

Longitudinal Socio-Emotional Learning Intervention for Autism Via Smartglasses: Qualitative School Teacher Report of Practicality and Efficacy in General and Special Education Classroom Settings.

Neha U. Keshav PhD¹, Arshya Vahabzadeh MD^{1,2}, Rafiq Abdus-Sabur M.Ed¹, Krystal Huey¹, Joseph P. Salisbury PhD¹, Runpeng Liu^{1,3}, Ned Sahin PhD^{1,4*}

¹Brain Power, 1 Broadway 14th Fl, Cambridge, MA, United States

² Department of Psychiatry, Massachusetts General Hospital, Boston, MA, United States

³Department of Electrical Engineering and Computer Science, Massachusetts Institute of Technology, Cambridge, MA, United States

⁴Department of Psychology, Harvard University, Cambridge, MA, United States

* *Corresponding Author. Ned T. Sahin, PhD, Brain Power, 1 Broadway 14th Fl, Cambridge, MA 02142, USA. Email: sahin@post.harvard.edu.*

Abstract

There is considerable demand for special education services for the over half a million students with autism in the United States. While assistive technology may help to augment educational services, their implementation is prevented by a number of practical and attitudinal barriers. These barriers are especially pertinent for the newest and least familiar digital systems, such as computerized smartglasses loaded with specialized software modules, a technology that has already been shown to have an ability to deliver educational interventions through augmented reality.

With this in mind, we sought to understand how school educators received and assessed the practicality of a smartglasses-based educational intervention in a single-subject study. The intervention is designed to aid with attention and social educational learning in autism. The intervention was delivered twice a day during a two-week study on a 13-year-old student with autism who attends a mainstream middle school in Massachusetts. Three different school educators delivered the

intervention: the student's general education teacher, special education teacher, and paraprofessional. Educators recorded their attitudes, practicality of the technology, and impact on the student and their classroom through the use of a digital log and a series of in-person interviews.

Overall, the school educators experienced a positive view of the smartglasses. The smartglasses intervention was found to be logistically practical to implement, easily usable by educator and student, and was not time consuming to learn or to implement. Educators also identified the experience as being fun for the student, and felt the student demonstrated improvement to verbal and non-verbal skills. There were no adverse effects on the other students or the classroom, and the technology did not result in a distraction. These findings suggest that social skills interventions delivered by smartglasses may be practical, useful, and may lead to improvements in social communication skills. Further research on smartglasses may help to clarify the future role for augmenting special education in students with autism.

Introduction

Over half a million students in the United States receive autism-related special education (1), and this number is expected to grow due to the rising prevalence of autism (2). School-based special education plays a central role in the lives of students with autism and their families (3), yet special education services have been strained by high demand (4), leading to burnout among school professionals (5) and parental unhappiness (6). While social skill-based educational interventions are effective for students with autism (7, 8), special education services have struggled to provide this type of service

(9). This is of concern given that the social and behavioral deficits addressed by these interventions are some of the most challenging and impairing problems for students with autism (10). Assistive technologies may help to address this need, and have proven themselves to be beneficial to people with autism (8, 11), and their need must be evaluated whenever an Individualized Education Program (IEP) is created or updated (12).

While assistive technologies are particularly useful in delivering social skills interventions (13, 14), many barriers exist to their use (15, 16). Ertmer outlined two types of barriers that prevent teachers from integrating

technology into their classrooms (17). These barriers are broken down into those that are considered “internal” or “external” to the teacher. Internal barriers include the teacher’s confidence, beliefs, and perception of the technology’s value, while “external” barriers consist of issues regarding availability of technology, support and training services, and financial barriers.

While external barriers are important to consider (18, 19), it is believed that internal barriers, such as teachers core attitudes and beliefs regarding learning and teaching, are of greater influence (20, 21). Even teachers who are highly successful in implementing classroom technology identified the attitudes of other teachers as being the most impactful barrier to further technology integration (20). Compared to their students, teachers may be more critical of the value of technology integration in schools (22). Some researchers believe that teachers may feel hesitant about technology because it can challenge their role within their own classroom (23), it may result in a need to change their classroom routine (24), and they may not feel confident in implementing such technologies (25). Internal attitudinal barriers may be especially pronounced when considering smartglasses, especially given past negative social perceptions (26, 27), concerns about the potential for technology to be a distraction (28), and reports of usage associated frustration and irritation (29). Given a relatively low business and consumer uptake of smartglasses, educator unfamiliarity with this technology is also highly likely.

