STORYSCAPE
An Inclusive, Creative Learning Technology

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Executive Summary

Over the last decade positive public awareness of autism has grown significantly. This awareness, along with the real needs of the autism community, has spurred an increased focus on the role of technology to assist individuals diagnosed with autism. Despite this awareness, the growing body of research that explores new technologies for supporting learning, communication, and language in the digital age focuses on the development of technology designed for neurotypical children. Those diagnosed with autism remain underrepresented and are left to appropriate those technologies that best fit their needs. In addition to the technology gap, multimedia targeting the autism community tends to be inferior to that targeting neurotypical children. This is concerning as such challenged learners may benefit most from appropriate technologies and media.

Much of the current cutting edge technology and research in “education” is focused on fostering “digital literacy” and engaging children as creators. Digital literacy involves the ability to effectively and critically navigate, evaluate, and create digital media from a range of digital technologies. It does not replace traditional literacy, rather it “builds on the foundation of traditional literacy, research skills, technical skills, and critical analysis skills taught in the classroom” [16]. While consideration of all learners is given by leading researchers, there are few examples of cutting edge technology being developed for or from the autism community with respect to “education” and digital literacy. Rather than appropriating learning technologies, the particular challenges of those diagnosed with autism
may actual provide a valuable source of innovation for learning technologies.

Because of the heterogeneous nature of autism, the support of individuals diagnosed with autism by many people, and the movement of young learners between “regular” education and “special” education there is a need for new technologies that can be used across a diverse community and environments. Ultimately learning technology should be users-agnostic and truly inclusive.

The characteristics and focus of participatory cultures (See 2.2.1) appear well suited to help inform new technologies for the autism community [16]. I propose a creative learning platform, StoryScape, built on the principles of constructionism and participatory cultures for the purpose of addressing learning needs of children diagnosed with autism. Specifically I will develop novel technologies that can support a community of users around the story process: creating, reading, interacting, and remixing multimedia stories.
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Abstract
Communication impairments are a core characteristic of autism, affecting social-emotional interactions and broader language skills. Literature suggests the single most important prognostic indicator for young children diagnosed with an Autism Spectrum Disorder (ASD) is language ability. The focus of new technologies to support learning and “digital literacy” provides an opportunity to address the unique needs of those diagnosed with ASD. In particular, technologies that implement constructionist principles through participatory cultures may be effective in supporting the educational and therapeutic needs of those diagnosed with ASD. Unfortunately, there is little cutting edge research and development of such technologies with or for the ASD community. In this proposal I explore the development, implementation, and testing of a creative learning platform, StoryScape, to support the unique needs around communication for those diagnosed with ASD.

1 Contributions
The main contributions of this thesis are described below:

1. The development of a novel learning technology, StoryScape, through user-centered design with the autism community.
2. The development and testing of tools for the creation of animated, interactive digital stories that allow for the easy recombination and personalization of digital stories.
3. The design and evaluation of a number of use cases of the StoryScape platform for supporting different users and user goals.
4. A demonstration of the effectiveness of the StoryScape platform for facilitating engagement around the story creation process.
5. A fully implemented StoryScape platform to support use at scale and contribute tools for furthering academic research and learning needs of the autism community.

2 Background
In this section, I will first provide an overview of ASD. Second, I will discuss the autism support network and how that motivates technology implementing the principles of participatory cultures. I will then provide support for the use of story as
a teaching tool for facilitating communication skills, followed by an overview of relevant autism technologies. Next, I will provide an overview of constructionism and participatory cultures, with examples of relevant state of the art technologies. Lastly I will provide a brief overview of the StoryScape platform.

2.1 Autism Spectrum Disorder

ASD is a complex neurodevelopmental disorder that affects approximately 1-in-68 persons and 1-in-42 boys [1, 10]. The condition is characterized by impairments in communication and restricted repetitive and stereotyped patterns of behavior. Communication impairments are a core challenge faced by individuals diagnosed with ASD. These challenges result in difficulties in the acquisition, interpretation, and expression of language and social-emotional dynamics. Within the ASD community, expressive communication ranges from complete mutism, to functional communication, to highly skilled language expression. Nearly 25% of individuals diagnosed with autism do not develop functional communication, while many more have impaired communication [32]. Ultimately, impairments are heterogeneous and affect multiple modalities of communication. Furthermore, communication challenges extend beyond the person themselves and affect their family, friends, and larger social network. The importance of language skills cannot be neglected, as literature suggests the single most important prognostic indicator for young children diagnosed with ASD is language ability [21].

