Would You Be Mine: Appropriating Minecraft as an Assistive Technology for Youth with Autism

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ABSTRACT
Those with disabilities have long adopted, adapted, and appropriated collaborative systems to serve as assistive devices. In this paper, we present the results of a digital ethnography in a Minecraft virtual world for children with autism, specifically examining how this community has used do-it-yourself (DIY) making activities to transform the game into a variety of assistive technologies. Our results demonstrate how players and administrators "mod" the Minecraft system to support self-regulation and community engagement. This work highlights the ways in which we, as researchers concerned with accessible and equitable computing spaces, might reevaluate the scope of our inquiry, and how designers might encourage and support appropriation, enhancing users' experience and long-term adoption.

CCS Concepts
• Human-centered computing → Accessibility → Accessibility technologies • Human-centered computing → Collaborative and social computing → Collaborative and social computing systems and tools.

Author Keywords
Assistive technology; DIY; appropriation; modding; Minecraft; virtual worlds; autism; disability.

1. INTRODUCTION
Collaborative systems, like virtual worlds, have long been sites of adoption, adaptation, and appropriation. People with disabilities, in particular, have always found creative ways to pick up everyday objects—including information and communication technologies—to do the work of assistive devices. Indeed, many closed, proprietary, or heavily customized systems are often abandoned [13,40] in favor of lower cost, less stigmatized, and more prevalent "mainstream" technologies that can be easily adapted to suit specific needs [48].

Noting the challenges to adoption and widespread dissemination, many assistive technology researchers have called for new ways to augment existing systems, such as using lightweight browser plugins instead of expensive screen readers [3], alternative and augmentative communication software built into "off the shelf" tablets [34] in place of pricey (and typically more robust) assistive devices, or repurposing commercial products for unintended uses [19,20,46,51].

Going one step further, some have advocated for and tested the feasibility of those with disabilities developing their own assistive devices [24,26]. As Hurst *et al.* [24] have suggested, the ability to Do-It-Yourself (DIY) or appropriate "off the shelf" commercial products to create assistive technology may improve the quality of experiences with those devices and software. Users adopt, adapt, and augment technology in ways designers do not envision, to support needs that may not have been fully understood or anticipated [14]. Often, this kind of appropriation takes mainstream or "off the shelf" technology and changes it to suit the needs of those who have differing abilities [24,52].

With this in mind, we sought to understand the DIY culture surrounding and imbued in a virtual world that has been appropriated as a safe space [44], a social skills intervention [45], and, as we explore here, an assistive technology. Autcraft, a Minecraft virtual world for individuals with autism[1] and their allies, serves all of these functions at once.

Minecraft is an open-ended virtual world with no particular goals or play requirements [17,21,39]. Players can build and create new objects by manipulating blocks in the game. The base software of Minecraft can be modified with other programs, called "mods." According to the Minecraft End User License Agreement (EULA), *"If you've bought the Game, you may play around with it and modify it by adding modifications, tools, or plugins, which we will refer to collectively as 'Mods.'"* Although the makers of Minecraft explicitly discourage negative behaviors, they mostly leave the system open for any kind of modification users might envision [54]. Mods are popular across Minecraft instantiations [12] and have been explored for a variety of purposes in the research literature, including teaching children how to program [23]. The Autcraft community has taken advantage of the open and easily adaptable nature of Minecraft and this "modding culture" to tailor their server to multiple user needs, all while maintaining the creative and imaginative atmosphere characteristic of the virtual world.

In this paper, we present results from a virtual ethnography of Autcraft, specifically examining how this community has appropriated the platform, transforming features of the virtual world into a variety of assistive technologies. In particular, our results indicate that players use mods and other DIY techniques to support themselves in terms of self-regulation and to support the community in terms of their interaction with others and

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[1] The term *autism* will be used throughout this paper to denote Autism Spectrum Disorder as well as Asperger's Syndrome as previously defined before the DSM-V changes [1].

socialization. This in-depth examination of a DIY assistive world highlights the ways in which we, as researchers, might reconsider the scope of our inquiry into accessible and equitable computing spaces. It also draws attention to the role designers can play in fostering accessibility through appropriation, leading to enhanced user experience and more widespread adoption and use.

2. Related Work

As this research focuses on issues of DIY and appropriation in assistive technology, we overview relevant literature about appropriation, particularly as it pertains to assistive technology. We then examine related literature describing how assistive technology and virtual worlds in particular have been used for individuals with disabilities.