External barriers, such as teacher training, are also widespread. Evidence suggests that neither general education nor special education teachers are adequately trained to apply assistive technology to their classrooms (30). Deployment of technology in a classroom requires both time and effort for preparation, implementation, and troubleshooting. Teachers may perceive that newer technologies may add to their workload, and result in them having to work beyond their scheduled school hours. Research has found that a teachers willingness to work beyond their contracted hours is predictive of their technology use in the classroom (18) .

While assistive educational technology for special education is generally believed to be beneficial, some educators have described both increased student distraction and frustration with the use of such digital devices (31). This is of particular concern among children with autism, as they commonly demonstrate inattention, and may also experience severe behavioral dysregulation from even minor technological mishaps (10). Distraction may also result when educational technology is used by students for non-educational purposes (32). This situation is more likely to occur

when students find the classroom tasks too easy or too difficult (33).

Smartglasses in Classes

New assistive technologies based on smartglasses, computerized glasses with an optical display, may herald a new approach to help augment special education services (34). Smartglasses, for example Google Glass, contain a complex array of sensors, and are able to collect video and audio data from the user and the environment. They are also able to monitor movement and velocity through inbuilt gyroscope and accelerometer. Smartglasses can provide users with video and audio guidance through an inbuilt display and bone conduction/audio speakers. However, there are substantial knowledge gaps in regards to how these devices may be used in real classrooms, and optimized for teaching and learning (35).

Specialized smartglasses designed for socio-emotional learning have been found to be feasible (34), well tolerated (36), safe (37), and help to reduce symptoms of autism (34) and attention deficit hyperactivity disorder (38). Additionally, despite past negative perceptions and stigma associated with such devices, children with autism express a desire to use these socio-emotional assistive smartglasses technology in the classroom setting (39).

However, real-world classrooms may provide a much more challenging setting for social skills interventions (40), than the controlled research environments where much of this research has been conducted. The teachers who utilize this technology during their normal school day will be able to rapidly assess key technical factors that have been shown to drive the adoption of this technology, such as its reliability, ease of use, and a belief that the technology can aid learning (41). There is also a need to understand the perceptions and attitudes of school educators, especially as smartglasses-based educational interventions are novel and largely experimental. Through exploring both practical issues and teacher’s personal perspectives, this report aims to shed light on internal and external barriers to the adoption of smartglasses as an assistive special education technology.

We sought to identify the perception and attitudes of the school educators in relation to:

1. The practical, logistical, and technical aspects of the smartglasses system intervention;
2. The impact of the smartglasses system on the student’s social, emotional, and academic skills; and

3. The broader impact of the smartglasses system on the educator, their teaching, and the rest of

the class.

Methodology

The Technology

The Empowered Brain is a smartglasses-based social skills coaching tool (34, 36). The system has been developed as a digital platform that integrates specialized modules on smartglasses, companion apps on smartphones/tablets, and a web-based data portal (Figure 1). The web-based data portal collects and analyzes real-time data to produce numerical reports of user learning and interaction.

The Empowered Brain is based on smartglasses that are worn by the student in similar manner to glasses, and provides an intervention while the student is interacting with a facilitator (e.g. a teacher). The smartglasses provide the user with contextually appropriate visual and auditory guidance and cues in real-time. For example, it can guide users to pay attention to the faces of people

with whom they are interacting through virtual guidance arrows and cartoon-like masks that are superimposed on the facilitator's face. The Empowered Brain incorporates game-like experiences, so that improvements in performance lead to in-game rewards such as points and unlocked levels. The Empowered Brain is able to recognize human faces, and decode facial emotions. While the user is utilizing the Empowered Brain, the facilitator prompts the user to engage in a conversation about educational topics, for example their current assignment, homework, and academic progress. The Empowered Brain monitors and stores data regarding the user's interaction with the facilitator, calculating the user's performance using sensors that monitor the user's interaction with the outside world, including the user's gaze, head movements, eye blink, and audio. The collected information is available for real-time review through a password-protected web portal.



