Online Multiplayer Games for the Social Interactions of Children with Autism Spectrum Disorder: A Resource for Inclusive Education

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Abstract

This article describes the support for social interactions received by three students with autism spectrum disorders through their multimodal engagements with *Minecraft*®. The data were collected through at-screen observations and semi-structured interviews. Multimodal analysis of the data demonstrated that online multiplayer games supported social interactions through modes, such as speech, writing and gesture, and within physical and virtual spaces. The analysis revealed that online multiplayer games provided platforms for the students to use speech to engage in reciprocal conversations, to share information, to make requests, to give commands and to direct others. Additionally, screen-based written texts were used to attract the attention of others, send messages, communicate rules and maintain engagements with others within the students' physical and virtual worlds. Furthermore, the findings showed that online multiplayer games supported the students' uses, interpretations and mirroring of gestures for social interactions. The findings have implications for providing opportunities to support social interactions in multimodal ways that social

spaces in face-to-face and offline contexts do not allow. The findings offer implications for targeting the students' interests in online multiplayer games to support their capacity to initiate and sustain social interactions in inclusive educational settings.

Introduction

One of the core characteristics of autism spectrum disorder (ASD) is persistent deficits in social communication and social interactions (American Psychiatric Association 2013). Children with ASD initiate less social interactions than their peers, and participate in fewer sustained social interactions than children without ASD (Ozuna, Mavridis, and Hott 2015). Individuals with ASD may demonstrate limited abilities with imperative and declarative initiations in social interactions (Charman 2003), initiations through the written mode (Geither and Meeks 2014), and initiations through gestures in physical spaces, such as classroom environments (Wong and Kasari 2012). Support for initiating social interactions is therefore vital for increased generalisation of necessary social interaction skills and positive social play with peers (Koegel et al. 2012).

Without adequate support for social interactions, students with ASD may find it difficult to reciprocate in conversations (Koegel et al. 2012), initiate and sustain interactions through multiple social communication modes, and may be rejected by their peer group (Watkins et al. 2015). This article reports on research describing the social engagements of three students with ASD with online multiplayer games. This research draws attention to the potentials of online multiplayer games for supporting the social interactions of students with ASD. The term 'potential' constitutes the perceived and actual provisions, and beneficial offerings of the online or virtual environments of multiplayer games (Gibson 1977).

Social Interactions through Multimodality and Affinity Spaces of Online Multiplayer Games

In this paper, the term online multiplayer games refers to video games that have two or more players engaging simultaneously in a common virtual environment, while in the same or different physical spaces (Quandt and Kröger 2014). *Minecraft*®, a popular sandbox multiplayer game, was chosen as the online multiplayer game to observe at-screen social interactions of students with ASD in this research. *Minecraft*® is a three-dimensional interactive digitalised game, created by Markus 'Notch' Persson. The game affords its players to socially interact through creative, survival, adventure and building challenges (Nebel, Schneider, and Rey 2016). *Minecraft*® could be considered as one of this decade's most important games (Arnroth 2014). Considering the millions of merchandise sales, forums and popular media sites associated with *Minecraft*®, the game's phenomenon is undeniable (Wernholm and Vigmo 2015).

Recently, researchers have shown an increased interest in *Minecraft*®. Dezuanni and colleagues (2015) focused on primary students' online and offline multiplayer interactions with *Minecraft*® through their speech, design, display and digital production. Similarly, one study conducted by Wernholm and Vigmo (2015) examined the semiotic resources of *Minecraft*® to capture children's collaborative online play and dialogues in informal learning environments. Semiotic resources refer here to the social communication modes, material resources, artefacts and digital tools (Jewitt 2017), such as the screens and game controllers that gamers use to support their virtual social interactions. Previous research has also explored the video game use of boys with ASD (Mazurek and Engelhardt 2013), and friendships and socialisation of adolescents with ASD through online multiplayer games (Gallup et al. 2016). However, this work is the first to our knowledge to provide descriptions

of the multimodal support of *Minecraft*® for supporting students with ASD to initiate and sustain social interactions.

The term multimodal in this research builds on the linguistic framework of social semiotic theory of communication (Halliday 1978). Multimodal is defined here as the combination of multiple modes for meaning making in various environments and contexts (Jewitt 2017). The multimodality of online multiplayer games allows players to use the modal elements of the games, such as speech, writing, image and gesture in physical and virtual spaces to make meaning for their social interactions (Gee 2015). Drawing on the works of Merchant et al. (2014) and Saunders et al. (2011) the term virtual space is defined in this paper as a digital, non-physical three-dimensional place or space in the environments of online player games where players interact in metafunctional ways individually or in groups. These ways are described as human like, experimental, logical, experiential, communicative, interactive and textual (Halliday and Matthiessen 2014). For example, a gamer's virtual space directly impacts meanings made for shared resources, avatar recognition and the social presence of all of the players (McCreery, Vallett, and Clark 2015). Additionally, tools, such as writing chat boxes, voice chats and video chats are critical components of social interactions in online multiplayer games (Gallup et al. 2016).