2.1 Appropriation for Assistive Technology

Appropriation covers many activities, during "*which technologies are adopted, adapted and incorporated into working practice,"* including customization, modding, and simply using artifacts for different purposes than originally designed [15]. This phenomenon fosters psychological satisfaction from exerting control and expressing ones' sense of identity [31]. Appropriation can lead to an empowering experience for youth [8,9] and people with disabilities [24], who often inherently feel disempowered.

The assistive technology community has long addressed how to make technology accessible and supportive for people with disabilities. These efforts have sometimes been addressed through the concept of "Universal Design," an approach towards design for the largest community possible [33]. However, designing too broadly has been associated with low acceptance and high abandonment of assistive technologies in particular [40]. On the other hand, designs that are too specific are often costly to produce and can result in a very small market. The DIY space offers an alternative [24,41]. However, these efforts to date have largely focused on physical supports and translation to less tangible forms of assistive technology (*e.g.,* commercial software) may be challenging [16].

Appropriation of "mainstream" technologies can also be helpful in reducing the stigma associated with assistive device use, an additional barrier to long-term adoption [48]. Stigma can result from aesthetically ugly devices, misunderstandings about an individuals ability, or social isolation for being marked as disabled [48]. Thus, many people have pushed for appropriation of so-called "mainstream technologies" that look like ordinary devices or even like elite products but act like assistive devices [14]. For example, by using iPhones rather than custom Alternative and Augmentation Communication devices, children with speech delays can move from the stigmatized "other" with a special device to the "cool kid" with their own iPhone. These efforts can also improve the technological experience for people without disabilities. For example, the effort to standardize and introduce a consistent experience across the web, unintentionally, made web browsing more accessible for everyone [42].

2.2 Virtual Worlds for Individuals with Disabilities

Research conducted on virtual worlds for community members with disabilities is still in the nascent stages. Work in Second Life has begun to describe how individuals with disabilities use virtual worlds—including creating dedicated zones, or "Islands," that are meant to be community areas for those with disabilities [4,25,50]. Research has explored how these specialized places serve as spaces for those with disabilities to feel safe, to socialize, and as places of community activism [4,25,44,45].

Virtual worlds offer an opportunity for those with disabilities to experiment with online avatars, living both real and fantastical experiences online [50]. Users have the choice of whether or not their avatar displays the same physical ability (*e.g.,* avatar using a wheelchair). This gives users the chance to play with possible identities, whether those identities have anything to do with disability or not. This opportunity for fantasy also allows individuals with disability to experience social interactions virtually that might not otherwise be available to them [49,50]. Those with disabilities often experience marginalization in the physical world (*i.e.,* low socio-economic status, limited access to transportation) [22,50]. Without the physical limitations found in the physical world, users in virtual worlds may find themselves able to experience newfound freedoms in social interactions. Conversely, some users may want to express their identity within the virtual world as having the same physical ability, which some virtual worlds provide the ability to do [49].

3. Methods

This paper reports on results from an on-going, qualitative digital study of an online community that has grown around a Minecraft server known as Autcraft. The Autcraft community was created for children with autism and their allies. This community maintains a Minecraft virtual world in tandem with other social media platforms, including YouTube, Twitch, Twitter, Facebook, and a community maintained website (including an administrator's blog, community forums, member profiles, and an in-browser web messenger). These platforms are all included in this study. Data were collected through interviews of children and parents, participant observations, directed and non-directed forum discussions, chat logs, and digital artifacts.

3.1 Setting

The Autcraft community uses an array of social media including: YouTube, Twitch, Twitter, Facebook, and a community maintained website, and a Minecraft virtual world. The multiplayer virtual world in our study, maintained by the Autcraft community, is a semi-private server on Minecraft created for children with autism and their families. As such, anyone wishing to join must first complete an application to be added to the white list. This application includes a declaration of having autism or being a friend or family member of someone with autism who plays on the server. Only those who have been added to the white list can access the server. Autcraft currently has more than 6,000 white-listed members with a daily average of approximately 50 players in-world at peak hours of the day and approximately 1,200 unique players[2] logging in each month. Because the Autcraft server requires all chat activities to be in English, most players are located in English-speaking countries. This server has strict rules for behavior that are enforced both by software modifications and a group of volunteer administrators and "helpers." There are important features that have been added via mods to the Autcraft virtual world, which we will discuss in detail in the results, but are defined here. These include the Autcraft "Spawn," teleportation, and mini-games.