Figure 1: The Empowered Brain platform. The Empowered Brain is a digital platform and includes apps that run on smartglasses (Google Glass), companion apps on phone/tablet that are used by a facilitator as needed, and a web data portal for documentation and analysis of user learning and progress.

The software applications of the Empowered Brain have been previously described, but include innovations through software, engineering, and data partnerships with a number of technology companies including X (formerly Google X, Mountain View, CA), Affectiva (a leading Emotion AI company, Boston, MA), and Amazon (use of an experimental AI technology).

The Participants

The participants included a student who was the recipient on the intervention, and several school educators who facilitated the interaction with the Empowered Brain. The student was a 13-year-old boy with a diagnosis of autism and received special education under an Individualized Education Program (IEP) at a mainstream public middle school in

Massachusetts. He was recruited to the study through an online research database. The school educators were the student's regular paraprofessional, general education teacher, and special needs teacher. They all had the opportunity to be orientated to the Empowered Brain, to deliver the intervention, and to provide feedback.

The Intervention

Over a two-week period, the student used the Empowered Brain in conjunction with one of their educators who acted as a facilitator. The intervention was provided in the classroom alongside his peers. The intervention duration was 10 minutes, and was delivered twice a day at approximately the same time. Each of the school educators had the opportunity to become orientated to the hardware and software of the

technology, and actively provide the intervention in the real-world setting. A total of 16 sessions of intervention were provided, with the majority provided by the student’s general education and special education teachers (Table 1).

Table 1. Delivery of Intervention by Educators. The table below outlines the number of sessions each facilitator conducted.

Type of Educator	School	Number of Interventions Delivered
Special Teacher	Education	7
General Teacher	Education	8
Paraprofessional		1

Data Collection

School educators were asked to describe their experience of the smartglasses intervention, with particular focus on the technical/practical aspects, the impact on the student, and the wider impact on their ability to teach the rest of the class. The educators were encouraged to describe their experiences through a digital diary and in-person interviews. This content was reviewed for themes that would help to identify the internal and external barriers to the adoption of this technology. Practical issues surrounding the delivery of the intervention, such as ease of use, adequate space, and time, were also noted. Importantly, the student’s response to the technology, and the teacher’s perception of whether the intervention was useful as an educational tool, were also noted. Educators were asked to think about whether the intervention would add to their workload, and how the intervention compared to past assistive technologies that they had utilized. School educators were specifically

asked if they felt the intervention proved to be a classroom distraction, whether they noticed any impact on the student, and if there were technical aspects to the intervention that could be improved.

Consent and IRB Statement

This research intervention performed under an IRB approved by Asentral, Inc., Institutional Review Board, an affiliate of the Commonwealth of Massachusetts Department of Public Health. The study was performed in accordance with relevant guidelines and regulations. Consent was obtained from the mother of the participant, and assent was obtained from the participant. Consent was also provided by all educators involved in the study.

Results

Practicality and Implementation of Technology

The general education and special education teachers both felt that the technology was easy to use, and manageable to implement in the classroom setting (Table 2). The paraprofessional identified that she did not fully understand the experience/mechanics of the game-like interaction that the student was experiencing. It would be noted that the paraprofessional only facilitated one session of the intervention, compared to the seven provided by the special education teacher, and eight sessions provided by the general education teacher. Additionally, the paraprofessional also noted that she felt her workload has increased, although she attributed this to the need for keeping documentation for the purposes of this research project as opposed to additional workload in providing the intervention. The special education teacher, who has experience teaching over 100 children with autism, noted that children have a fondness for technology, and this appears to be the case for the Empowered Brain.

Table 2. Educator perception of the practicality and implementation of the Empowered Brain. Perceptions sourced from video interviews and typed digital logs are outlined below.