Following Gee's (2015) views, online multiplayer games are theoretically described as online affinities with multimodal communication systems because they provide many contextual ways to engage in social interactions through discourses and shared affinities in virtual and physical spaces. The term discourses embodies ways of thinking, talking, writing and acting through modes, such as spoken and written language. Hence, student engagements with *Minecraft*®, and teacher perspectives on the multimodality and affinity spaces of online multiplayer games for the social interaction of students with ASD are worth examining and describing.

Inclusive education is about embracing different modal elements, and inclusive practices and resources to ensure that students, including those with ASD, receive multimodal and differentiated support for social interactions within the context of education (Carrington and MacArthur 2012; Whitburn, Moss, and O'Mara 2017). Research on support for the social interactions of students with ASD include the effectiveness of speech (Almirall et al. 2016), the power of the writing (Asaro-Saddler 2016), the continued development of gestural production (So et al. 2014) and the modification of space (Pengelly, Rogers, and Evans 2009). However, there is a lack of research on how the multimodality of online multiplayer games support the abilities of students with ASD to initiate and sustain social interactions within formal inclusive settings.

Support for initiating social interactions refers to the opportunities to enable and enhance a person's ability to request his or her social partners' interactions in activities, events and conversations through multiple modes (Block et al. 2015). This is important because the ability of students with ASD to initiate and sustain social interactions is often limited (Charman 2003). In the context of inclusive education, this support may involve a broadened perspective about the needs of students to engage in communicative behaviours, such as commenting on observations or topics of interests, requesting others' shared engagements in play, and the implicit and explicit desiring for social interactions (Deckers et al. 2014; Mortier, Van Hove, and De Schauwer 2010). Similarly, support for sustaining social interactions is defined here as the availability and offer of opportunities to promote, develop, maintain and participate in social interactions (Sansosti 2010).

This paper aims to describe how multimodal interactions with online multiplayer games support the capacity of three primary students with ASD to initiate and sustain positive social interactions. Furthermore, it presents descriptions from the perspective their teachers in

relation to the support provided by online multiplayer games to improve the quality of the social interactions of students with ASD.

Methodology

This study has an ethnographic case study design (O'Reilly 2004). The descriptor 'ethnographic' emphasises the study's approach to document and describe the students' daily interactions as they unfolded in their homes and school (Robben and Sluka, 2015). Qualitative approaches were applied as key aspects of ethnography (Creswell 2015). Therefore, this ethnographic case study reports findings from the video-recorded, at-screen observations of students with ASD as they engaged with *Minecraft*®. These findings enable the description of the potentials of online multiplayer games for their social interactions. Additionally, video-recorded and audio-recorded semi-structured interviews were central to accurately capturing teacher perspectives about the potentials of online multiplayer games for supporting the social interactions of students with ASD.

Participants

The research participants included three students and three teachers. The student participants described in this paper included three nine-to-ten-year-old boys diagnosed with ASD. The student participants with ASD were diagnosed using the Diagnostic and Statistical Manual of Mental Disorders, Forth Edition, Text Revision (DSM-IV-TR) (American Psychiatric Association 2000) criteria, by experienced clinicians including psychiatrists, paediatricians and neurologists. In addition, the students had received an ASD verification through the state government verification process in its Education Adjustment Program to identify their need for support within the public education system (Queensland Government 2017). "Purposeful sampling" was used to draw research participants from students who had high levels of

interest in *Minecraft*®, experiences with online multiplayer games, and were willing to participate in the study (Suri 2011).

Additionally, there were a sufficient number of interested teacher participants at one school with experience with the students with ASD to be able conduct the research. Therefore, following notion of sampling with a purpose (Palinkas et al. 2015; Patton 2015), the teacher selection was based on the teachers' involvement with students with ASD in the school setting. The teachers included some of the students' regular classroom teachers and support education teachers, and teachers who taught students with ASD and had knowledge about their experiences with online multiplayer games. Data collection from the teachers provided insight into how online multiplayer games can be used as inclusive resources to support the students' social interactions in physical and virtual world contexts.

Data Collection and Analysis

Video-recorded observations were conducted in the three students' homes to digitally capture their social interactions as they engaged with *Minecraft*®. The version of *Minecraft*® that was observed was *Minecraft*® 1.8 which was released in September 2014. Several other editions of *Minecraft*® have also been released between 2009 and 2018. Two digital video-recording cameras were elevated above the floor to record the students' at-screen interactions. One digital camera captured the students' bodies as they interacted at the screens. The other digital camera captured the details on the screens. A total of four and a half observation hours of at-screen data were recorded from the three students. Specifically, nine segments of 30-minute, video-recorded observations were collected from the three students as they engaged with *Minecraft*®. Each of the three student was recorded for one and a half hour.

