1. Introduction

Autism Spectrum Disorder (ASD) describes a range of neurodevelopmental disorders characterised by impaired social and communication development, repetitive behaviours and restricted interest (Kanner 1943; Asperger 1944). Early intervention for children diagnosed with ASD has shown promising results with improvements in both social and non-social deficits over time (Duncan and Bishop 2015). However, ASD is a lifelong condition and the strong research focus on early childhood leaves a gap in the study of social and emotional interventions with adolescents and adults with ASD. Adolescents with ASD often face challenges with social interaction and have fewer friends than their peers without ASD (Rowley et al. 2012). In addition, adolescents with ASD are also more likely to face rejection and be bullied by peers as a result of their social awkwardness (Cappadocia et al. 2012; Attwood 1997). The lack of social skills in people with ASD may further lead to the development of anxiety and depression (White and Roberson-Nay 2009).

Community ASD support groups can provide the opportunity for adolescents with ASD to have a social life outside of school. Parents involved in these support groups also have the opportunity to meet others with similar experiences and to exchange information (Weidle et al. 2006). For some adolescents with ASD, the community support groups may be the only social activity involving peers on a regular basis apart from school. Moreover, most adolescents with ASD view the group meetings as a positive activity and attend regularly however, the social interaction among the support group members often does not extend outside of organised activities.

Social networking sites provide a platform to support communication and relationship building with family and friends. Many adults with ASD use some form of social networking sites (Mazurek 2013). However, a study by Carrington et al. (2017) suggests the number of

adolescents with ASD on online social networking sites is decreasing due to the risk of being cyberbullied. Parents/carers are also generally cautious with social networking sites due to potential problems with cyberbullying and inappropriate content (O'Keeffe and Clarke-Pearson 2011). Nonetheless, previous studies have described positive outcomes of using digital technology and the importance of user involvement in ASD research (Alarcon-Licona et al. 2018; Soysa and Mahmud 2018; Khan et al. 2019). A well-designed technology-based solution can assist people with ASD to attain skills for increased adaptive functioning. Equally, a poorly designed solution can create the opposite effect of socially isolating a child (i.e., only interacting with a machine and not with other people) (Ploog et al. 2013). The relationship between the person, technology, and the environment should be considered in designing a technology-based solution (Silva and Teixeira 2019). Gabriels and Hill (2010) suggest that technology-based solutions designed for people diagnosed with ASD should allow the user to operate the device independently and the attitude of all stakeholders involved plays a role in the implementation of the technology-based solution. As such, the development of a technology-based solution can no longer merely focus on the delivery of the technology. Instead, the design approach should be inclusive and partner with users and communities to increase acceptance and adoption (Scherer 2002).

A community led social networking platform for adolescents with ASD may encourage the healthy use of social networking in a safe space. User-involvement during design and development can lead to an increase in uptake of the final product (Francis et al. 2009). However, people with ASD may find participation in standard co-design methods such as the use of personas or usability questionnaires difficult due to particular communication needs and preferences of the participants (Neale et al. 2003). Prior studies have adapted co-design methods to support the potential difficulties for participants with ASD by using visual and concrete examples to initiate and prompt ideas rather than relying on abstract concepts for

discussions (Bossavit and Parsons 2016; Benton et al. 2012; Nastasi et al. 1998).

Co-design is a methodological approach that includes stakeholders, such as potential users, in the design process (Fuad-Luke 2013). The iterative process in the co-design approach allows the developer and participants to make fine-grained adjustments to the application functionalities and interface design as the project progresses with the aim of improving *User Experience* (UX) (Steen 2013). Co-design in software design has been adopted in previous ASD research. Frauenberger et al. (2016) conducted a co-design study to co-create smart objects with four children with ASD and their study suggests that children with ASD can explore design spaces that are unique and unimaginable even for the adult designers. Wilson et al. (2019) conducted a co-design study that merges existing co-design methods with practice-based methods from Speech and Language Therapy which are child-led and interests based. Though their study focuses on the importance of working towards methods, designs, and mind-sets that are inclusive, supportive, and empowering of the minimally-verbal children with ASD, their study also recorded many instances of increased eye contact and increased sociality. Due to co-design's emphasis on balancing power inequities, participants in this study reported feeling valued, safe and able to contribute meaningfully to the design process. This involvement can increase user "buy-in" and support the likelihood of an end product that is useful, usable and desirable (Frauenberger et al. 2011).

In this study, we investigate how adolescents with ASD can be involved as co-designers in building a community social networking site (InterestMe) through an iterative software design process over an extended period of time. This paper presents the results of the study and discusses the role of adolescents with ASD as participants in the co-design process and how other stakeholders, such as community support groups and/or parents, play a pivotal role in supporting the co-design process.

2. Co-designing with people with ASD

Co-design has been adopted in previous ASD research however the participation level of users and other stakeholders has varied. Frauenberger et al. (2012) suggest three categories of co-design approach with people with disability: 1) non-participatory; 2) participation via proxy; and 3) full participation (Table 1).

Table 1: Co-design approaches with people with disability

Approach	Description
Non-participatory	Design is informed by best practice or prior experience. Users have no direct involvement in the design process
Participation via proxy	Design is informed by subject matter expert or those with intimate knowledge of the user population, such as parents and teachers. Users have no direct involvement in the design process
Full participation	Users are directly involved in the design process

Most co-design based ASD research has been conducted with participants in early childhood and has adopted the participation via proxy approach. The proxy approach involves parents, carers or psychologists in the design process but not with the children themselves. This approach is preferred with young children with ASD, as they can have considerable challenges in communication, as well as cognitive and behavioural difficulties (Francis et al. 2009). However, participation via proxy does not allow the actual end-users of the software (i.e., people with ASD) to directly influence design decisions.