Facilitator	Source	Quote
General Education Teacher	Video interview	“As a novice, I feel like it is extremely easy to use, between turning it on, and prepping it all. It is very user friendly, after a few tries, it is easy to figure out how to utilize the technology. I feel like it would be beneficial and doable for anyone, even somebody who has no knowledge of, or is not good with technology”
Paraprofessional	Video interview	“I don’t know exactly what he is seeing, if like slight turns would stop accumulating [points]”
General Education Teacher	Typed digital log	“As the teacher administrator, it only took me a few tries to figure out how to use the google glasses and brainpower software with great success”
Special Education Teacher	Video interview	“With videogames, you can get into your own world, you cannot really interact. You have to interact with the glasses, but I think with the format, it is less abrasive, less daunting,

		and more doable. I cringe at videogames as they do not promote social interaction, but this causes them to be interactive, there is a give and take. I think the glasses are great for that”
Special Education Teacher	Video interview	“One thing that I like about the glasses is that it taps into the love for technology, kids love technology, and that’s just a big draw for them, they like that incorporation bigtime”

Student Usability of Technology

There were a variety of observations from school educators regarding how the student used the system. School educators found that the student could use the system and have the intervention delivered to him, however both the special education teacher and the paraprofessional noted that the student appeared to be

very focused on the game. The special education teacher noted that it took several minutes before the student adopted a less tense posture when using the smartglasses. Table 3 outlines direct quotes of the educator’s perception of the student’s experience using the Empowered Brain.

Table 3. Educator perception of the student’s usability of the Empowered Brain. Perceptions sourced from video interviews and typed digital logs are outlined below.

Facilitator	Source	Quote
Paraprofessional	Typed digital log	“[Student] has done a remarkable job paying and demonstrating attention when wearing the glasses, yet he seems to have a stiff and perhaps overly intense posture and gaze.”
General Education Teacher	Video interview	“He understands the game, from day one, it was a smooth transition”
Special Education Teacher	Video interview	“Performance anxiety, that I think naturally comes, he worked through it, and it was fine.”
Special Education Teacher	Video interview	“At the start, for the first minute, I could tell he was very tense, but he loosened up after a couple of minutes, and was fine with it. To say that he was completely stress free and had no stress would not be accurate, but it wasn’t to the point that he couldn't do the task.”

Impact on the Student

Both the student’s special education and general education teachers noted that the student demonstrated improvements in his level of eye contact and participation in classroom activities/discussions during the study. His general education teacher identified an

improvement in the student’s conversation skills during the intervention. While the special education teacher noted a sustained improvement and mindfulness of eye contact, he did not notice any changes translate to the student’s reading comprehension. See Table 4 for further details.

Table 4. Educator perception of the Empowered Brain’s impact on the student’s behavior. Perceptions sourced from video interviews and typed digital logs are outlined below.

Facilitator	Source	Quote
General Education Teacher	Typed digital log	“I would say that I do see some improvement in his conversational skills and that if [Student] was to continue using [the Empowered Brain], his skills may continue to progress.”
Special Education Teacher	Video interview	“I think it has been very useful for [Student], in terms of being mindful of eye contact, it has helped him be more aware of the need for eye contact, for my students one of the biggest struggles they have is with eye contact.”
General	Typed digital	“We discussed how he felt about the project and eventually

Education Teacher	log	the conversation turned to his experience using [the Empowered Brain]. He said his overall experience was “awesome!” and hoped that his friends would be able to use the technology as well. I followed up by asking him if he felt that playing the game has helped him be more aware of maintaining eye contact after the game was played.”
Special Education Teacher	Video interview	“I have noticed that when the glasses have been taken off, the eye contact is still there, it is not there the whole time, but I have noticed an increase amount of sustained eye contact.”
Special Education Teacher	Video interview	“I do think that [the Empowered Brain] promotes mindfulness of eye contact, makes it into the front of their mind. I think the [Empowered Brain] prompts that to be part of their scheme, to be part of their mindset, because one thing that is good about students with autism, once it is part of their mindset, they will stick with what they adopted it. [The Empowered Brain] will add that schema to their mindset.”
Special Education Teacher	Typed digital log	“I did notice a change in [Student]’s academic performance in the classroom. While [Student] would usually look away during class discussions and be silent much of the time, I did notice that this week he increased his level of participation in the class discussions about the book we are reading as a class. In fact, he volunteered to provide answer to a proposed question on three occasions within the past week. In terms of mastery of various reading comprehension skills taught in the class, I did not see a significant increase or decrease in his performance. In other words, his level of competence with regards to reading comprehension has stayed the same.”