Transcription laid a useful beginning to the coding, description, and understanding of how students initiated and sustained social interactions within the context of online multiplayer games. The transcription process drew on the notion that individuals simultaneously use multiple modes during social interactions (Jewitt 2017). Hence, data from the two digital video-recording cameras were manually transcribed in a verbatim manner to represent multimodal meanings (Halcomb and Davidson 2006).

The transcription spoke for itself as a conceptual tool for thematic coding, following qualitative methods for inductive coding (Creswell 2015; Thomas, 2006) and methods for multimodal transcription and text analysis (Baldry and Thibault 2006; Flewitt et al. 2017). The at-screen data were transcribed frame-by-frame with second-by-second time frames. The video-recorded observations of the screens, and the students' multimodal engagements with *Minecraft*® random online players, the videogame controllers, the researcher, and their physical environments were watched and listened to repeatedly. Additionally, the transcriptions were reread to make detailed meanings about social communication modes and the themes that emerged. The verbatim transcription process was consistent the warning of Evers (2011) and Flewitt et al. (2017) that the transcription of video-recorded data can be time consuming and intensive. The transcriptions of each video-recorded session were represented as typed text into tabular observational protocols that contained the data transcription and coding. The tabular format and conceptual headings of multimodal features' and 'themes' allowed the introduction of an inductive approach to thematic coding at the time of data transcription (Thomas 2006).

The data analysis was integrated within the processes of data transcription, description and interpretation and used an inductive approach (Simon 2009; Thomas 2006). The analysis of the at-screen data applied multimodal analysis (Jewitt 2017). Multimodal analysis began with repeated viewing and listening of the video-recorded at-screen data for transcription. A

summary of the multimodal features and themes arising from the coding of at-screen data are provided below in Table 1. (Please place Table 1 near here).

In addition, three segments of 30-minute semi-structured interviews were collected from three teachers. The teachers were interviewed at the school site. To guide the multimodal analysis of the semi-structured interviews, three interview protocols were created. The video and audio recordings of the teacher interview data were transcribed in a verbatim manner to ensure accuracy of the participants' responses (Evers 2011). Inductive coding identified the teacher perspectives on online multiplayer games for initiating and sustaining social interactions (Thomas, 2006). The inductive coding of the data continued until no new or relevant data emerge about the social interaction support provided by online multiplayer games. The literature on multimodality theory (Flewitt et al. 2017; Jewitt 2017), video games (Beavis and Apperley 2012; Gee 2015) and ASD (American Psychiatric Association, 2013; Ozuna et al. 2015) was drawn upon to guide analysis of the social interaction support that the students received.

The trustworthiness of the data was positioned through member checking (Birt et al. 2016). For example, the research participants were given opportunities to check and confirm specific aspects of the data and whether transcripts of their interview comments and responses were reported accurately and fairly, in the context of the research (Berg and Lune 2017). Member checking afforded the participants opportunities to challenge what they perceived as misinterpretations, fill in omissions, and correct errors and misunderstandings, lest any misinterpretation of the data existed. Equally important, the supervisors checked that the emergent themes were supported by the data and thereby the increased the rigor of the qualitative analyses and reliability of the results. Necessary adjustments to the coding were made (Simons 2009).

Ethics

The research received ethical clearance by a human research ethics committee (1500000470). After the parents gave their consent for their children's participation, the research purpose was discussed individually with the students through an informal discussion. The students were required to give written assent to participate in the research process, ensuring that they were able to understand the motives and agenda of the study and were capable of providing positive agreement to participate in the research (Farrell 2005). To assure the students' understanding of the research purpose, the research purpose was rephrased for the students. The students could withdraw from participation in the video-recorded observations at any time. The participants were also informed of the plans for the data and offered a summary of the study's results. Both sets of participants remained anonymous during the voluntary participant recruitment and data collection. During the data reporting stages, the names of all participants were coded with pseudonyms to protect their anonymity.

Results

This section describes findings from the at-screen video-recorded observations of the students and teacher semi-structured interviews. These findings provided insights into how *Minecraft*® supported the students' capacity to initiate and sustain social interactions in both online and offline contexts.

At-screen Findings of Support for Initiating and Sustaining Social Interactions

Observed instances of social interactions were coded in the data to reveal patterns of support provided by the multimodal design of the user interface of *Minecraft*®. Hence, the descriptions below focus on how the content and material in *Minecraft*® supported the

students' initiating and sustaining of social interactions through a multimodal configuration of speech, written text and gestures within physical and virtual spaces. Additionally, the students randomly engaged with online players who were known and unknown to them. The researcher's knowledge of the identity of the online players was not necessary for the purpose of this research. Therefore their identity remain anonymous. All random online players will be referred to as 'Steve'. All random avatars will be identified as 'Stevatar'.