The *Autcraft Spawn* is the staging area where players arrive when they first log into the virtual world. It is a common meeting space,

[2] AutCraft Wiki. *AutCraft*. Retrieved April 30, 2016 from http://autcraft.com/wiki/m/34575523/page/Autcraft_Wiki

with names of administrators, helpers, and players of the week displayed. This is also the access point for the gateways to the other areas of the virtual world.

Teleportation is enabled in Autcraft through which avatars can travel instantly "in-world," but only under certain circumstances. This includes, teleporting to the player's set "home" coordinates, to Spawn, or to another player.

Mini-games are small, enclosed games in designated areas of the virtual world. Mini-games must be reached via teleportation from Spawn. These games include: Paint Ball, Hide & Seek, Wither Battles, Parkour, and Spleef. In each area, players are given the equipment they need to participate in the game upon arrival to the area.

3.2 Data Collection

Our work employs ethnographic methods established by other studies of virtual world communities [4,6,25,35,38]. The first author has five years' experience playing Minecraft recreationally approximately 15 hours per month. She then gained access to Autcraft via permission of the server's creator for the purposes of this study and uses an avatar labeled as a researcher in world (See Figure 1). The researcher's presence and purpose was made clear to the community through both the Autcraft web-based forum as well as in the in-world chat. Community members were able to ask the researcher questions about the study through the forums or by visiting the researcher at an in-world "home office." Parents were informed of the lead researcher's presence via a parent message board and the Facebook page of the community. The lead researcher also maintains a public website with postings of updates from the study, including any publications.

The lead researcher collected approximately 80 hours of immersive in-world observations, including participating in activities on the server, recording chat-based dialogue, and field-notes on everyday practices of community members and events as they occurred in the virtual world. The lead researcher also participated in community activities outside the virtual world, including observing discussions in the forums and on the social networking sites. In addition, focus groups were created informally on the online forums through prompts, including open-ended questions of the community. Digital artifacts from the various platforms used by the community were also included in analysis. These data were collected over a period of 24 months and include approximately 5,000 forum threads and 150 blog posts created by players, parents, and administrators.

3.3 Data Analysis

We used a three-phased approach to our data analysis. We first become familiar with the data as individuals and then drafted and shared memos related to themes within the team. Finally, we reviewed the themes collaboratively in meetings, searching the data for indicators or support for our hypotheses, as well as for conflicting data that was not well explained by our initial interpretation. This approach was iterative, meaning that the team revisited each phase multiple times, as is an established best practice for qualitative data analysis [11].

4. Results

Members of the Autcraft community work together to create the technological infrastructure that is Autcraft. When one member lacks the expertise to "hack the system" (*e.g.,* programming knowledge to modify the Minecraft software), others in the community step in to create the desired result. In the following, we describe some of the ways Autcraft community members have

Figure 1. Avatar of lead researcher in Minecraft virtual world.

appropriated the software, virtual world space, and other technologies in the Autcraft community to help players *internally regulate themselves* and *externally manage engagement with others*.

4.1 Regulating the Self

Self-regulation is a "response to the continuously changing conditions of the social world," which "depends…on the ability to evaluate and modify our own behavior and responses" [30]. Community members use Minecraft in a variety of ways to self-regulate, including both sensory regulation and mood regulation.

4.1.1 Sensory Regulation

Everyone needs occasional down time or time alone to calm down, relax, and recalibrate. In addition, individuals with autism often struggle with sensory processing disorders (SPD). These disorders stem from challenges in integrating and interpreting sensory input, which can result in anxiety and feelings of being overwhelmed [2,10].