Table 5. Educator perception of the Empowered Brain’s impact on the student’s attention. Perceptions sourced from video interviews and typed digital logs are outlined below.

Facilitator	Source	Quote
General Education Teacher	Video interview	“I am able to have his undivided attention for a solid 6-7 minutes, which for most autistic children, or really for any child, that's very difficult, that is precious time you get to have them be rewarded for playing this game, while also being able to have their undivided attention so that you can get a better sense of what they are understanding”
Special Education Teacher	Typed digital log	“I did notice a slight change in the level of [Student]'s distractibility. Overall, there was a slight increase in distractibility with [Student] during this past week. There was no academic tradeoff for using Face2Face during class.”

Impressions of the effect of the intervention on the student’s attention was varied (Table 5). During the exercise, it appeared that the student demonstrated very high levels of attention, and was able to stay on task. However, a slight increase in distractibility was noted by his special education teacher, although this apparently did not impact his academic work.

The student was concerned that he would be missing out on other activities while he had the intervention (Table 6). His general education teacher believes that it is important to explain to the student the purpose of the game as an attempt to alleviate the stress of the student

feeling that they are not getting through the other work of the day. It should be noted that this student participated in one daily session of the intervention during his Civics period, in which the teacher was providing the class independent study time to complete their class projects. The student often aimed to complete as much of his homework during the school day, and was concerned that the time he was doing the intervention would take away from time completing his project. This may be particularly important in children with autism, as they can demonstrate rigidity and a need for sameness in regard to their activities and schedule.

Table 6. Educator perception of the impact of the Empowered Brain on the student’s classroom tasks. Perceptions sourced from video interviews and typed digital logs are outlined below.

Facilitator	Source		Quote
Paraprofessional	Typed log	digital	“[Student] expressed to me while filling out the after survey that he is concerned that he isn't getting his Civics project completed.”
General Education Teacher	Typed log	digital	“I'm not sure that [Student] (or most students for that matter) will get over the fact that the game is more than just an exercise to help with focus, eye contact, etc. without a clear rubric. I also feel that the rubric should be given and thoroughly explained to the student when explaining the game itself. That, I hope, would alleviate the stress of "missing out" on class time.”

Impact on Teaching and Classroom

The educators stated that they enjoyed spending time with the student, and did not feel that the intervention was a distraction to their classroom activities (Table 7). Additionally, they felt that providing the intervention was actually time well spent, and they felt like had more quality time with the student (Table 8). The special needs teacher felt that while other students in the special needs class were curious about the technology, the intervention did not lead to any disruptions, specifically no class arguments or fights. His general education teacher was very happy about having real-time feedback, and being able to adjust his teaching to the needs of the student with this information.

Educators also provided some additional feedback regarding the use of the web portal that is integrated into this technology. They noted that some improvements could be made to the web portal where data regarding the intervention was obtained. They stated that having access to a better wireless internet connection would be useful, as initial use of the school wireless service was unsuccessful. Educators also wanted the web portal to have added functionality where communication could occur between educators, and auto-generated reminders are also available.

Table 7. Educator perception of classroom distraction during intervention use. Each facilitator rated whether the intervention distracted their typical classroom functions during each session.

Did the intervention distract the class significantly? (no. of intervention sessions)			
	Yes	No	Total Sessions Delivered
Special Education Teacher	1	6	7
General Education Teacher	0	8	8
Paraprofessional Teacher	0	1	1

Table 8. Educator perception of the advantages of the Empowered Brain on their classroom. Perceptions sourced from video interviews and typed digital logs are outlined below.