Software design approaches that are inclusive and partner with users and communities

often increase the acceptance and adoption of the application (Scherer 2002). Prior studies have shown that adolescents with ASD can participate in a co-design process (Bossavit and Parsons 2016; Madsen et al. 2009). However, these studies only involve participants in either the early stages of a co-design process or over a single co-design cycle. An iterative co-design process allows the researcher and participants to critically examine the impacts of the incremental redesigns in progress (Spinuzzi 2005). A study to develop facial expression recognition software with adolescents with ASD found the use of co-design improves the UX of the software and was critical to the uptake of the technology (Madsen et al. 2009). The study also highlights the importance of gaining cultural insights from ASD community such as parents and carers in the design process.

3. Research methods and experimental set-up

This study adopted the key principles of shared outcomes and community immersion from *Participatory Action Research* (PAR) as overarching principles. Three phases of co-design activities were implemented in conjunction with the standard software design process. The design team (here defined as the researcher and participants) completed three software iterations in this study. A software iteration is a single development cycle (plan, design, build, test and review).

The design team used methods like group discussion, sketching and dot-voting to frame requirements and prioritise software requirements in the *problematising* phase. In the *solutioning* phase, the design team used low-fidelity prototypes such as sketches and paper storyboards along with group discussions to generate design artefacts. These artefacts were used by the researcher as design references in developing the software. Finally, in the *experiencing* phase, the design team used methods like storyboarding, comparison matrices and reflection to test, review and document perceptions regarding the use of the software

(Figure 1).

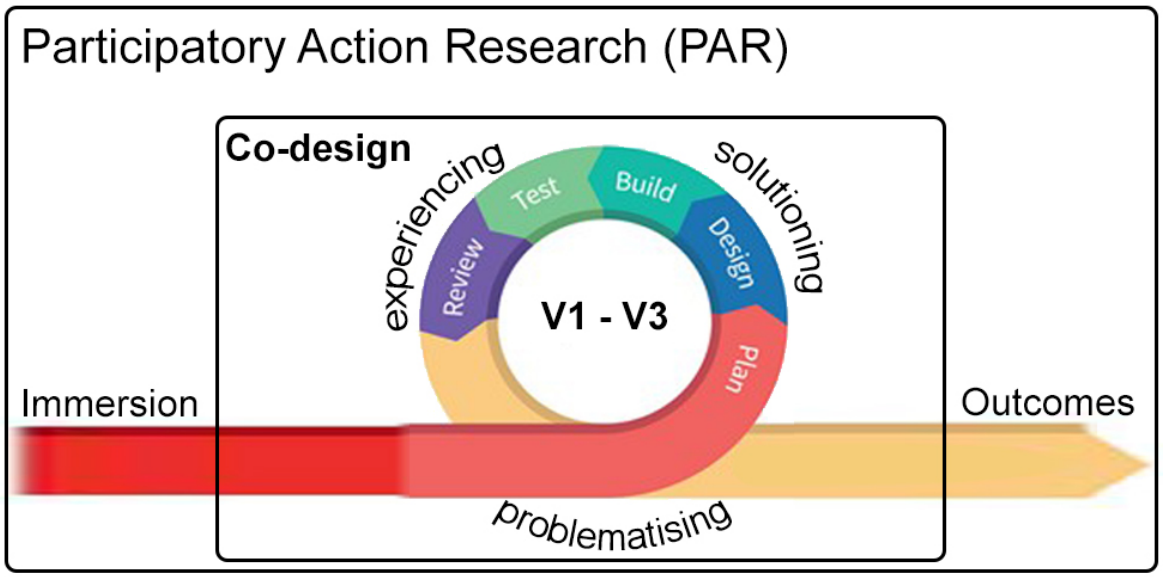

Figure 1: Iterative methods for each phase of the study

Co-design workshops were conducted monthly at a fixed venue and time over eight months. Each workshop lasted for two hours and was audio recorded. All workshop conversations were transcribed and analysed together with other artefacts like drawings and voting results using thematic analysis.

Thematic analysis allowed the researcher to identify emerging concepts and to understand participants' concerns, particularly those that were not predicted or prompted by planned questions (Tanaka et al. 2012). The transcripts were analysed in this study using thematic data analysis processes defined by Braun and Clarke (Braun et al. 2019). The results were shared with the participants at the start of every workshop. A member-checking method was applied, which encouraged participants to correct any misinterpretations of the data points documented in the study and the results.

3.1 Participants

Participants were all members of the North Queensland Autism Support Group

(NQASG) between the ages of 14 to 16 years and were studying in Townsville, Queensland state high schools upon recruitment. To be eligible to take part in this study, they were required to have been diagnosed with Asperger's (DSM-IV) or ASD without language or intellectual impairment (DSM-V) classifications based on the *Diagnostic and Statistical Manual of Mental Disorders* (DSM).