Opportunities to Support Speech for Social Interactions

The data revealed that *Minecraft*® supported the students' ability to use speech for social interactions even though only a small portion of speech was transmitted to other online players. To explain, the semiotic resources that Mason used momentarily enabled him to engage in conversations with Steve about their play together online. During his conversation with Steve, Mason said that he wanted '*to have a go of Minecraft*®' for '*one hour*' and communicated his plans to '*play*' with Steve the following day.

Drawing on the work of Halliday and Matthiessen (2014) on systemic functional grammar, this section describes how *Minecraft*® provided opportunities for the students to initiate social interactions through interrogative, imperative and declarative speech. A notable use of interrogative speech was when Noah requested that Steve socially interact with him in his '*secret hideouts*'. He asked, '*So what do you say we do today buddy? Let's play some Hide and Seek*?' An example of how *Minecraft*® supported social interactions through imperative and declarative speech was when Noah directed Steve to '*follow*' him so that he could '*show*' Steve his '*secret hideout*'. Furthermore, the three students' uses of collective pronouns, such as '*we*' as well as personal pronouns '*you*', '*me*' and '*us*' in their spoken requests and directives pointed to their intentions on initiating and sustaining shared activities in social interactions, rather than single player engagements on the activities.

Similarly, the students' social interaction initiations with the researcher included verbal statements and directives that motivated the researcher to '*look at*', '*watch*' and '*see*' the visible content and material of *Minecraft*®. To demonstrate, Ethan engaged in a six-minute conversation with the researcher after he said, '*Okay, come on (Steve) let's go. I'm going to The End*' and, '*Steve's entered The End like me*'. The conversation between Noah and the researcher included discussions about:

- Steve '*chatting with (their) enemy*';
- Noah and Steve collaborating to defeat the '*Ender Dragon*' and '*Ender men*';
- Sharing a '*sweet little…Ender pearl*' and a '*precious…Ender Dragon egg*' with Steve.

Supporting Social Interactions through Written Texts

The students with ASD continuously used written texts within *Minecraft*® to initiate and sustain social interactions. The support afforded by the written texts ranged from initiating social interactions through alphabetical symbols, to sustaining social interactions through sentences. A notable example of alphabetical symbols use to initiate social interactions was when Noah expressed his '*love*' of typing '*g*' in *the* '*book and quill*' to bid Steve to engage with him in '*Minecraft® Hide and Seek*'. Noah said that Steve understood that a typed '*g*' meant to '*go*' and '*hide*'. Additional initiating of social interactions was made when the students scrolled through up to 45 pages long of '*friends*' lists and sent online players written '*messages*'. Furthermore, Noah relied on his written phrases ('*Minecraft® hide and seick (seek)'* and *'no cheting (cheating)'* that he created on written signs, to play '*Hide and Seek*' with Steve.

The students also wrote clauses to welcome other players to their environments within *Minecraft*®. To demonstrate, Mason '*created*' a '*new world called Christmas world'* which displayed the written sign that read '*Welcom (welcome) to my Christmas WORLD Still in*

progress OK (okay)'. The '*chat*' function in *Minecraft*® enabled the students to communicate to other players and to give commands within the game. Additionally, the clauses '*invite to party and chat*' and '*join session in progress*' are two examples of many clauses that the students had access to click on to support their spoken desires to '*join*' in and '*play*' with other players in *Minecraft*® activities. Likewise, the semiotic resources of *Minecraft*® supported the students' abilities to use '*chats*' through entering written texts in dialogue boxes. For example, Ethan wrote sentences in chats to other players, such as '*Do you want to team up?*'

Social Interactions Support through Gestures

During their at-screen engagements, the students with ASD used multiple hand, body and facial gestures. Their smiles were configured with laughter, giggles and spoken words, such as 'l*ove*' and '*like*' and expressions, such as '*wee!*' The students also made frequent eye contact with the researcher. *Minecraft*® also supported their abilities to initiate and sustain social interactions through other gestures, such as hand-pointing towards the screens and digital-gestural pointing through the screen cursors. The digital-gestures through the use of cursors supported the students' bids for the researcher to '*look*' at, '*see*' and '*watch*' images, such as bodily parts of avatars including heads, '*legs*' and 'faces'. The use of cursors also supported the students' ability to point to their virtual creations, and blocks and items that they drew from categories, such as '*building blocks*', '*foodstuffs*', '*tools*' and '*weapons and armour*'.

The findings also showed that *Minecraft*® supported the students' initiated and sustained social interactions through the gestures of their avatars. To explain, the students' avatars made eye contact with other avatars and gazed jointly with other avatars towards the visible elements of *Minecraft*®. Additionally, their virtual hands moved to point to virtual

images, and '*punch*' and '*hit*' other avatars to initiate attention and play. Their avatars' hands also moved to '*mine*', '*dig*' and '*place*' blocks to sustain shared activities. Likewise, their avatars' heads shook to give '*yes*' and '*no*' responses. The students also interpreted similar gestures of other avatars when they required a '*yes or no*' response to sustain social interactions. To demonstrate, Mason asked Steve if he knew the video game '*FNAF*' *(Five Nights at Freddy's™)'*. After Stevatar '*shook his head*' up and down, Mason told the researcher that Steve '*was saying 'yes he wants to help'* to build a FNAF '*pizzeria*'.