Facilitator	Source	Quote
Special Education Teacher	Video interview	“My other students who are not wearing the glasses are curious about why eye contact is helpful.”
General Education Teacher	Video interview	“Would it be time lost on the content that needs to be covered? I’ve found so far that it really hasn’t, I have had this chunk of time to talk to the student.”
Special Education Teacher	Video interview	“It went smoothly with the students and [Student], they didn’t try to take it from him or try to play with it. I could see if you didn’t give that pre-discussion, it could be seen as a toy, try to play with it, take it, and have fights over it.”
Paraprofessional	Video interview	“I really enjoyed the 10 minutes because he and I don’t get that personal time, anything beyond ‘don’t forget to do this homework’.”
General Education Teacher	Typed digital log	“The game has allowed for me to get a better sense of [Student]’s overall comprehension of the subject matter in my class. Furthermore, while playing the game, I am afforded the time to clarify any confusion or questions he or I may have while maintaining his undivided attention.”
General Education Teacher	Typed digital log	“It has worked out very well, where it really has not been a distraction, even though I am spending some quality time with the student, before and after playing the game, I am able to address the other students as well. If nothing else, it has been more beneficial as they understand what’s going on and they love it”
General Education Teacher	Video interview	“You get that real-time feedback, as teachers you strive to get, time is obviously of the essence for anyone, being able to assess a student immediately, allows you as a teacher to adjust curriculum. Having that done automatically for us is even better.”

Discussion

Demand for special education services for students with autism remains high, and novel assistive technologies may help to augment current efforts. However, research has identified a range of barriers that impede the implementation of technology in the classroom. These barriers are especially problematic for special education. Modern lightweight smartglasses with educational software may prove to be a useful assistive technology. These devices are powerful face-worn computers that are sensor rich, and able to collect information and provide feedback to users.

Despite a range of potential attitudinal and practical issues, this study found that this unique smartglasses-based educational intervention, the Empowered Brain, could be delivered by educators in a typical classroom setting. Educators felt positive about using the technology and found it to be a practical and useful tool in the classroom. Smartglasses are an emerging technology, and it was promising to see that teachers

found the system to be reliable and robust over the course of two weeks of testing. Potential concerns about technology not being suitable in a classroom setting were allayed in part by the finding that teachers were able to logistically allocate time and physical space within both special education and general education classroom schedules to provide the intervention. In almost all circumstances, the concurrent delivery of the intervention within the classroom did not result in any significant distraction to the rest of the students in the class, despite no change in educator staffing levels. Reassuringly, educators found the intervention to be helpful to their relationship with the student, and even result in reports of improved class participation, social interaction, and eye contact. However, other areas of academic performance such as reading comprehension were not affected.

While the qualitative findings of this preliminary report are positive, there are a number of important limitations. Firstly, the individual student cannot be considered to be representative of all students with autism, or of all

students receiving special education. In this light, this research group is conducting further studies with a larger student and educator group across a series of school systems in the United States. Secondly, while qualitative teacher reported insights suggest improvement to the students functioning, quantitative measures, including validated outcomes measures, would provide for additional supportive evidence. Thirdly, this study assessed 16 intervention sessions over a two-week period. More longitudinal study into the use of the Empowered Brain would also be warranted to determine whether there would be future practical or reliability issues, or whether educator attitudes would change over time.

Overall, it appears that despite many potential practical and attitudinal barriers to the implementation of this technology for special education intervention in the classroom, the Empowered Brain social communication intervention was found to be practical, feasible, and resulting in improved student social interaction as reported by a group of school educators.

Acknowledgement

The authors thank Google, Inc. for a generous grant, and the Glass team at X (formerly Google X) for technical guidance on Glass software development. This work was supported by the Office of the Assistant Secretary of Defense for Health Affairs, through the Autism Research Program under Award No. W81XWH 17-1-0449. Early work to transform smartglasses into biomedical sensors was supported in part by the United States Army Medical Research and Materiel Command under Contract No. W81XWH-14-C-0007 (awarded to TIAX, LLC). Opinions, interpretations, conclusions, and recommendations are those of the authors and are not necessarily endorsed by the Department of Defense.