Virtual spaces are, for the most part, less engaging from a sensory point of view (*i.e.,* they only engage with *some* of the senses) and are mostly housed within the confines of the computational platform being used to render them. However, they can still be overwhelming to people who struggle with self-regulation in the face of sensory stimulation. To address this challenge, players in Autcraft created sensory regulating spaces within the virtual world almost from the launch of the server. Players used the limited tools available to them within the game to create these sensory spaces:

I came across a hole in the ground, like a small, dark chamber just big enough for an avatar to stand inside. A member informed me that it was built to give them a "sensory break." When they went inside and plugged the top of the hole, their screen would go all black. (field notes)

What is remarkable about this choice is that the players do not necessarily want to leave the virtual world altogether. Rather, they continue to gain much from being in the environment but simply need a "sensory break." While some research has documented players' lived experiences through their virtual avatars, we know far less about these experiences for individuals with autism [36]. If a player feels visually over-stimulated, one possible solution would be to just turn off the monitor or leave the game. But, as we see here, that is not always the preferred path. In this case, the player took the time and the care to "physically" dig a hole and move their avatar inside it, covering the avatar with virtual dirt, to sit in darkness. The screen is black, just as it would be if the

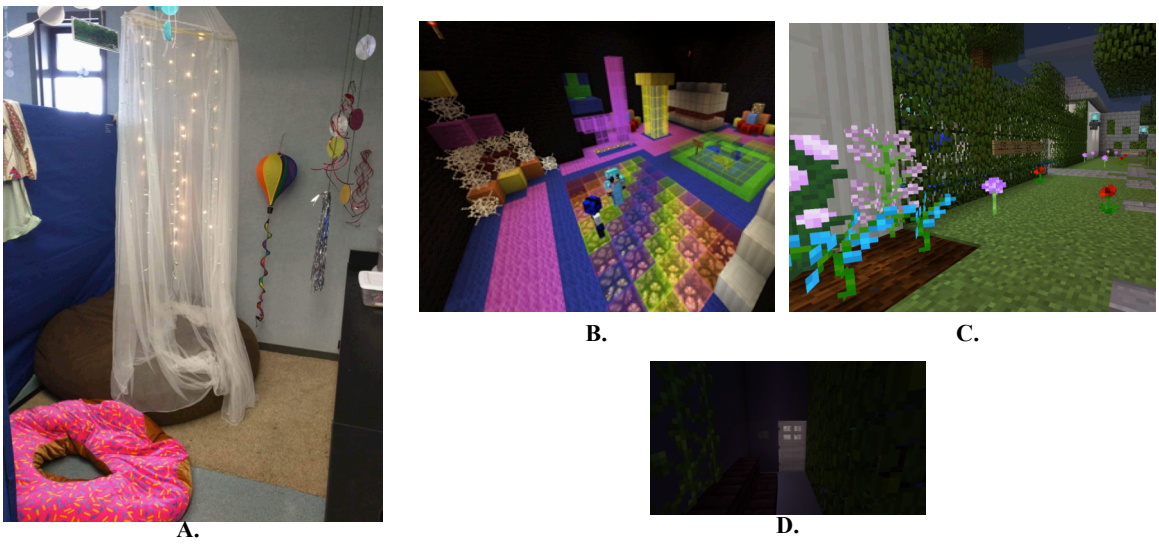

Figure 2. A. Multi-sensory environment in a physical classroom. B. Brightly rainbow colored Sensory Room in Autcraft. C. Calming garden in Autcraft. D. Dark room where the lights can be turned on and off in Autcraft.

monitor were turned off, but the avatar is also experiencing the black space, which is distinct from the experience of turning off the screen. Players enact virtual embodiment while controlling their avatars, highlighting the complex experiences of virtual and physical worlds [5].

Beyond simply supporting people with SPD, and other related challenges, when they need a break, therapeutic interventions also support teaching other coping processes. For example, multi-sensory environments (MSE) have been shown to help people support sensory integration. Typically, these physical environments, often called "sensory rooms," are saturated with visual, audible, and tactile stimuli and used therapeutically by trained professionals [47] (See Figure 2A).

Certainly, the complexities and nuance of a clinically designed MSE cannot be easily replicated in a virtual space. However, in noticing the player-driven self-regulation practices, the Autcraft community administrators built their own version of Sensory Rooms within the virtual world as a quiet space for members to go and relax. In these Sensory Rooms, chat is disabled and the environment is meant to be tranquil and with minimal sensory input. The administrators usefully "modded" and appropriated the Minecraft platform to create Autcraft, and the Autcraft platform to create carefully regulated spaces for sensory relief.

Members can choose three different styles of room, each tailored to meet different kinds of sensory needs (*i.e.,* a calm garden (See Figure 2C); a small, plain room with a light switch (See Figure 2D); and a brightly colored room (See Figure 2B)). In many ways, these rooms mimic the environments found in physical world Sensory Rooms. The community imbued the virtual spaces with assistive properties by mirroring physical therapeutic spaces.