To illustrate further, Noah initiated and sustained social interactions with Steve through '*Minecraft® Hide and Seek*'. The game involved the use of his avatar's bodily movements in, around and out of '*hiding spots*'. Similarly, *Minecraft®* supported Noah's virtual mobility to '*play catch 'and throw' with the book*' with Stevatar. Furthermore, Noah repetitively raised his virtual hand towards Stevatar and gave '*high fives*' to compliment Steve on his '*good…teamwork*' in defeating the '*Ender Dragon*'. He said, '*…I love giving him (Steve) high fives in this game (Minecraft®)'*. The gestural potentials for social interactions within *Minecraft®* were also observed in the students' abilities to fly over villages and across terrains, jump from tall buildings, and eat underwater with other avatars.

Social Interaction Support in Virtual Spaces

Support for initiating and sustaining social interactions was evident when the students invited other *Minecraft®* players to '*join*' them in shared spaces, such as their own online servers. The game also enabled their joinability to the virtual spaces of mini *Minecraft®* games. Once other players joined the students' servers, they also sustained the social interactions by sharing spaces, such as a lab, caves, houses, villages, secret hide outs and beds. By sharing sleeping spaces with other players, time in *Minecraft®* skipped from night to '*dawn*', and Noah and Steve avoided the '*hostile*' night creatures.

Notably, the students' capacity to initiate and sustain creative, adventurous, competitive or combative social interactions were supported by their teleportation of avatars across *Minecraft*® spaces. The term '*teleport*' in the context of *Minecraft*®, means to transport avatars from one virtual space to the other without the use of transportation or body movements. Teleportation-type initiations in *Minecraft*® were enabled through the selection of written commands, such as '*Teleport to me, Stevatar*'. Additionally, the students spoke with the researcher about their engagements with the teleported avatars across different spaces: '*Look, I'll just teleport him here*'. To end, the students also revealed that they played online multiplayer games with peers and siblings in their own homes, and played in the homes of their material-world friends.

Teacher Perspectives of Online Multiplayer Games to Support the Social Interactions of Students with ASD

The teachers were asked to share their perspectives on the potentials of online multiplayer games for the social interactions of their students with ASD. According to the teachers, engagements with online multiplayer games seemed to offer opportunities to motivate students with ASD to '*blurt out*' words, such as '*Hey, I play Minecraft® too!*' The students' '*passion for*' online multiplayer games gave '*a common thread*' and motivation to '*spark up*' conversations with their peers and adults. In these conversations, the students asked their peers' opinions about the games. They also talked about the features of the games' characters, their accomplishments, '*their high scores*', who or what they had '*killed*' or '*beaten*', and what '*they had won*' in battles.

The teachers also revealed that they observed changes in the students' '*confidence*' level during social interactions. The teachers believed that the games influenced the students' confidence level to initiate and sustain social interactions through speech, images, written and

gestures associated with online multiplayer games. For example, the teacher responses indicated that there seemed to be an increase in the students '*self-esteem*' when they were viewed by their peers as '*experts*' and asked to share information about their video gaming. Opportunities for some students to share information and knowledge about video gaming boosted confidence and made the students '*feel good*'. Changes in confidence levels to initiate and sustain social interactions though spoken and written language, and gestures were particularly noticeable in students who: were '*generally isolated*' '*within their own worlds*', engaged in '*parallel play*' and who did not have a '*good social network in school*'.

Similarly, the teacher interview data revealed that the discourses of online multiplayer games supported the removal of gestural '*barriers*' to social interactions. This support was exemplified when the students '*naturally*' made '*eye contact*' while they engaged in conversations about the games. The teachers also discussed that some students made eye contact and shared visual attention between printed texts and the faces of their social partners during the times that they:

- Played cards and created drawings that were similar to the games' images
- Wrote stories about their video games experiences
- Read printed texts related to online multiplayer games.

The pressure to make eye contact was lost in the positivity, '*happiness*' and '*excitement*' that their students associated with the games. The students did not have to '*worry about*' their gestures, because of their '*common (gaming) interest*'. Furthermore, some of their students with ASD engaged in fantasy play about the games and mimicked some of the gestures of the games' '*characters*' and avatars. The gestures included '*turning*', robotic walking and arm movements, '*leaps and curls*' and shooting.