References

1. Snyder TD, de Brey C, Dillow SA. Digest of Education Statistics 2014, NCES 2016-006. National Center for Education Statistics. 2016.
2. Christensen DL, Bilder DA, Zahorodny W, Pettygrove S, Durkin MS, Fitzgerald RT, et al. Prevalence and characteristics of autism spectrum disorder among 4-year-old children in the autism and developmental disabilities monitoring network. *Journal of Developmental & Behavioral Pediatrics*. 2016;37(1):1-8.
3. White SW, Scahill L, Klin A, Koenig K, Volkmar FR. Educational placements and service use patterns of individuals with autism spectrum disorders. *J Autism Dev Disord*. 2007;37(8):1403-12.
4. Yeargin-Allsopp M, Rice C, Karapurkar T, Doernberg N, Boyle C, Murphy C. Prevalence of autism in a US metropolitan area. *JAMA*. 2003;289(1):49-55.
5. Corona LL, Christodulu KV, Rinaldi ML. Investigation of School Professionals' Self-Efficacy for Working With Students With ASD: Impact of Prior Experience, Knowledge, and Training. *Journal of Positive Behavior Interventions*. 2017;19(2):90-101.
6. White SE. Special education complaints filed by parents of students with autism spectrum disorders in the midwestern United States. *Focus on Autism and Other Developmental Disabilities*. 2014;29(2):80-7.
7. Watkins L, O'Reilly M, Ledbetter-Cho K, Lang R, Sigafos J, Kuhn M, et al. A Meta-analysis of School-Based Social Interaction Interventions for Adolescents with Autism Spectrum Disorder. *Review Journal of Autism and Developmental Disorders*. 2017;4(4):277-93.
8. Locke J, Kasari C, Rotheram-Fuller E, Kretzmann M, Jacobs J. Social network changes over the school year among elementary school-aged children with and without an autism spectrum disorder. *School Mental Health*. 2013;5(1):38-47.
9. Wei X, Wagner M, Christiano ER, Shattuck P, Yu JW. Special Education Services Received by Students with Autism Spectrum Disorders from Preschool through High School. *J Spec Educ*. 2014;48(3):167-79.
10. Association AP. *Diagnostic and Statistical Manual of Mental Disorders (DSM-5®)*: American Psychiatric Pub; 2013.
11. Stasolla F, Boccasini A, Perilli V. Assistive Technology-Based Programs to Support Adaptive Behaviors by Children with Autism Spectrum Disorders: A Literature Overview. *Supporting the Education of Children with Autism Spectrum Disorders*: IGI Global; 2017. p. 140-59.
12. Koch K. Stay in the Box! Embedded Assistive Technology Improves Access for Students with Disabilities. *Education Sciences*. 2017;7(4):82.
13. Grynszpan O, Weiss PL, Perez-Diaz F, Gal E. Innovative technology-based interventions for autism spectrum disorders: a meta-analysis. *Autism*. 2014;18(4):346-61.
14. Bauminger-Zviely N, Eden S, Zancanaro M, Weiss PL, Gal E. Increasing social engagement in children with high-functioning autism spectrum disorder using collaborative technologies in the school environment. *Autism*. 2013;17(3):317-39.
15. Gamble MJ, Dowler DL, Orslene LE. Assistive technology: Choosing the right tool for the right job. *Journal of Vocational Rehabilitation*. 2006;24(2):73-80.
16. Keengwe J, Onchwari G, Wachira P. Computer technology integration and student learning: Barriers and promise. *Journal of Science Education and Technology*. 2008;17(6):560-5.