2.1.1 Autism Support Network

To fully understand ASD, and to develop technology for supporting learning and communication, it is important to understand those diagnosed with ASD and their support network. Typically there is a network of stakeholders involved in the education and support of children diagnosed with ASD. This network includes family, friends, teachers, occupational therapists, speech and language pathologists, psychologists, and others.

Perhaps the most cohesive support network around a child diagnosed with ASD is the “school team.” The school team typically includes teachers, occupational therapists, speech and language pathologist, and psychologists. The school team works in collaboration with a student diagnosed with ASD and their parents. While an individual diagnosed with ASD may also have other people, outside of the school team, providing them care and support, for the sake of this proposal stakeholders are considered the family and the school team. It is this group of
stakeholders that are involved in the day-to-day support, teaching, and therapy of children diagnosed with ASD.

In supporting an individual diagnosed with ASD, and developing technologies to assist, it is also important to consider the stakeholders and their interaction with the individual. The needs of the stakeholders and their use of technology has to be taken into consideration too. We feel that characteristics of participatory cultures (see 2.2.1 and 2.2) account not only for the relationship of the individual diagnosed with ASD and stakeholders, but also for the heterogeneous characteristics of those diagnosed with ASD.

2.1.2 Learning and Communicating Through Illustrations

The use of illustration and text, e.g. picture books, is a common introduction to language for most children. While this is also true for children diagnosed with ASD, they will typically use illustrated media for a longer time and in more extensive ways. Illustrated media provides visual support for learning tasks and concepts for those that struggle with written language. Much of this type of illustrated media used with the ASD community has a picture story format and is used for teaching skills and concepts through a narrative structure.

In addition to using illustrations for teaching purposes, illustrations are used for communication too. The most common example of illustration based communication is the Picture Exchange Communication System (PECS). The PECS system combines visual icons coupled with extensive teaching and reinforcement to allow individuals with speech or other language impairments to communicate with others via illustrations.

The following are examples of how stakeholders use illustrations for teaching and communication.

- Teacher
  - Teaching through Social Stories: Social Stories are short, accurate, and unassuming illustrated stories that teach a specific situation, skill, or concept [14].

- Speech-language Pathologists
  - When working with children on verbalization and pronunciation it is common to use illustrated media for visual representations of the simple dialogue or to represent the desired target words.
Occupational Therapists

– Teaching motor skills through sequencing involves breaking some skill, such as washing one’s hands, into a set of sequences. In addition to physically teaching this, media is often created which represents the steps as sequential visual elements with or without associated text and may be incorporated into a story structure.

Parent

– Many parents report spending time with their children creating stories. This often involves a collaborative effort between parent and child to create the story arch, illustrations, and write the story. In addition, parents report making their own Social Stories for use with their child.

2.1.3 Teaching and Therapy With Stories

The use of stories as an educational tool is common, when considering young children this typically includes the use of illustrations too. Both formal (school setting) and informal (home setting) introductions to language involve the combination of illustration and text in story format.

Stories are complex structures that may include a visual grammar, textual grammar, and story grammar. Visual grammar relates to the coherence of the visual objects in the story to convey meaning. Textual grammar relates to the grammatical rules of the language. Story grammar refers to the aspects of story structure such as, setting, characters, goals, actions, reactions, and outcome [13].

The use of stories as a teaching tool is common in many settings. Children with learning disabilities were shown to improve reading comprehension in a study that focused on story and story grammar questions [13]. In this study, the teacher would ask the child “who” and “what” questions related to the story grammar as a means of facilitating active processing of the text.

Research has also shown that parent-child story reading is important for children to gain knowledge about oral and written language [17]. Similarly, works have demonstrated access to story books, repeated readings of stories, story retelling, and direct listening-thinking activities can result in a significant improvement in literacy skills compared to those that do not engage in such activities [22].