Participants were recruited via NQASG communication channels such as Facebook page and monthly newsletter. The NQASG committee members actively use Facebook to share the latest development in ASD research/intervention and as a channel to inform members of the latest group events. Thus, the recruitment ad was posted on NQASG Facebook in addition to the monthly newsletter emailer in order to reach out to more members. As the researcher was an executive member of NQASG and the organiser of the NQASG computer club, the recruitment ad was put up by a neutral committee member to prevent any perceived coercion. Furthermore, the recruitment ad included a neutral NQASG member's contact details where interested participants might also seek clarification before committing to the research project. An information sheet was made available to the potential participants after they had responded to the recruitment ad.

Six participants – five boys and one girl, participated in the study. Only one participant had prior experience in game design. All participants were diagnosed with ASD without IDD (Table 2).

Table 2: Participants demographics

	P1	P2	P3	P4	P5	P6
Age	16	14	14	15	14	16
Gender	M	M	M	F	M	M
Technology background	Nil	Game design	Nil	Nil	Nil	Nil
ASD diagnosis	All Asperger's syndrome (DSM-IV)					

Five participants were recruited at the beginning of the study while the last participant joined from workshop three onwards. Participants were regularly reminded that attendance at workshops was voluntary and they could withdraw at any time if they felt uncomfortable (Table 3).

Table 3: Participants attendance for each workshop

	P1	P2	P3	P4	P5	P6
WS1	√	√	√	√	√	
WS2	√	√	√			
WS3	√	√	√			√
WS4	√	√	√			√
WS5	√	√	√			√
WS6	√	√	√			√
WS7	√	√	√			√

3.2 Community immersion and shared outcomes

A community immersion approach was adopted. The researcher joined the North Queensland Autism Support Group committee as an executive member ten months prior to the first workshop. As an executive member, the researcher participated in monthly committee meetings and social and fundraising activities organised by the support group. Attendees at the Autism Support Group activities include members with ASD and their parents/carers. The researcher set up a Computer Club for the Autism Support Group with the support of the executive committee. The Computer Club provided a platform for members with ASD who are interested in technology to socialise and exchange ideas through monthly "meet-ups". The researcher planned and organised the monthly Computer Club meetings which included liaising with parents on registrations and providing mentorship for the club members.

Through the community immersion, the researcher found that many parents/carers maintain a daily routine for their child and reported that having a daily routine can help to reduce their child's anxiety and meltdown occurrences. In addition, having a single point of contact for parents/carers and members with ASD facilitated the communications between the facilitator and other members. The facilitator sent out emails and put up Facebook posts to inform and remind parents/carers and members with ASD of the next activity. Parents/carers are all familiar with this practice. As such, the computer club adopted the same practice and has had regular attendance since its inception.

The Computer Club ran for eight months prior to the first co-design workshop. This immersion approach in the research environment provided the researcher with key insights that were valuable in designing the research study as well as providing opportunities for the participants to become familiar with the researcher and the research study prior to the study commencement. Stakeholders in the research study, which include the Autism Support Group,

participants, parents/carers and the researcher, were able to establish and understand the shared goals and potential outcomes of the research study.

3.3 Ethics

Ethical clearance was obtained for this study from the James Cook University Human Research Ethics Committee (JCU HREC Approval Number H7366). In conformity with the approval, participants and their parents/carers were informed that they could withdraw from the study at any time without explanation or prejudice and to withdraw any unprocessed data they have provided. This research followed standard procedures to ensure that participants' rights were protected during the research study. Participants and their parents/carers were presented with a study Information Sheet before the commencement of their first workshop. To participate in the workshops, participants and parents/carers had to sign an Informed Consent Form as an acknowledgment that they were informed about the research and agreed to participate in this study.

4. Research Activities

Seven co-design workshops were conducted over eight months. After the first workshop, the design team, which consisted of the participants and the researcher, determined that there was a need for a safe online platform for teens with ASD to communicate and socialise. The design team used the remaining workshops to co-design the UX of a community social networking platform. The co-design stages and activities for each workshop are shown in Table 4.

Table 4: Co-design Stages with *workshop* (WS) activities

Co-design Stages	Software Design Process	Activities
Iteration 1		
WS1	Plan	Become familiar with co-design activities
	Design	Co-design nature of software
Break (1 month)	Build	Software development
WS2	Test	Install software
		Introduce user testing process
Break (1 month)	Test	Field trial
Iteration 2		
WS3	Review, Plan, Design	Review key software features
		Improve UX through interface design
Break (1 month)	Build	Software development
		Field trial
WS4	Test	Receive software updates
Break (1 month)	Test	Field trial
Iteration 3		

WS5	Review, Plan, Design	Prepare for software release
		Review UX through interface design
Break (1 month)	Build	Software development
		Field trial
WS6	Test	Receive software updates
		Prepare for software release
Break (1 month)	Test	Field trial
WK7	Review	Review co-designers experiences

4.1 Iterations

Iteration one had two main goals: 1) determine the nature of the software to be designed; and 2) familiarise the participants with co-design methods. Results from the group discussion and voting activities were used to determine the nature of the software to be designed. Low-fidelity prototypes were created through sketching and storyboarding activities (Fig. 2). The first version of "InterestMe" (Fig. 3) was developed and participants were given a month to perform a field trial. Participants were instructed to use the software at least once a week during the field trial.