17. Ertmer PA. Addressing first-and second-order barriers to change: Strategies for technology integration. *Educational Technology Research and Development*. 1999;47(4):47-61.
18. Vannatta RA, Nancy F. Teacher dispositions as predictors of classroom technology use. *Journal of Research on Technology in Education*. 2004;36(3):253-71.
19. Chmiliar L. Perspectives on Assistive Technology: What Teachers, Health Professionals, and Speech and Language Pathologists Have to Say. *Developmental Disabilities Bulletin*. 2007;35:1-17.
20. Ertmer PA, Ottenbreit-Leftwich AT, Sadik O, Sendurur E, Sendurur P. Teacher beliefs and technology integration practices: A critical relationship. *Computers & Education*. 2012;59(2):423-35.
21. Hixon E, Buckenmeyer J. Revisiting technology integration in schools: Implications for professional development. *Computers in the Schools*. 2009;26(2):130-46.
22. Li Q. Student and teacher views about technology: A tale of two cities? *Journal of research on Technology in Education*. 2007;39(4):377-97.
23. Zhao Y, Frank KA. Factors affecting technology uses in schools: An ecological perspective. *American educational research journal*. 2003;40(4):807-40.
24. Bitner N, Bitner J. Integrating technology into the classroom: Eight keys to success. *Journal of technology and teacher education*. 2002;10(1):95-100.
25. Benton-Borghgi BH. A Universally Designed for Learning (UDL) infused Technological Pedagogical Content Knowledge (TPACK) practitioners' model essential for teacher preparation in the 21st Century. *Journal of educational computing research*. 2013;48(2):245-65.
26. McNaney R, Vines J, Roggen D, Balaam M, Zhang P, Poliakov I, et al., editors. Exploring the acceptability of google glass as an everyday assistive device for people with parkinson's. *Proceedings of the 32nd annual ACM conference on Human factors in computing systems*; 2014: ACM.
27. Profita H, Albaghli R, Findlater L, Jaeger P, Kane SK, editors. The AT Effect: How Disability Affects the Perceived Social Acceptability of Head-Mounted Display Use. *Proceedings of the 2016 CHI Conference on Human Factors in Computing Systems*; 2016: ACM.
28. Sawyer BD, Finomore VS, Calvo AA, Hancock PA. Google Glass: A driver distraction cause or cure? *Human factors*. 2014;56(7):1307-21.
29. Yung K, Eickhoff E, Davis DL, Klam WP, Doan AP. Internet addiction disorder and problematic use of Google Glass™ in patient treated at a residential substance abuse treatment program. *Addictive behaviors*. 2015;41:58-60.
30. Nelson B. On Your Mark, Get Set, Wait! Are Your Teacher Candidates Prepared to Embed Assistive Technology in Teaching and Learning? *College Student Journal*. 2006;40(3):485-94.
31. Harris WJ, Smith L. Laptop use by seventh grade students with disabilities: Perceptions of special education teachers. *Maine Learning Technology Initiative*. 2004.
32. McCoy B. Digital distractions in the classroom: Student classroom use of digital devices for non-class related purposes. 2013.
33. Aagaard J. Drawn to distraction: A qualitative study of off-task use of educational technology. *Computers & Education*. 2015;87:90-7.
34. Liu R, Salisbury JP, Vahabzadeh A, Sahin NT. Feasibility of an autism-focused augmented reality smartglasses system for social communication and behavioral coaching. *Frontiers in pediatrics*. 2017;5:145.
35. Coffman T, Klinger MB, editors. Google Glass: using wearable technologies to enhance teaching and learning. *Society for Information Technology & Teacher Education International Conference*; 2015: Association for the Advancement of Computing in Education (AACE).
36. Keshav NU, Salisbury JP, Vahabzadeh A, Sahin NT. Social Communication Coaching Smartglasses: Well Tolerated in a Diverse Sample of Children and Adults With Autism. *JMIR mHealth and uHealth*. 2017;5(9):e140.
37. Sahin NT, Keshav NU, Salisbury JP, Vahabzadeh A. An Augmented Reality Social Communication Aid for Children and Adults with Autism: User and caregiver report of safety and lack of negative effects. *bioRxiv*. 2017:164335.
38. Vahabzadeh A, Keshav NU, Salisbury JP, Sahin NT. Preliminary Report on the Impact of Smartglasses-based Behavioral and Social Communication Aid on Hyperactivity in Children and Adults with Autism. *bioRxiv*. 2017:165514.
39. Sahin NT, Keshav NU, Salisbury JP, Vahabzadeh A. Second Version of Google Glass as a Wearable Socio-Affective Aid: Positive School Desirability, High Usability, and Theoretical Framework in a Sample of Children with Autism. *JMIR Hum Factors*. 2018;5(1):e1.
40. Lawton K, Kasari C. Teacher-implemented joint attention intervention: pilot randomized controlled study for preschoolers with autism. *J Consult Clin Psychol*. 2012;80(4):687-93.
41. Butler DL, Sellbom M. Barriers to adopting technology. *Educause Quarterly*. 2002;2:22-8.