In keeping with other Autcraft research [44], we see here that administrators manage the rules and norms of these spaces through multiple venues. They use the mods as the primary infrastructure, but build upon that visible set of instructions and policies for enforcing behavior. The instructions in reaching the Sensory Rooms say, *"Need a place to calm down? Quiet? Peaceful? Choose a Calm Room to visit here. In these rooms [t]here is no chat. It's a place to relax. Visit any time."* In an announcement about the opening of these rooms, an administrator emphasized the importance of having the chat disabled in these rooms:

The best part is that in these rooms, chat is disabled! You can still private message back and forth with people but the public chat will be muted and you can't talk into public chat either. This means that you can experience the lights and the sounds and the calming nature of the rooms without a whole bunch of text flying across your screen. (forums, P29, age 30, m)[3]

Other members also used these Sensory Rooms to take a break from being in the public chat, which can be helpful when trying to self-regulate exposure to chat conversations:

This really helped me today there was a trigger for some bad memories in chat and it calmed me down wish i could visit this in real life[4]*. (forums, P31, age 15, f)*

Because these are virtual avatars, members are able to "transport" themselves to these Sensory Rooms at any time. Thus, in the virtual world players are able to regulate input in real time, nearly instantly. This player, however, points out that you cannot simply transport yourself to calming spaces in the physical world. This ability to instantly transport oneself into an environment that helps in self-regulation creates an assistive technology space—which is potentially better or used differently than in the physical world because it gives the player an ability and experience in the virtual world they might not otherwise have.

The actual interface of the game can also be overwhelming at times for some members, particularly if there are a lot of people logged in or a particularly chatty group are talking in chat. When the text scrolls too quickly in chat and visually becomes over-stimulating, players can seek relief simply by transporting to the Sensory Room:

i like going there when chat is going to fast and i need to take a break [really] calming and relaxing (forums, P4, f)

[3] Each quote includes: (source of quote, participant number, age of participant, and identified gender if available in member profile)

[4] Here participants use *"real life"* to indicate the physical, offline parts of their lives. Also, *"irl"* seen later means the same.

Not only do players use the community-created spaces for sensory self-regulation, they also contribute to these spaces. One member posted in the forums, informing others he had created an instruction manual of how to use the Sensory Rooms:

I think sensory rooms are a fantastic idea. And I added a book In calm room 1 its about what to do and about calm rooms (forums, P33, m)

Much like in the example above, the Autcraft virtual world is being shaped by each of the players as they participate in community life. This support can also be seen as administrators, noticing the players creating the sensory holes described at the beginning of this section, and then responding by building these sensory rooms. Each player, through their own acts of appropriation within the virtual space, shape what their virtual world looks like and how it functions to assist them as they engage with the world.

These spaces are also different from other virtual worlds in that they are specifically built for members with autism. Unlike other online communities, where adolescents socialize and "hang out," these platforms are being augmented for this specific population. Interestingly, despite sensitivity to sensory input, members interacting within the Autcraft community do not seem to have a problem with the overwhelming amount of choices given to them both within the Autcraft virtual world interface and throughout the various platforms the community uses. Community members are able to deal with a lot of the visual stimuli of the virtual world interface in spite of their SPD symptoms. In fact, members seem to be able to choose from the various options to create a social and sensory experience that feels right for them, giving them the opportunity to have the embodied experience they want—something that is more easily done in a virtual space than a physical one. This may be because Minecraft, although not a typical game with "levels" and other stated goals, follows a classic game-style genre, allowing the players familiarity as they navigate the world like they would in many other games with a typical, first person perspective.

Dealing with sensory overload can be a difficult experience for anyone with autism, particularly for children and adolescents who are still learning coping skills. Members of the Autcraft community have created spaces within the virtual world and the other platforms to help even the youngest members learn to deal with these sensory needs. As in the example of the sensory holes, one player appropriated materials at hand (in this case, virtual dirt) and inspired others to modify the actual software of Autcraft to create similar experiences for everyone. Individual players appropriate the Autcraft virtual world to suit their own needs, shaping their virtual environment, embodied experience, and, in time, influencing the overall experience for everyone in Autcraft.