Social Stories are perhaps one of the best known examples of story use as a teaching and therapy tool for individuals diagnosed with ASD. Social Stories are short, accurate, and unassuming illustrated stories that teach a specific situation,
skill, or concept [14]. The use of Social Stories are common across stakeholders [5, 30, 31].

2.1.4 Autism Technologies

Over the last 10 years there has been a significant increase in research and testing of novel technologies for those diagnosed with ASD. Active technology research areas for ASD include: computer aided instruction (CAI), robotics, tangible interfaces, intelligent tutors, and augmented and alternative communication devices to name some [4, 6, 26, 29, 35]. Interestingly, there is little research and technology to enable story creation. The following describes some technologies related to communication, language, and story.

The TeachTown software is an example of common software for the autism community with a focus on communication and language teaching [36]. Such software falls into the category of CAI. Game like interactions are leveraged to try to engage the learner. Multiple choice selection is most commonly employed for teaching concepts, words, and simple sentences. The learner does not actively constructs any materials.

While the use of Social Stories is common across stakeholders there is a surprising lack of quality tools to support the construction, sharing, and remixing of such media. Constantin et al. review 6 tools marketed for making “Social Stories” and determine that none provide sufficient features to support the needs of actual practitioners [9]. Most stakeholders use tools such as pen-and-paper, Microsoft Word, and Microsoft Powerpoint to create illustrated materials. Boardmaker is the most widely used software by teachers and therapists specifically designed for social stories and visual media for the autism community. Boardmaker allows for the construction of illustrated media that then can be printed onto paper for subsequent use. Overall, there is a significant lack of quality tools for supporting the creation of illustrated media for the autism community. Furthermore, multimedia quality is poor for such tools as Boardmaker, while users of Powerpoint and other tools typically incorporate random images from Internet searches. Overall the multimedia is poor and may have a negative affect on engagement with learning materials.

2.2 Constructionism

Constructionism has its roots in Jean Piaget’s epistemological theory of constructivism. Constructivism describes what a child is interested in and able to achieve
at different stages of development. The theory describes how children’s ways of
doing and thinking evolve over time [24]. At the root of Piaget’s constructivism
is the notion that knowledge is actively constructed. In terms of a child they do
not learn simply because they are told some fact, but they actively construct an
interpretation of the word and hence their knowledge of it. Likewise the heart of
Papert’s constructionism is rooted in the notion of knowledge being constructed.
Constructionism builds from constructivism, but focuses on the art of learning.
The path to this learning is through making things, or “learning-through-creating.”
Papert is focused on how people construct knowledge most effectively when they
are actively constructing things in the world, whether these are physical things or
conceptional things. The tools used for creating, the media, the context, and the
process are all important to learning [3, 23].

2.2.1 Participatory Cultures

Participatory cultures represent constructionist principles with a specific focus on
how communities are structured to facilitate learning. Jenkins describes a partici-
patory culture as [16]:

- Culture with relatively low barriers to artistic expression and civic engage-
  ment
- Strong support for creating and sharing one’s creations
- Informal mentorship, whereby what is known by the most experienced is
  passed along to novices
- Where members believe that their contributions matter
- Where members feel some degree of social connection with one another

Whether the Amateur Press Association in the middle of the 19th century, the
Samba Schools described by Papert, or the many Internet based platform such
as, Wikipedia, Youtube, or Facebook, participatory cultures have long been a part
of our world [2, 32]. Something that has changed though is the proliferation and
access to such cultures due to the Internet.

2.2.2 Scratch

Scratch was developed at the MIT Media Lab as an learning platform to support
young people learn to think creatively, reason systematically, and work collabor-
oratively [28]. The Scratch platform consists of a unique online programming
environment and social network. The Scratch programming environment allows individuals to easily create video games, interactive stories, music videos, computer programs, and much more. The Scratch social network supports a vibrant community and allows people to share and collaborate on Scratch projects, learn from each other, interact with one another, and share projects. The Scratch community has grown to over two million members, and several million-user projects, most developed by young children. Scratch is successfully supporting learning, discussion, and the creation of new knowledge.

