACCESS TO THE SLACK CHANNELS.

In addition to using chat logs as data, we conducted participant and direct observations at the DHF print shop from the time it opened. During the first year of the print shop's operation, the first author of this paper was a participant observer who traveled to DHF 3-5 days per week during work shifts, once a week to sit in on operations meetings held by the print shop's management team, and once a month to sit in on all-employee meetings with managers and youth present. When visiting DHF, we recorded observations using written notes which included descriptions of employee interactions with each other, with technology in the workspace, and with members of our research team. After cohort 2 transitioned into the print shop our first author stopped regularly observing work shifts but continued to observe operations meetings (which shifted to a bi-weekly basis), and monthly all-staff meetings (when possible). Our research team's continued presence at these meetings has been a valuable opportunity to remain abreast of the regular activities and challenges encountered in the print shop. As mentioned, three members of our research team have had access to the print shop's Slack channels since they were created. This has primarily been in an observational capacity, but we have on rare occasions, responded to technical questions about 3D printing and shared resources with youth employees.

This fieldwork afforded our research team the opportunity to develop a rich understanding of our research context – including knowledge about how the print shop is structured

Channel Name	Channel Age	Total Messages Sent	Avg. Per Work Day
staff-3dprintshop	36 Months	1,295 Messages	**1.8** Messages
printshop-standup	24 Months	760 Messages	**1.5** Messages
printer-health	20 Months	163 Messages	**0.4** Messages
All Channels (Total)	—	2,218 Messages	—

TABLE III
HIGH-LEVEL SUMMARY OF OVERALL SLACK USAGE IN THE PRINT SHOP.

User Group	Staff	Standup	Printer Health	Total
Standard Youth Employees (10 Users)	241	434	71	746
Senior Youth Employees (2 Users)	248	279	36	563
Print Shop Managers (3 Users)	590	34	55	679
Other DHF Staff (9 Users)	172	0	0	172
Research Team (3 Users)	22	1	0	23
Bots (4 Users)	22	12	1	35

TABLE IV
TOTAL NUMBER OF SLACK MESSAGES SENT BY EACH USER GROUP

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within DHF, the various roles, and tasks regularly performed by workers, and how effective communication – or a lack thereof – impacts employee productivity. While this study is largely informed by the analysis of chat logs, the insight from these longitudinal observations was instrumental to our ability to interpret the results from our analysis of Slack logs.

V. FINDINGS

A. Overview of Youth Employees' Slack Usage

Thirty-one unique users and bots were granted access to at least one of the print shop's Slack channels (Table II). This included all 12 youth employees (10 standard, 2 senior), who were involved in day-to-day operations and expected to regularly communicate with their peers. Three users were print shop managers (one who oversaw daily operations, along with two in more senior positions at DHF). All managers were full-time staff members at DHF who regularly interacted with print shop employees. Nine additional DHF staff members had access to these channels and served in various roles across DHF (e.g., after-school program staff who teach courses, operations manager, director of education) and none were regularly involved in print shop operations. Finally, three members of our research team and four bots (including Geekbot and Google) had access to these channels. Our research team has had access to and has been able to observe activity in all three channels since their creation.

Table III shows the average number of messages sent in each channel per day. 1,295 messages were posted in the general staff-3dprintshop channel over a period of 36 months, 760 were shared in the mandatory printshop-standup channel over 24 months and 163 messages were posted in the printer health channel over 20 months. The staff-3dprintshop channel was the most active, receiving approximately 1.8 messages per work day, while the printer-health channel was the least active, receiving 0.4 messages per work day.

Table IV shows the total number of messages sent by each user group. Given their high levels of involvement in performing or supervising daily activities, we were not surprised to find that the three groups who posted the most messages were the standard youth employees (10 users, 756 messages), shop managers (3 users, 679 messages), and senior youth employees (2 users, 563 messages). However, we do note that there are some disparities in where groups posted their messages. Both standard and senior youth were most active in posting in the mandatory print-shop standup channel, while their managers were more than twice as active in the staff-3D printshop channel than any other group. We believe that it is also important to note that the two senior youth employees – despite being fewer in number, working similar hours, and performing similar tasks to their peers – posted more messages in the staff-3D printshop channel than the rest of their peers combined. This points to possible disparities in how different youth adopted and used this tool. To further investigate this, we quantified the individual Slack usage of each youth employee.