4.1.2 Mood Regulation

Learning to manage one's moods is a fundamental part of human development. However, mood regulation is not straightforward for many with autism [27,32]. Not only are mood and anxiety disorders more prevalent in those diagnosed with autism [27], but there is some concern by clinicians that emotional regulation is simply a more difficult task for these individuals [32]. Youth with autism tend to ruminate over their negative moods and experiences [43]. This kind of behavior was evidenced in Minecraft among many other more positive emotional engagements. For example, one member described his strong emotions and some of the consequences:

I do notice that at least a few emotions are often stronger than others. Its mainly anger and fear that are the very strong emotions that I experience. I am generally not a super emotional person, but anger and fear are the hardest emotions for my mind to process. (forums, P35, age 17, m)

Members are able to put into words their emotional experiences, safely share and vent their feelings with others, on the forums and through in-game chat. They can do this in Autcraft without the fear of reprisal from bullies or trolls—which is something they fear in other online spaces [44]. While this type of behavior may not be unique to Autcraft, the ability to vent in this safe space is possibly unique for the community members personally. They may have communication challenges in their physical environments that limit their abilities to express their feelings fully [43].

Autcraft is a highly visual and active environment. Although much of this paper has so far focused on text chats, text from the forums, and so on, it is this visual and active orientation that may actually provide the most support for emotion and mood regulation. Just as members appropriated virtual "physical" tools like shovels to dig holes for sensory regulation, they appropriate other tools to manage their moods. For example, one early teenage boy described killing monsters in mini-games to release some anger to feel better:

"i also like to play the minigames on here It helps me take my anger out on [the monsters] :P… My parents say since ive joined i have been nicer irl If i am sad irl or angry on here i come and everyone brightens up my day I usally forget why i was sad/mad" (interview, P1, age 13, m)

Mini-games are group activities created by Autcraft administrators originally as a place for members to come together to play (*e.g.,* paintball tournaments, hide and seek). These games were created to support socialization and play, cornerstones of the Autcraft community [45]. While being able to let out some frustration and anger on digital monsters is helpful, it is also interacting with the community that elevates the interviewee's mood. When discussing mood moderation, he said that *"mostly the people"* help him feel better when he gets online and that *"sometimes i get so into talking i forget what i was doing :P"*. Because these interactions with others are an important part of being in the Autcraft community, members have also created many ways to help support interfacing and engaging with others.

Mini-games are an example of how community administrators in Autcraft have appropriated Minecraft to create a separate space within the virtual world. However, beyond this original appropriation, players in Autcraft have then appropriated these mini-games—originally as places to play and socialize—to help with other aspects of their life, including mood moderation.

4.2 Interacting with Others

Although Autcraft community members have creatively adapted and appropriated the platform to serve the needs of individuals, it is still fundamentally a collaborative platform. As such, it should come as no surprise that members of the Autcraft community have appropriated the entire ecosystem of technologies surrounding Autcraft to support interfacing and engaging with others. These efforts support engagement with both the internal community and across community boundaries by *supporting sociality* explicitly.

4.2.1 Supporting Sociality

Socialization and supporting the various ways members want to be and are social is an important aspect of the Autcraft community

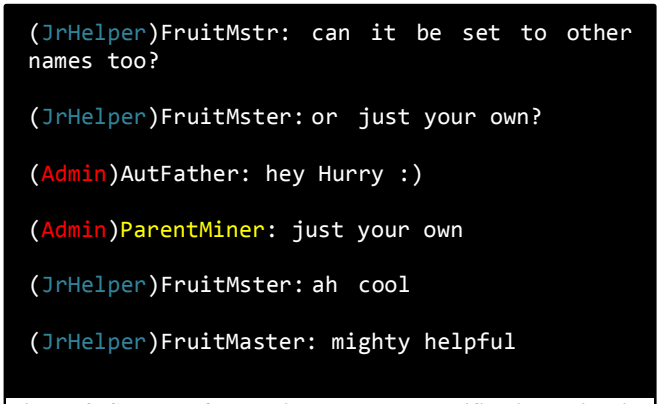

Figure 3. Sample of the splitchat screen modifications with line breaks and highlighting in Autcraft.

for its members [45]. As normative face-to-face interactions are challenging for many individuals with autism, members of this community rely heavily on avatar interactions and the text-based chat functionality [29,37,45,53].