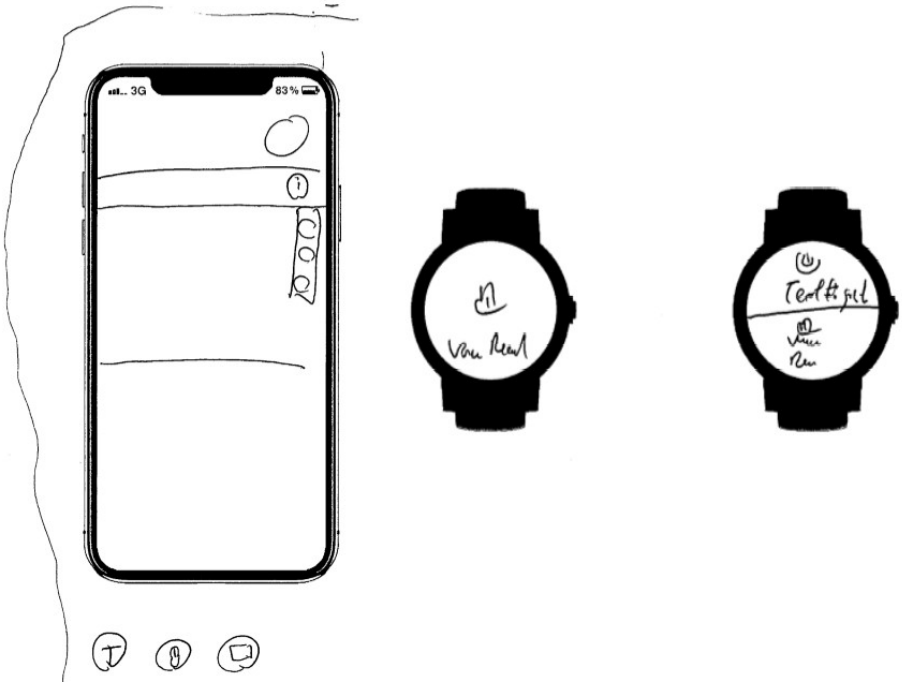

Figure 2: Low-fidelity prototyping

Figure 3: The InterestMe (V1) app interface

The two goals of iteration two were to: 1) review key software features; and 2) improve UX

through interface design. A whiteboard was set up as a common space for the design team to discuss UX, interface design and software changes. Dot-voting was conducted to shortlist the top five software changes for the next iteration (Table 5) and low-fidelity prototypes for the required software changes were created by the design team. InterestMe (V2) was developed and the participants tested the software during the one month field trial.

Table 5: Software changes

Features	Mobile	Wearable
Send pictures	√	
Send voice clip	√	√
View user's status	√	√
Add animations	√	√
Add tutorials	√	√

The two goals of iteration three were to: 1) prepare for software release; and 2) review co-designers experiences and used the same methods as iteration two. The design team discussed and reviewed the result of software testing. Final software changes and UI adjustments were made in InterestMe (V3) (Fig. 4 and 5). In addition to reviewing their co-design experiences, the design team also discussed the implementation plan to have other adolescents of the Autism Support Group onboard the platform.