2.2.3 Participatory Learning Platforms

While Scratch is the best known example of an academically developed participatory learning platform Alice Storytelling, LookingGlass, and Moose Crossing are other examples [7, 18, 19]. Similar to Scratch, Alice Storytelling and Looking-Glass teach computer programming concepts. The main focus of these works is animated storytelling, but they require programming to construct the animations and story interactions. The earlier work of Moose Crossing also has a focus on stories and computer programming, allowing the users to create text-based virtual story worlds. Each of these works explores how learning can be supported by community and how to facilitate learning in a fun and engaging manner.

While storytelling is a core feature of Scratch, Alice Storytelling, Looking-Glass, and Moose Crossing it is not the main intention of these platforms. The creation process is driven by computer programming, which is the main learning feature of these platforms. Our goal is to engage and facilitate people around the story process, allowing them to focus on the communication, language, and art of story. These are some of the reasons that it was necessary to create the StoryScape platform. There are also several commercial products that allow for the creation of digital stories, but none of them had the full feature set that we wanted to explore. Again, for exploring the role of a participatory platform for the autism community structured around the story process it was necessary to create a tool with many new capabilities.

2.3 StoryScape Platform Overview

The following is a brief overview of the StoryScape platform. Please see appendix A for a more detailed description of StoryScape features and motivations.

StoryScape is comprised of five main systems (See Figs. 1, 2, 3). The first is a set of web-based authoring tools for creating interactive art sets, and author-
ing stories. The second is the media library that contains all art for use in story creation. The third is a mobile story reader (MSR) application built for Android powered devices. The forth is a set of NFC tagged objects. The fifth is a Bluetooth enabled hardware and sensor network using the IOIO board. The entire system is integrated around the authoring tools and MSR. Published stories are available online or via download to the MSR. Only stories on the MSR can take full advantage of the many interactivity and remix features. Stories can leverage the MSR’s sensor platform and connectivity to create unique interactions with the story. The platform connects web, mobile, and physical technologies around the story process.

Story construction can include creating original artwork, choosing artwork for use in a story, the choosing of individual scene backdrops, the choosing and layout of actors within a scene, the construction of the story dialog, the actual typing of words and sentences, the integration of physical assets. The full process of creating a story includes the construction of visual grammar, textual grammar, and story grammar.

3 Proposed Research

The primary aim of this research is to explore the effectiveness of StoryScape as a tool for supporting learning around communication and language for children diagnosed with ASD. We feel it is necessary then that StoryScape must engage users and sustain that engagement to be useful for supporting learning. As research shows there is strong empirical support for the connection between engagement and academic achievement [20, 27]. Furthermore, given our argument that the best way to do this is by supporting a community around the story process it is also necessary to test StoryScape across a range of users and user needs related to enhancing communication skills for those diagnosed with autism.

To achieve these goals we have been actively engaged in the development, testing, and refinement of StoryScape. Because of the scope of work required to develop the StoryScape platform it has been necessary to work on the development for an extended time. During development we have actively engaged with potential users of the system in an iterative process of design, development, and testing across a number of users and use-cases. From this, we have made significant refinement to the platform and research goals. As a result, we have identified the primary area of interest for this research study: student engagement during story co-creation.
Story co-creation is the process of two or more persons actively constructing a story together. The process involves social engagement and collaboration around story construction. Story construction involves the picking of an art set, the choosing of individual scene backdrops, the choosing and layout of actors within a scene, the construction of the story dialog, the actual typing of words and sentences. The full process includes the construction of visual grammar, textual grammar, and story grammar.

The following provides an overview of completed pilot studies followed by the research plan for completing the “student engagement during story co-creation” research study.

3.1 Overview of Completed Pilot Studies

During the course of development of the StoryScape platform a number of pilot studies have been conducted across different potential users and use-cases. These include the use of StoryScape with children diagnosed with ASD, teachers of students diagnosed with ASD, and neurotypical students. For the purpose of this study we focus on those studies with the children diagnosed with ASD. These pilot studies have been integral in the development and design of StoryScape. In addition, these pilot studies have helped shape deeper research question and the feasibility of such work. For brevity the early pilot studies using StoryScape for creating individualized education materials, and teaching verbs through stories have been included in the appendix of this paper (See Appendix B).