B. Slack Usage Among Different Employee Groups

Table V shows the total and average number of messages sent by each youth employee per month worked. This analysis confirms that the two senior employees, P2 (9 messages per month) and P6 (7.1 messages per month) were among the most active. This was anticipated given their length of employment, and position as role-models to their peers. We also found it notable that P9 (8.4 messages per month), was more active on Slack than P6. They were the most active member of their cohort in the staff-3dprintshop channel, and also the most active among all employees in the printer-health channel. During operations meetings, one of the managers explained that many of these messages were initially posted as the direct result of their prompting. However, they felt that over time, P9 naturally started to more regularly share printer updates on their own.

There are also some notable differences in how the standard youth employees from cohort 1 and 2 used Slack. Each youth from cohort 2, on average, posted more messages per month than their peers from cohort 1; P3 was the one exception to this rule. Table V also shows that youth in cohort 1 posted more messages in the staff-3dprint shop channel than the youth in cohort 2. This is not surprising given that that the print-shop

Cohort	ID	Slack Channel			Total	Avg. Mon.
		Staff	Standup	Printer		
Cohort 1/2 (Senior)	P2	145	157	12	314	9.0
	P6	103	122	24	249	7.1
Cohort 1 (Standard)	P1*	6	—	—	6	0.9
	P3	65	41	2	108	6.0
	P4	31	4	0	35	2.9
	P5	50	9	5	64	4.3
	P7	12	27	8	47	2.6
	P8	40	32	0	72	4.0
Cohort 2 (Standard)	P9	24	89	39	152	8.4
	P10	5	84	7	96	5.3
	P11	0	41	0	41	5.1
	P12	8	107	10	125	6.9

TABLE V

OVERVIEW OF SLACK USAGE ACROSS ALL YOUTH EMPLOYEES. 1,309 MESSAGES SENT IN TOTAL. P1 LEFT THE SHOP BEFORE THE *print-shop standup* OR *printer-health* CHANNELS WERE CREATED.

standup and printer-health channels were created in the later months of this group's employment experience. We also note some slight differences in the activity levels of P3, and the rest of the standard employees from cohort 1. They posted more messages each month than any of their peers, and also completed more standups – even when compared against P7 and P8 who worked the same number of months (18).

C. Activity in the Staff and Printer Health Channels Over Time

To better understand if youths' Slack usage changed, we also examined their activity levels over time, Table VI shows the average number of messages sent in the staff-3D printshop and printer-health channels by each employee over four month time intervals. This table examines activity in the staff-3D printshop and printer-health channels because both were voluntary, unlike the standup. This provides insight into how/if youth chose to use Slack on their own accord. Four month time intervals were selected due to the relatively low number of messages sent over a longitudinal period of time (not all youth posted messages every month). This data shows that most youth who worked during cohort 1 (P1, P3, P4, P5, P7, P8) posted more frequently on their own accord after spending several months in the print shop. Senior employees, P2, and P6, gradually followed a similar trend. In contrast, youth working in cohort 2 (P10, P11, P12), with the exception of P9, posted minimally in these channels on their own accord, if at all.

VI. DISCUSSION

There is a narrative that has likened youth to "'native speakers' of the digital language of computers, video games, and the Internet" [34]. In this line of thinking, youth (i.e., "digital natives") have been significantly changed by their exposure to technology, developing new skills and literacies that adults (i.e., "digital immigrants") and our education system are not equipped to deal with [34]. Over the years, this narrative has been a significant point of discussion – critics have noted that the categorization of "digital natives"

and "digital immigrants" lacks nuance and over-emphasizes a divide between generations that may not be insurmountable [4], [39]. This discourse has also led to the creation of alternative frameworks which suggest that most individuals actually fall somewhere on a spectrum between being a digital "resident" and "visitor" depending on motivation and context [26], [46]. This alternative way of thinking suggests that there is no correlation between technical proficiency and age [26].

Our study adds to this previous work by showing that our youth participants, despite having prior exposure to inter-connected technologies, had varying experiences adapting to the use of digital communication tools. Several factors seem to have played a role in youth uptake of Slack, including seniority, length of time working at the print shop, and the clear communication of required and structured updates (i.e., the print-shop standup channel). With respect to the last point, it is important to note that in our observations youth working in cohort 2 were generally perceived by the senior employees as being more effective communicators over Slack. Our quantitative data shows that cohort 2 achieved this reputation while being generally less active in the voluntary staff-3D printshop and printer-health channels, but more reliable in completing their mandatory standups (Table V)). Standups were valued in the print shop and considered mandatory because they helped incoming shifts orient themselves with the status of ongoing work. Interestingly, the use of standups was not established at the beginning of cohort 1's work and was developed in response to challenges in communicating about job completion status when changing shifts.