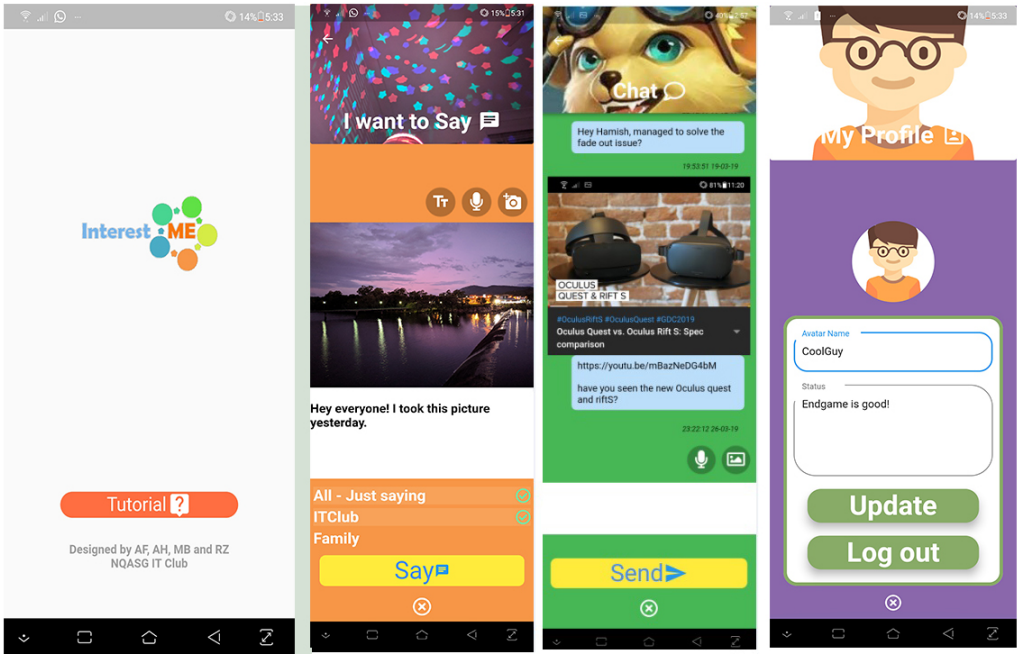

Figure 4: The InterestMe (V3) mobile app interface

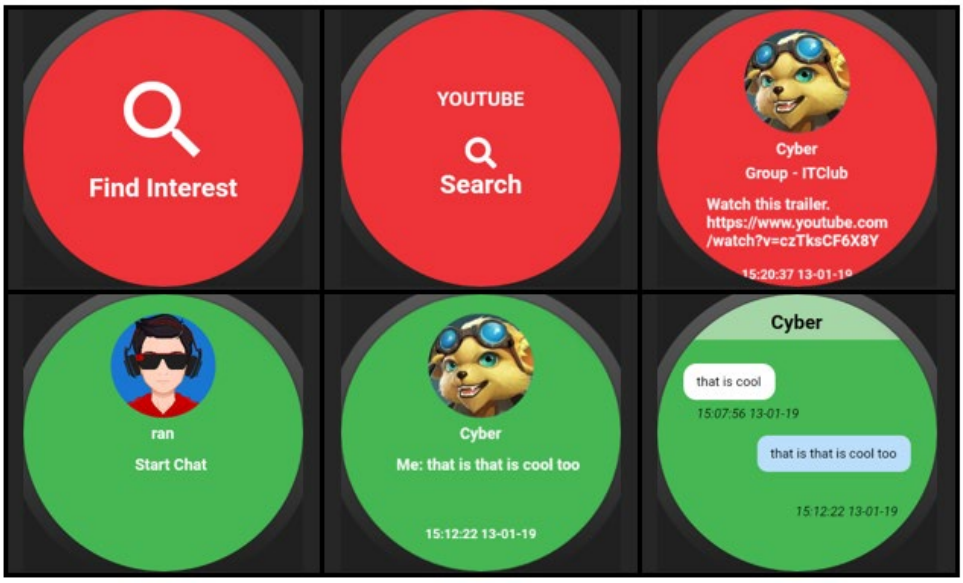

Figure 5: The InterestMe (V3) smartwatch app interface

4.2 Co-design activities and artefacts

Co-design activities that use visual and concrete examples to initiate and prompt ideas were used over the series of workshops (Table 6).

Table 6: Co-design activities

Co-design activities	WS1	WS2	WS3	WS4	WS5	WS6	WS7
Group discussion	√	√	√	√	√	√	√
Sketching	√	√	√	√	√	√	√
Storyboarding	√	√	√	√	√	√	√
Dot voting	√	√	√	√	√	√	√
Reflection	√	√	√	√	√	√	√
Mind map		√	√	√	√	√	√

These activities generated design artefacts that were used as design references for development or during member checking to correct any misinterpretations of the researcher. Table 7 describes the co-design activities and their usage in this study.

Table 7: Co-design activities/description

Co-design activity	Description	Rationale
Group discussion	Share views/opinion in response to semi-structured questions	Freely exchange ideas/thoughts/feelings
Sketching	Draw screen interfaces, images or tasks related to the discussion	Use visual aids to express ideas and solutions
Storyboarding	Draw or verbalise	Use narrative and storytelling to

	scenarios related to the discussion topics Example: use case of a specific software feature	the use case of an idea
Dot voting	Make design decisions such as prioritisation development of software features	Ensure equities in making design decisions
Reflection	Share views/opinion on workshop experiences	Improve communication methods in creating a safe environment
Mind map	Visualise the themes captured in the previous workshop	Correct any misinterpretations of the researcher notes

Figure 6 shows a sketch by one of the participants and the corresponding actual software interface developed and Figure 7 shows a mind map used for member checking.

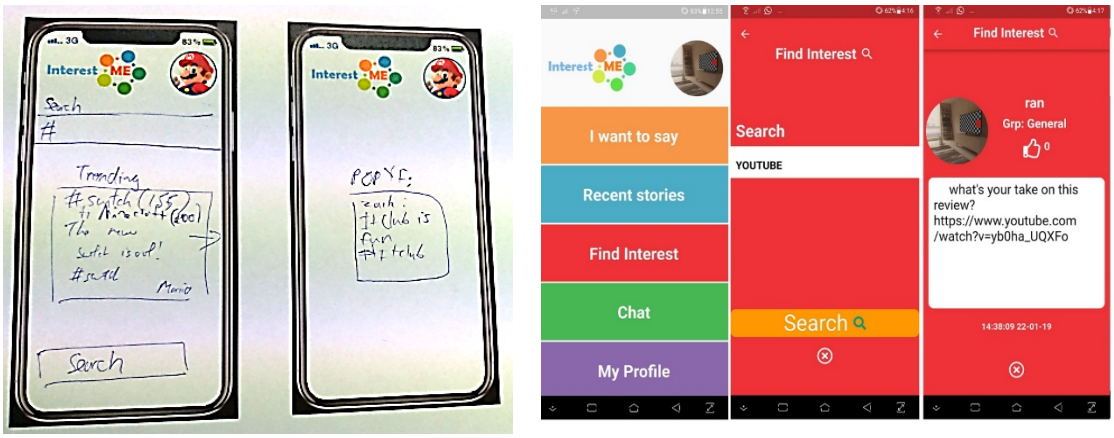

Figure 6: Sketching done by the participants were used as design reference for development