It became clear from the teachers' responses that online multiplayer games and their semiotic resources have opened up a '*door*' into '*a world*' where the games' '*graphics*' look

'*real*' and the instant '*feedback*' from the modes were '*shaping'* the social interactions of their students with ASD. The teacher participants discussed that due to the characteristics of ASD, students with ASD face '*difficult times*' in social interactions and '*interact less*' in physical spaces. They explained that virtual spaces enabled participation in social interactions that was difficult for some students with ASD physical contexts. Additionally, they believed that some of these interactions were perceived as impossible in the physical world because of financial reasons, and physical and geographical boundaries. Hence, engagements with online multiplayer games gave their students social interaction '*opportunities'* they had not previously been '*able to access*' '*geographically*' nor '*economically*'. The teachers implied that social, financial, and physical barriers are being removed so that students with ASD can '*bring the world*' into their gaming spaces, and socially interact beyond the physical school environment, with worldwide gamers.

Additionally, the teachers stated that to maximise support for offline and online social interactions with their peers, that students with ASD '*network in the same room*' in a '*face-to-face (peer) group*'. In this way, students can:

- '*Challenge*' peers in the games
- Request immediate '*feedback*' about their gaming activities
- Develop their abilities to read facial gestures and '*body language*' that are often used in initiating and sustaining social interactions.

The teacher responses also indicated that the games' discourses supported the students to build '*little communities*' and interest groups in which they and their peers '*support*' each other.

Discussion

This paper aimed to describe the potentials of online multiplayer games for supporting the initiating and sustaining of social interactions of students with ASD. The findings revealed that the multimodality and discourses of *Minecraft*® provided opportunities for the students to initiate and sustain social interactions through speech, written texts and gestures, and within physical and virtual spaces. The findings of the current study are consistent with the work of Gee (2015) who argues that the multimodality of online multiplayer games allows players to use the games' modal elements and discourses for their social interactions. The findings from the at-screen observations and the semi-structured interviews were synthesised in the discussions below according to their implications for supporting the initiating and sustaining of social interactions of students with ASD in offline and online contexts.

Support to Use Speech in Social Interactions

Oral language, speech and conversational reciprocity are significant in communicating meanings and sustaining social interactions (Paul et al. 2009), but these are often areas of difficulty for students with ASD (Lanter and Watson 2008). The analysis revealed that online multiplayer games provided platforms for the students with ASD to use speech to engage in reciprocal conversations, to share information, to make requests, to give commands and to direct others. This study aligns with the findings from Gallup et al. (2016) that online multiplayer games can enable some adolescence with ASD to speak to and take conversational turns with other gamers. An important implication of these findings is that online multiplayer games could provide opportunities to support these students to practice oral skills, such as speech, conversational reciprocity, and information with their peers and adults who observe their online gaming experiences.

Additionally, the students' at-screen engagements were filled with laughter and giggles, suggesting that they had some levels of enjoyment in their social interactions. These

results concur with previous studies which have shown that some students with ASD enjoyed engagements with video games and as a result they may be more motivated to participate in social interactions with peers and friends in familiar environments and activities (Gallup et al. 2016). The findings also imply that online multiplayer games could support opportunities for students to enhance and extend their motivation, enjoyment and participation in conversations and discourses with their peers and others (Gee 2015).

Support for Using Written Texts in Social Interactions

Students with ASD often experience writing difficulties in self-regulation, planning and imaginary writing (Asaro-Saddler 2014). Difficulties with written communication and written expressions can impact on their abilities to initiate and sustain social interactions that occur through the written mode (Zajic et al. 2016). Conversely, this research findings revealed the potentials of online multiplayer games to support the social interactions of students with ASD through the typing, clicking, reading and selection of written grammatical units, such as alphabetical letter, words, phrases, clauses and sentences. These grammatical units may be used to attract the attention of others, send messages, communicate rules and maintain engagements with others within the students' physical and virtual worlds. Taken together, the findings have shown that the production of written texts through virtual signs and virtual books, and writing chat boxes were important components of the students' social interactions. These components were especially beneficial when the students were unsuccessful in initiating, transmitting and sustaining their social interactions visually and orally.

In addition, the evidence from this study suggested that the semiotic resources of online multiplayer games should be targeted to support the reading and selection of screen texts for social interaction (Gee 2015). Likewise, the findings indicated that engagements with online multiplayer games could motivate students with ASD to initiate and sustain face-

to-face social interactions through written texts that they draw, read and produce about online multiplayer games. Students' written data about their social interactions through *Minecraft*® may provide insight into how their digital gameplay with others can support their face-to-face and online social interactions (Dezuanni et al. 2015).