One mod, teleportation, enables players to jump from one place to another in the Autcraft virtual world nearly instantly. This mod, which can be found on a variety of Minecraft servers, is enabled by administrators of the server. In the case of Autcraft, the administrators enabled teleportation to create a "safer" virtual world experience and to support socialization among community members [44]. Teleportation is available through various waypoints within the Autcraft Spawn area as well as through the text chat window.

Community members can use teleportation to return to the Autcraft Spawn area or to teleport to their own designated "home" (*i.e.,* the area the member has set to be their personal property). In this way, players have a safety net for their avatar. They are able to return "home" whenever they need to. This is helpful particularly if a player gets stuck somewhere they cannot get out of or if they get lost in the world—something that can happen frequently, because the world is very large.

Teleportation allows a person to "call" someone else's avatar to them from anywhere in the world and the other person must consent to this teleportation. When this happens the avatar appears next to the caller. Because the virtual world is so vast, this is the fastest and easiest way for community members to get to one another. To consent to being teleported, the member must invite the other to teleport to them and the invitee must "accept" the teleportation:

```
[CHAT] To teleport, type /tpaccept.
[CHAT] To deny this request, type /tpdeny.
```

Community members use this functionality to teleport to each other in order to play, build together, or participate in other activities together. In the following example, P38 is inviting others to roleplay in the "hard world" (*i.e.,* where a member can die and there are monsters, unlike Autcraft in which protections are in place to avoid such negative experiences) and to teleport or *"tp"* to him:

```
<(Autcrafter) P38> [Role play] in hard world tp to me if u want to join there is food!
<(JrHelper) P39> tpa [P24] i found a nice spot
<(Buddy) P24> [P39] i tped [P40] here :P
<(JrHelper) P39> tpa if you want to be blown up!
```

This teleportation functionality not only enables these quick avatar interactions, but also gives community members an ability that they do not have in the physical world. This helps support empowering these young community members to engage in socialization with their friends, when and where they choose. For children, who often must rely on the graces of their parents or older siblings to transport them to a friend's home, the ability to rapidly and easily have access to their friends can be particularly freeing. The "reduced bandwidth" provided by high structured of computer mediated communication provides relief from deciphering nonverbal cues, while enabling control, clarity, liberation, and empowerment [7]. Here we see a novel way to engage and disengage in social interactions.

Additionally, for children with autism, a play date may end rapidly when one child has reached the limit of socialization they can—or choose to—have in a day. In physical spaces, a parent is then likely called, requiring waiting and often continued uncomfortable interactions. In Autcraft, one player can simply teleport home and away from the other. The consequences of playing to these characteristics of autism (*i.e.,* "inflexible perception of others' intentions and difficulty understanding how others perceive their actions" [7]) may have long term repercussion in maintaining relationships [7]. Thus, learning to accept one's denial of teleportation and accepting another's need to teleport away from another take the perspective of the other and can help players develop empathy.

Many players have additional disabilities and health challenges. The particular intersection of health concerns, developmental differences, and a spectrum of life experiences related to race and gender can come into play [18]. The administrators of the Autcraft server attempt to address these additional challenges as they arise. For example, one young member disclosed to the Autcraft community administrators that he had lost vision in one of his eyes and was slowly losing vision in the other eye. He had to explain that this is why he was repeating characters (*e.g.,* >>> or ---) in the chat window. This character repetition, which initially looked like spam or harassment, helped him to break up the text and make it readable. The administrators not only implicitly supported this choice by allowing him to behave in this way. One explicitly tackled the issue in a post to the community:

A quick message to the other admins and helpers on the server and now we're all aware of this and going to support him with his needs even if it means explaining to the other players that in his case, it's OK to do what he's doing. This is just one of the many ways that Autcraft is different from all other servers. (Facebook post, P29, age 39, m)

Following on this policy and behavior change, the administrators also modified the software to change the text chat capabilities. This modification is optional for players, meaning they can choose to use all, parts, or none of the new functionality. The modifications include: personal name highlighting, splitting the chat lines with a personalized character (See Figure 3), and distinct chat "channels" that thread specific conversations together:

… it's customizable. We know not everyone wants yellow so there's actually a command to change the color using Minecraft color codes…. (Facebook post, P29, age 39, m)

The modified text chat has come into regular use among community members. Not only did this end up helping those with visual impairments, but other members as well:

This was the BEST idea ever! Chat is so much easier to see now. I don't have poor vision (Or at least that I know of) but it STILL so much easier to see (forum, P40, f)

Members began asking questions in the forums about other uses this new chat functionality might have, including ways to create separate channels for different activities. One member even posted a screen shot of his joke about the split chat "dividing" the chat screen using the mathematical divide symbol (*i.e.,* ÷), *"when you said splitchat divides chat i didnt know you actually meant it divides chat..." (forum, P41, age 12, m)*.