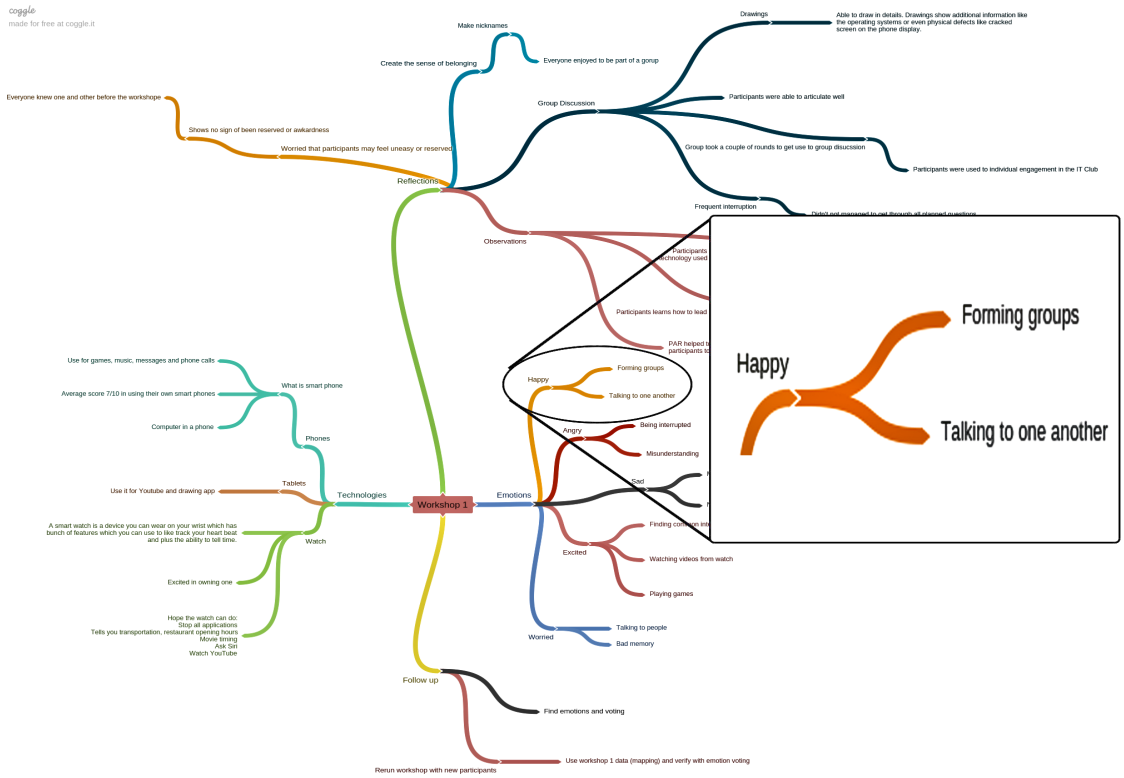

Figure 7: Collaborative mind map is used for member checking at the start of every workshop

Findings

5.1 Stakeholders: roles and impact

Three major themes that relate to the stakeholders were identified in this study: 1) team membership; 2) safety; and 3) parental support. Team membership was displayed throughout the workshops. Participants were exhilarated to see their design ideas adopted over the software design cycles and they also acknowledged their peer's contributions. The participants were observed to be more proactive and engaged over time as evidenced by their conversations from workshops 3 onwards. From our observations, participants were also more motivated to complete the software design and development process knowing that the application will serve other Autism Support Group members.

Participants shared that they felt safe and comfortable with the researcher, fellow

participants and the activities conducted in the workshops. The Computer Club facilitated the creation of a safe and familiar environment leading to the co-design workshops as participants were familiar with the venue and people. As such, most participants showed no observable sign of social awkwardness despite their ASD condition even in the first workshop. Participants were also able to engage in small talk with each other on topics outside of the research activities during the workshops. Key statements from the participants are listed in Table 8.

Table 8: Themes related to stakeholders

Theme	Participant	Quotes
Team membership	P1	"Hey look! My ideas were put in"
	P2	"Yeah. We definitely should fix this up, get more users like a community-based."
Safety	P1	"I know you, I know you! I feel safe to say whatever I want here"
	P3	"I feel comfortable to talk in this group"
Parental support	P1	"My dad will sometimes ask me and hey, you should go check if you have any messages on the watch"
	P2	"Yeah. My mum sometimes will ask me if I have used the watch today as well."
	P6	"My mum thinks the workshop will inspire me in my interest in technology"

Parental support for the research was evident and critical in this study. Although

parents/carers were not directly involved in the co-design workshops, their support and encouragement to actively participate in the workshops was crucial. We found statements from participants 1, 2, 3 and 6 that indicated the importance of the parents/carers. The researcher also received positive feedback from participants 1, 2, 3 and 6's parents through email and face-to-face communications.

5.2 Co-designers: making better design decisions

Two major themes that relate to the co-designer experience: 1) technology reference; and 2) software design experience were identified in this study. From our observations, participants became more aware of the impact of their design decisions after each iteration. Participants framed requirements and made design artefacts in the first iteration based on their technology reference. Their technology reference was mostly based on prior knowledge obtained through existing applications on their devices. In the first iteration, participants suggested the feature to share video, particularly YouTube videos through the software. Participants also suggested features like "Likes" and "Followers" which are features found on Pinterest. The design team voted and implemented these features however, some of these features have low to zero usage as the software moved into iteration three.

Most participants did not have prior software design experience. Participants 1, 2 and 6 commented that they learned how software is designed and distributed over content stores like Google Play Store through the study. They also commented that they enjoyed the experience and felt that they would be able to contribute more in the co-design activities through the self-reflection process in each iteration. Participants also commented that they felt more confident to participate in the co-design activities after iteration 1. A sample of feedback from the participants is listed in Table 9.