Gestural Support for Social Interactions

Previous research findings have found that children with ASD often have limited skills to receive, understand and produce non-verbal modes of social communication during their social interactions (Grossman and Tager-Flusberg 2012). However, this research's findings showed that online multiplayer games supported the students' uses, interpretations and mirroring of avatar gestures for social interaction. Likewise, initiating and sustaining social interaction through the digital-gestures of cursors offers implication for bidding and engaging the attention of peers to at-screen social interactions (Shih, Shih, and Wu 2010). Furthermore, the support to use virtual gestures through their avatars could be especially beneficial for some students with ASD who have preferences for limited physical touch during social interactions (Riquelme, Hatem, and Montoya 2016). The findings also have implications for supporting the social interactions of students with ASD who may experience difficulties in using their physical bodies in material-world settings to engage in shared play activities (Freeman, Gulsrud, and Kasari 2015). Similarly, the support to mimic some of these virtual gestures for social interactions in the school environments is significant because the research indicated that one obstacle in social interactions of children with ASD is their development and sustainment of symbolic and representational play (Hobson, Lee, and Hobson 2009). Another implication is that age appropriate gestures from virtual spaces in online multiplayer games may be replicated in face-to-face contexts to enhance the use and understanding of gestures for social interactions in school environments. This implication is significant given

the correlation between video game use and problem behaviours of students with ASD (Mazurek and Engelhardt 2013).

This study has also shown that online multiplayer games supported the students' abilities to frequently smile and make eye contact with adults and peers in more natural and comfortable ways without any pressure to do so. Forced eye contact with children with ASD causes discomfort and resistance to social interaction (Joseph et al. 2008). These findings provide implications for online multiplayer games to support students with ASD to spontaneously and comfortably use gestures as they socially interact with peers and adults who observe them play online and who socially interact with them in online and offline contexts (Gallup et al. 2016).

Support to Use Affinity Spaces for Social Interactions

The findings revealed that online multiplayer games supported the students' social interactions by providing them with unlimited virtual spaces to join and play. These spaces and the game play within them were personal, but yet sharable. These findings further support the idea that multiplayer games synchronise modes and enable shared gaming experience while gamers socially interact on servers and in virtual spaces (Stagner 2013). The servers and virtual spaces for game play within *Minecraft*® acted as main hubs for personal and sharable interactions between the students and other online players. Likewise, the students controlled who they invited and joined in virtual environments, and progressed through the games' spaces with, through collaborative, creative and competitive social interactions. Technology that supports the personalisation of space for social communication acknowledges the diversity in the social interaction preferences, behaviours and needs of individuals with ASD (Porayska-Pomsta et al. 2012). These findings may help us to understand how to better support students with ASD to have personal control over how,

when, and with whom they socially interact in virtual spaces. This control is preferable and more effective for sustained social interactions than the unpredictability of face-to-face social interactions (Gallup et al. 2016).

Additionally, the findings revealed that online multiplayer games opened doors to virtual-world spaces in which the modal experiences are as realistic as those in the face-to-face contexts, and gave instant feedback for the students' sustained social interactions. This supports the argument of Stagner (2013) that virtual gaming experiences are the closest of artificial intelligence to make a person feel like they are playing with a real person in face-to-face contexts. Additionally, the virtual spaces of *Minecraft*® supported the students' engagements in superhuman experiences, such as teleportation-type initiations and flying.

These findings may broaden our understanding about the potentials that virtual spaces of online multiplayer games have to bypass limitations to social interactions that may often experience in physical environments, such as classrooms and school playgrounds. These findings also have implications to extend the social spaces of students with ASD to realistic virtual environments, when physical environments for social interactions are physically and financially inaccessible. There are also implication to create affinity spaces that could support: situated uses of multimodal forms of social communication; local and worldwide contexts for social interactions; integrated, shared, and common affinities; and collaboration, learning, motivation and social skills for social interactions within virtual and physical inclusive settings (Gee 2015; Hayes and Duncan 2012). Additionally, the findings suggested that the multimodal (Jewitt 2017) and metafunctional (Halliday 1978) potentials of online multiplayer games in physical and virtual spaces may support social interactions through the discourses of spoken ideas, written texts, and visual and gestural representations.

Recommendations

The findings and notion of inclusive support (Whitburn et al. 2017) guided recommendations for targeting the multimodal potentials that online multiplayer games could afford, and to provide scaffolded support for diverse areas of student social interactions as students require. Based on the findings, teachers should use online multiplayer games as inclusive resources within the classroom setting by enabling opportunities for students to initiate and sustain social interactions. For example, students should be allowed to speak about their gaming interests, virtual gestures, images, characters, actions and settings, and the strategies that are used during online gameplay. Oral support is also encouraged given the conversational potentials of online multiplayer games (Gee 2015) and the difficulties that some students may experience orally in social interactions (Lanter and Watson 2008; Paul et al. 2009).

In addition to oral support, educators should provide inclusive educational support by providing opportunities for students to initiate and sustain social interactions through the production and reading of written grammatical structures. For example, students' interests in online multiplayer games should be targeted to support their capacity to initiate and sustain social interactions through virtual signs, virtual pages and books, and online message boxes and group chats. Opportunities for students to receive differentiated written support for social interactions within the context of education is also encouraged given the performative and representational potentials afforded by video games (Dezuanni et al. 2015) and the difficulties that some students may experience with written communication and written expressions (Asaro-Saddler 2014; Zajic et al. 2016).