As the children worked within the confines of the virtual world to make their environment more usable by appropriating with what was available, administrators are able to then iterate on these appropriated instances to re-appropriate the software itself. Thus, administrators, following the cues of the children within the virtual world, are able to instantiate these appropriations and make them available to everyone on Autcraft.

5. Conclusion & Future Work

Minecraft is imbued with and built on the values of enabling customization through building and creating. Starting from the basic blocks, players work to build massive in-world structures and complex machinery, just as architects and engineers would do in the physical world and as children do using Legos and other physical building supplies. Modification has been made relatively easy and explicitly encouraged by the creators of Minecraft in their EULA, an attitude that supports a culture of making and remaking [12]. Modding can be usefully related here to "maker culture" that has resulted in a variety of DIY assistive technology efforts [26]. Similarly, outside of the assistive technology world, this kind of modding happens regularly around popular games (*e.g.,* World of Warcraft [28]) and has a variety of benefits, including teaching players important STEM and computing concepts and skills [24]. These movements set the stage for and enable the appropriation we see in the Autcraft community.

Community members built, augmented, and tailored Autcraft to serve their individual needs over several years. Their actions addressed individual players' needs while creating a beneficial environment for the community, often in ways they themselves did not expect. As we have seen, a simple mod to make text more readable for individuals with visual impairments becomes a tool for self-regulation and a fun form of self-expression available for everyone. Administrators appropriated Minecraft to create Autcraft, their own DIY virtual world. Players, "helpers," and yet more administrators then appropriated Autcraft to craft their own parts of this virtual world. We see here how a culture and ethos of DIY appropriation permeates all levels, from the platform to the virtual world and to individual experiences.

As a group, children with autism are doubly disempowered: both as children and as people living with disabilities. Here, however, we see how this kind of technological openness allows them to customize and create their own play spaces, a type of autonomy that is inherently empowering.

This kind of "bottom up" engagement indicates the need for and potential of a different kind of assistive technology design process. Common methods include research-originated approaches that focus on developing new technologies based on theoretical models or empirical data, as well as participatory approaches that focus on co-creating assistive technologies. This work indicates that a third space may be equally as important: child-initiated design processes. Arising organically from within the Autcraft world, the administrators have taken on a child-initiated design process without explicitly labeling it as such. Observing and working to understand what DIY practices the children were already doing to address their own needs, administrators can then open up yet more possibilities for creation and modification as well as developing similar solutions to those offered by the children to the wider Autcraft community.

As researchers, DIY and appropriation offer us additional data about and insight into how mainstream technologies, even games, can have assistive properties and therapeutic uses. This new class of assistive technology is not always immediately recognizable as such, but provides a new opportunity to consider the scope of our engagements. This paper highlights the importance of a focus on situated practices involving technologies, allowing us to attend to the assistive qualities they may take on in particular contexts.

There are still challenges here. Even in an inclusive community like Autcraft, there can be a drive to focus on safety and on the needs of those who are youngest or have the greatest challenges, limiting the experience for others. Like other models of design (*e.g.,* Universal Design [33]), constructing a single device for everyone often fails to meet the unique needs of the individual. Devices and systems that allow for users to easily "hack" or "mod" represent a good first step in creating more individualized and equitable use—allowing designers to focus their efforts on further developing existing child-initiated activities into mods for an entire community. Going forward, designers and researchers alike must engage with these kinds of spaces and technologies to understand how to best support the full complement of abilities and interests of the users.

In summary, this work has explored how designers and researchers can learn by observing how even the youngest of users augment and appropriate mainstream technology to become assistive in their daily lives. This work highlights the ways in which researchers concerned with accessible and equitable computing spaces might reevaluate their scope of inquiry and how designers might encourage and support appropriation, enhancing the individualized experience and long-term adoption of assistive devices and systems. The appropriations we observed in Autcraft point to a future model where child-initiated modifications can guide research and design, providing greater access for disempowered communities.

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