Table 9: Software design inputs

Theme	Participant	Quotes
Technology reference	P1	"I have drawing app, I have Minecraft, I have YouTube. I got Pinterest."
	P5	I guess I prefer to share pictures more than YouTube videos"
		"What it could amaze me the most if you can watch any YouTube video on your watch."
Software design experience	P1	"I am sure if we do this again, I have a better idea of what I am doing"
	P2	"I learned how mobile and smartwatch software are made"

5.3 Social media and networking sites

Two major themes that relate to the use of social media and networking sites: 1) impression of social networking sites; and 2) content censorship were identified in this study. Participants expressed scepticism about social networking sites and had a negative impression of popular social networking sites like Facebook. Participants reported that comments on Facebook are *"rude"* and *"mean"* and expressed that social networking sites should be more regulated. Content censorship was also suggested and implemented as one of the software requirements for the InterestMe app. InterestMe filters all messages using a list of banned words. Interestingly, all participants used social media platforms to obtain information but rarely participated in content creation. Key statements from the participants are listed in Table 10.

Table 10: Themes related to social media and networking sites

Theme	Participant	Quotes
Impressions of social networking sites	P1	"Facebook is mean. I don't really have much privacy. I don't do much social media in the sense like Facebook."
	P2	"Facebook is less regulated and has rude people at the moment."
Regulating social content	P1	"Yeah. Build an AI that takes out bad words. Recognise the F word and censor it to a dot...something. Then we can be in a safe place"
	P2	"Maybe we can have sort of censorship. Maybe with dots or hashtag. I think that is an important to add before we go on a wider scale"

5. Discussion

Co-design methods can be adapted to support the difficulties for participants with ASD. However, stakeholder's involvement and the co-design environment also play an important role to ensure participants can freely and comfortably participate in a co-design study.

6.1 Iterative co-design process encourages self-advocacy for people with ASD

Co-design methods allow the researcher and participants to unearth tacit knowledge and examine the impact of their design decisions. Our findings corroborate with prior findings that

adolescents with ASD can collaborate and contribute as co-designers in a software design implementation. In addition, our findings suggest that participants demonstrate an increase in self-advocacy skills in an iterative software design process.

Self-advocacy is the ability to understand one's own needs and effectively communicate those needs to others (Brinckerhoff 1994). Though participants showed no sign of awkwardness despite their ASD condition in the first workshop and were able to engage in small talk with each other, they seldom commented or expressed their views on other participants input during the first iteration. Participants reported in their reflection of workshop one that they were unsure of their own needs despite the use of visual and concrete examples in the co-design activities. However, they also reported that they felt more aware of their roles and needs after the first field trial as they were able to experience the software as a user.

Participants were observed to be less engaged in the co-design activities in the first iteration as these activities were mostly guided by the researcher. Participants reported in the workshop two reflections that they were not familiar with co-design activities and were unsure of how to express their views and opinions. However, participants subsequently reported in workshop four reflections that they were now familiar with the co-design activities and the design team members and felt comfortable and confident in leading some of the activities or making a debate with fellow team members. The researcher also observed more active discussion and debate among the participants in iteration two and iteration three.

Participants became more aware of their design decisions after each iteration. The iterative process in the co-design approach allowed the researcher and participants to make fine-grained adjustments to the application functionalities and interface design (Steen 2013). Participants framed requirements and made design artefacts in the first iteration based on their technology reference, which was mostly based on prior knowledge obtained through existing

applications on their devices. As inexperienced software designers, some of the participant's design choices were not technologically feasible but they were able to learn and understand the impact of their design decisions through the self-reflection process in each iteration. The iterative process allowed the participants to learn and understand their needs and interests while the co-design methods provided a platform for them to express their views about design changes.

6.2 A conducive co-design environment for people with ASD matters

A safe and familiar environment encourages adolescents with ASD to participate in a co-design study. This ideal "environment" may include the support from the: 1) community group; 2) parents/carers; and 3) design team. In this study, the researcher was immersed in the ASD community by joining the Autism Support Group, which gave access to community, cultural insights and shared goals. A study on school-based social skills program with children with ASD suggests that this process helps to promote stakeholder buy-in because it directly addresses their goals and needs (Ostmeyer and Scarpa 2012). The common goal with all stakeholders in this study was to provide a platform where adolescents with ASD can interact and socialise.

Parents/carers also played an important role in this study through support, encouragement and advice for the participants. Through the Computer Club, parents/carers had the opportunity to interact with the researcher and were able to establish a positive relationship with the researcher prior to the study and throughout via regular email updates. Our findings show that parents/carers were very supportive of the study and constantly reminded participants to attend the workshops or review the software during the field trial.

The establishment of the Computer Club provided the opportunity for potential participants to interact and exchange ideas prior to the study. Most of the participants had

attended the Computer Club prior to the first workshop so a team membership had been established. Participants mentioned and agreed that they enjoyed attending the workshop because of the companionship of fellow participants over the workshop reflection. These findings corroborate prior findings that people with ASD prefer fixed routines and can better communicate with peers having similar interests. Participants P2 and P3 commented that they may face difficulties expressing themselves verbally and the use of group discussions allowed them to build on top other's view or correct themselves if other's misunderstood their words. Participants also commented they felt comfortable to share ideas and exchange ideas or thoughts through the use of drawings. In addition, all group discussions began with an introductory statement to remind participants about the content of the discussion, the expected length and update on the research process. An introductory statement may be particularly relevant for people with ASD given their general preference for preparedness.