These results challenge the notion that home or school use of digital tools easily translates to effective workplace communication practices for youth and necessitates the careful planning of digital communication tool roll-outs at the workplace, and perhaps more importantly, the need to develop workplace communication training modules to help train future or current employees. In considering these results, it is important to also recognize that challenges of introducing new collaborative technologies to the workplace, such as getting workers to buy-

Time Period 3-14 1-1 (Month/Year)	Youth Employee												Avg.
	P1	P2	P3	P4	P5	P6	P7	P8	P9	P10	P11	P12	
1 — 10/16 – 01/17	3	2	4	0	11	0	2	5	—	—	—	—	3.4
2 — 02/17 – 05/17	3	4	11	3	8	4	5	12	—	—	—	—	6.3
3 — 06/17 – 09/17	—	12	13	28	0	20	3	6	—	—	—	—	11.7
4 — 10/17 – 01/18	—	24	16	—	25	43	2	16	—	—	—	—	21
5 — 02/18 – 05/18	—	15	23	—	11	24	8	1	2	0	0	1	8.5
6 — 06/18 – 09/18	—	10	—	—	—	8	—	—	12	8	0	5	7.2
7 — 10/18 – 01/19	—	45	—	—	—	18	—	—	32	4	0	10	18.2
8 — 02/19 – 05/19	—	34	—	—	—	10	—	—	12	0	—	2	9.7
9 — 06/19 – 09/19	—	11	—	—	—	0	—	—	5	0	—	0	2.6

TABLE VI

AVERAGE NUMBER OF MESSAGES SENT BY EACH YOUTH EMPLOYEE IN THE *staff-3D printshop* AND *printer-health* CHANNELS OVER 36 MONTHS. ACTIVITY IS SHOWN OVER FOUR MONTH TIME PERIODS. TIME PERIODS IN WHICH EMPLOYEES DID NOT WORK ARE LEFT BLANK. NOTE THAT THE TRANSITION BETWEEN COHORT ONE AND TWO OCCURRED DURING PERIOD 5.

in to reach critical mass, are not unique to the print shop context or youth employees (e.g., [21], [23]). An implication of our findings is that it is worthwhile to develop training modules focused on professional technology-mediated communication for inclusion in afterschool learning experiences for youth. These modules can be integrated with other engaging digital fabrication, physical computing, and progamming activities that are shown to have significant learning impacts [3], [25], [36].

Our quantitative analysis provides an interesting high-level perspective on the number and frequency of Slack messages sent by youth employees in the work context. Despite its important limitation of not studying the context of specific messages sent by youth, this analysis can provide an overview of communication patterns both to the designers and educators in this space and also be used as a teaching and reflection tool for the youth themselves. Previous research has shown that in work contexts, youth employees value practicality over data privacy (e.g., [16]). If used carefully and with consent and input from youth, similar quantitative analysis tools, perhaps combined with data visualization techniques, may be helpful. Despite this possibility, great care needs to be taken to avoid workplace surveillance and privacy violations that can be real possibilities when employee data is accessed by management or other figures of authority.

VII. LIMITATIONS AND FUTURE WORK

This study can be expanded in several directions in the future. A limitation of our study is that we only had access to public Slack messages and did not collect private messages. We also did not analyze the content of the messages and used metadata to look at high-level activity on the platform. Also, to preserve participants' privacy, we did not have access to messages on youth's other communication mediums, such as email or text messages, which might have been used as alternatives or backup to Slack. In the absence of providing specific criteria for the youth on how to assess their successful use of the tool, it is difficult to know if they understood if they were using the tool correctly or not. In the future, similar programs can include an on-boarding session focused on using communication tools in the workplace that, in addition to providing guidance on how to use them effectively, would also inform participating youth that the contents of their messages

created in the work setting may be used for research purposes. This would allow for a more comprehensive research process that also respects youths' privacy.

Finally, another limitation of our study was that our participants were all high school-aged youth with sometimes conflicting obligations on their schedules (e.g., school attendance, sports practice) which impacted their participation in print shop and data collection activities, and also in some cases (e.g., P1, P4, P11) caused them to unexpectedly stop working for certain periods of time or entirely.

VIII. CONCLUSION

Given the increasingly hybrid nature of the modern workplace, it is important to investigate how employees adopt and use communication and coordination technologies, such as chatting platforms. In particular, research needs to investigate the relationship of the prevalent use of digital technologies in youth's everyday lives to how they adopt and continue to use these tools in work contexts.

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 difficulty using the communication tool consistently. However, over time and with increased experience and structure, their uptake of the technology improved and, in particular, senior employees and the later cohort were able to communicate more consistently and effectively at work. These findings show that even with increased exposure to digital communication tools, youth need support and training to be successful at professional communication.

IX. ACKNOWLEDGMENTS

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