In addition, educators should target the gestural potentials of online multiplayer games so that social interaction support through online multiplayer games is extended beyond oral and written language. For example, students should be encouraged to use physical and virtual gestures for their social interaction functionality to point to and communicate meanings about screen images, written texts, avatar gestures and other multimodal cues.

Gestural social interaction support through online multiplayer games is also encouraged given that the games may enhance students' abilities to recognise and execute actions and movements through their avatars (Beavis and Apperley 2012) and
some students may experience difficulties may experience difficulties to use their physical bodies to engage in shared physical activities (Freeman et al. 2015).

The findings are also consistent with the notion that with the expansion of gaming information, gaming technologies, and increasingly globalised societies, students are developing sophisticated multimodal abilities to socially interact with others through online multiplayer games (Garcia 2017). Hence, it is also recommended that educators provide opportunities to support social interactions in other multimodal ways that social spaces in face-to-face and offline contexts do not allow. For example, educators should target students' interests in online multiplayer games and extend their affinity spaces beyond their physical classroom environments to online and international contexts, so that they can engage with peers around the world.

This study has implications for international research of students with ASD on how their social interactions extend beyond their school and local contexts with peers to other affinity spaces with online international players (Gee 2015). There is also abundant room to expand the research topic to other online multiplayer games that are played across international contexts. Future comparative studies could investigate the differences between how the social interactions of students with and without ASD are supported through their engagements with Minecraft® and other online multiplayer games. Further research may also explore how social interactions may be supported through other video gaming platforms for example, virtual reality. Future studies with the application of multimodal analysis may provide broader understandings online social interaction practices of students with ASD.

Conclusion

The results showed that a main benefit of the students with ASD's engagements with online multiplayer games was the support that they received for initiating and sustaining social interactions with online gamers, their peers, friends, teachers and the researcher. Support for initiating and sustaining social interactions was offered through a configuration of modal elements, such as speech, writing and gesture within social spaces. Student abilities for initiating and sustaining social interactions observed here offer insight into the novel ways that other students with ASD may be supported by online multiplayer games. They may be supported to show interest in others, attract attention and maintain engagements with others within virtual-world and face-to-face contexts. Previous research has documented that multiplayer games are potential motivators for social interaction in classroom and extracurricular activities (Metzger and Paxton 2016).

The empirical findings in this study enhance our understanding of how online multiplayer games motivate the interests of students with ASD to socially interact, and how their online multiplayer gaming interests could be channelled in multimodal ways to further support, promote, develop and sustain their capacities for social interaction within inclusive educational settings. Finally, continued support of student initiations and sustained social interactions through multimodal communication systems, such as online multiplayer games, is vital given the increased prevalence rate of ASD (Christensen et al. 2016) and the growing affinity of individuals with ASD to technology and video game engagements (Mazurek and Wenstrup 2013).

Table 1. Multimodal features and themes arising from 20 seconds of transcription and coding

Transcript	Multimodal Features	Themes
Screen: Displays texts: '8,7,6, ….1 seconds remaining!'; 'Voting! Prepare to start voting! Placed magical crit effect (x2)'; 'Vote for your competitor's plot'; 'The theme was whale'; 'Use the items in your … (remainder of text uncaptured by video recording)' Displays a white fish shaped image 'Plot owner: Stevatar'. Ethan's avatar walks and flies around plot, hand points to image. Several avatars walk and fly around plot.	Written/visual - black, yellow and red text Visual - images Gestural - virtual	Support to initiate and sustain social interaction - signal transition, voting, creative/ competitive activities
Ethan: Looks at screen "Oh, this fella done a dolphin. Umm, not exactly a whale but I'll go, good." Raises eyebrows when speaking. Types on keyboard.	Oral - speech Gestural - physical Written text	Support to initiate sustain social – shared attention to images, engagement in conversation, declarative speech, reciprocal feedback
Screen: Text box to the right displays 'vote: good'		
Researcher: "Are you voting on his and he is voting on yours?"		
Ethan: "Yeah."		
Screen: Multiple view of plot. New plot displayed. Middle displays 'Plot owner: EthanMBrown'. Text box to the right	Written text	

displays ‘vote: own plot’. Multiple avatars walk around plot. Ethan: “This is mine!” smile, high pitch. Screen: Pans around his whale in multiple directions. Avatar hand points to whale. Displays several avatars walking and flying around whale and plot. Ethan: What do they think of mine? What do they think of it? What do they think of it?” Lowers voice at the end. Eyebrow raised. Researcher: “I would give you ten out of ten.” Ethan: Moans. “What do they think of it? What do they think of it? What do th (incomplete)?”	Gesture - virtual and physical Visual – image Gestural - virtual Oral - speech	Support to initiate and sustain social interaction – shared attention, declarative and interrogative speech, shared attention, verbal repetitiveness

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