Notably, having a conducive co-design environment does not guarantee participants' attendance. Two participants who had participated in previous Computer Club meetups did not continue with the study after the first workshop. Their parents informed the researcher that their child wanted to stay out of all group activities for a period. The researcher understands from the parents that self-initiated social isolation is common with people with ASD.

6.3 A safe social networking site for marginalised groups

Our findings corroborate prior findings that adolescents with ASD continue to face social challenges in their daily lives in finding friends with similar interests. Though our participants are active on social media sites like YouTube and Pinterest, they do not participate or engage in online interaction. Our finding also suggests that participants are avoiding popular social networking sites such as Facebook as they found them lacking social etiquette. Though no participants had any prior experience of being cyber-bullied, participants have reported that

they have been subjected to some form of bullying in school. As a result, participants do not feel safe to communicate, share and socialise under this perceived harsh environment. Social networking sites provide a platform for people to support communication and maintain relationships with family and friends. A study by Mazurek (2013) suggests that many adults with ASD use some form of social networking sites. However, our finding corroborates with the findings by Carrington et al. (2017) that adolescents with ASD are avoiding social networking sites. This disconnect in findings between adolescents and adults with ASD is worth investigating in future studies.

A community led social networking platform may provide the opportunity for adolescents with ASD to gain confidence and encourage healthy use of social networking. In this study, participants were safe to express themselves freely over the platform and with familiar audience. Parents/carers are generally cautious with social networking sites due to potential problems with cyberbullying and inappropriate content. An inclusive approach to include parents/carers in the design or implementation process of a closed group social networking platform may alleviate their concerns. In our study, parents encouraged their child to make use of the developed social communication platform because they were familiar with all the members on the platform and understood that the content on the platform was regulated.

6.4 Limitation and Future Work

We acknowledge that some of our findings are limited due to the number of participants in the study and would benefit from follow-up studies. The design team intends to perform follow up studies investigating adoption rate, feedback, and usage by the support group members. The results demonstrated the potential and benefits to co-design with people with ASD. A future collaboration that involves people with different cognitive and sensory abilities may find the insights from this research useful. Such a project could propose new viewpoints

and methods. For example, a person with Attention Deficit Hyperactivity Disorder (ADHD) may have different needs and wants regarding technologies and his/ her circumstances may inspire a different genre of designs. New co-design engagement methods could surface from such a collaboration.

7 Conclusion

This study investigated how adolescents with ASD can collaborate as co-designers in designing a local community group social networking software through an iterative software design process. Designing applications for people with special needs has always been a challenge in terms of application usability and usefulness (Frauenberger et al. 2011). Methods like community immersion can complement a co-design study and an iterative process allows knowledge transfer within the design team to make better design decisions. Participants learned through experience and became more aware of their design decision after each iteration. We also observed that the participants found the overall co-design experience interesting, enjoyable and engaging.

Participants were also observed to demonstrate more self-advocacy skills and understanding of the co-design activities and their needs better after the first iteration. The use of reflections for each workshop allowed participants to reflect on their needs and roles in the study. These factors may promote participants' self-advocacy skills over the course of an iterative software design process.

The participants identified themselves with the researcher as an exclusive group and this group identity suggested that participants had accepted the researcher as part of the community and felt safe in sharing their experience with each other. Through the community immersion, the researcher gained local ASD community insights and established a positive relationship prior to the co-design workshops. Most participants were already familiar with the

researcher and were able to establish rapport easily and engage in both verbal and non-verbal communication. Participants prefer a routine, predictable timetable and as such, workshops are set up at a time and place where the participants have their usual group activities. In addition to the making adaption to co-design methods such as using more visual and concrete examples, an empathetic and inclusive design approach should be taken to ensure equal power relationships between designers and users for people with special needs (Madden et al. 2014). These factors promote a safe and familiar environment that can encourage active participation from adolescents with ASD as co-designers.

Social networking sites provide a platform for people with ASD to communicate and socialise with family and friends. However, people with ASD and their parents/carers are avoiding social networking sites due the potential risk of cyberbullying and inappropriate content. A local community such as a support group may provide a familiar and regulated social networking site for people with ASD. In this study, the community led social platform aimed to provide a safe and localised environment for the Autism Group members to socialise and interact online. Participants commented that they felt safe to comment and post on the community social networking software. North Queensland Autism Support Group has since adopted the social platform and is in the process of extending the platform to all their members.

Though there is an increasing call to adopt User-Centred Design approach in software design, many software designers face challenges in adopting these approaches when designing for groups with special needs. Both community immersion and co-design approaches require significant time investment and proficiency of researcher/designer to carry out the activities. Organisations may not have the resources to invest in long hours of community immersion prior to the design phase. In addition, organisations may not have trained designers that could

adapt co-design methods to suit the capabilities and needs of people with ASD. Organisations developing software for people with ASD can consider partnering with existing community groups such as support groups or schools in co-designing the software. Co-design methods and principles can be shared with personnel from the community groups and they will conduct the co-design workshops with the target users. Extensive community immersion would not be required in this approach since personnel from the community group would be familiar with the culture and design practices of the group and with potential participants. This approach could shorten the development time and is more scalable as multiple personnel from different groups can be trained with the co-design methods and principles at the same time.

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8 Disclosure statements

The authors declare no conflict of interests.

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