3.1.1 Story Co-Creation Pilot Study

A pilot study was conducted with two classes of children diagnosed with ASD at a private school for children diagnosed with ASD using StoryScape as a classroom activity to facilitate social engagement and communication through story co-creation. Two special education teachers and 10 students aged 8-14 years participated in the pilot study. The aim of the pilot study was to determine the feasibility of a larger subsequent study of StoryScape as a tool for facilitating social engagement and communication through story co-creation.

StoryScape co-creation sessions were conducted as a class activity over a three week period. Sessions were conducted 2-3 times per week during their class technology time. Sessions typically included 4-8 students, a teach and teacher assistant, and lasted 30-45 minutes. During each session the StoryScape authoring tool was projected onto a 77” smart whiteboard. Students sat in a simi-circle around
the whiteboard and took turns adding elements to the story. The whiteboard allowed for touch interaction, so students typically walked up to the whiteboard and selected elements for constructing the story scene. In addition, there was a desktop computer that was the actual computer accessing the StoryScape website that students could use for constructing the story too. A wireless keyboard was used by students to write the text of the story, this keyboard could be passed to different students to enter text or used from the computer desk. Story topic and creation was driven by students with the teacher and teacher assistant serving as support for the process.

Students and teachers found using StoryScape to be easy and enjoyed the task. Overall feedback from teachers and students was very positive. Teachers reported that students asked to use StoryScape daily, even near the end of the study. Teachers reported that students were “more engaged.” They related this as the students spending more time on task with less support, prompting, and effort on the teachers part. In addition, teachers reported that the students “really enjoyed” making stories. They also reported that students spoke more, and used words and concepts the teachers did not know the student(s) knew. Teachers thought possible factors for increased engagement were: how easy StoryScape was to use; the quality of art used; the animations; the ability to create unique scenes; and that creating stories is a fun activity.

The StoryScape co-creation pilot study went very well and indicates there may be substantial benefit for engaging students in social communication activities using StoryScape. To better understand what features of StoryScape may enhance student engagement a more in-depth study is planned for the beginning of the fall semester of school. A full write up of this study is planned.

### 3.2 Story Co-Creation Research Study

Following the results of the above story co-creation pilot study, we are planning an in-depth study using StoryScape and story co-creation to determine what features of StoryScape may enhance student engagement. Story co-creation sessions will take place in a classroom setting. Sessions will involve a class of 4-8 students with teacher and teacher aids, collaborating to create a story. During each session the StoryScape authoring tool will be projected onto a 77” smart whiteboard as a shared interface for the class. Students will be allowed to use the smart whiteboard to create/modify the story. In addition a desktop computer will be included for the children to use for story creation/modification as needed. A wireless keyboard will be used for story text entry. Despite the touch interface of the smart whiteboard
a wireless mouse for manipulating the interface will also be provided as needed. The goal, if possible, is to allow the students to lead the story creation activity and for the teacher to support them in this process. The teacher will be instructed to allow the students the maximum freedom in the story creation process, while supporting their abilities and needs. The study will take place over approximately one month. There will be two or more classes included with 8-12 students aged 8-14 years.

3.2.1 Research Question

Does story co-creation using StoryScape result in increased student engagement?

It is worth considering why engagement is a worthy area of research with respect to StoryScape’s usage and the autism community. There is strong empirical support for the connection between engagement, achievement and school behavior across individuals [20, 27]. Anecdotally, it is understood to be difficult to engage students diagnosed with ASD in learning activities. Therefore, engaging children diagnosed with ASD in a communication centered activity may have significant benefits for supporting achievement and behavior with respect to communication skills. While the topic of the role of engagement in education is rich and well studied, there is no single definition or method for studying engagement [8, 25, 34]. This is also true for the study of the role of engagement related to the usage of technology by the ASD community.

Despite there not being a single definition, measure, or method for studying engagement all works have at their root a common understanding and focus that engagement reflects a person’s involvement in a task or activity across physical, cognitive, or emotional behaviors [8, 15, 20, 25, 27, 34].

In this study, I propose to use measures and methods similar to those used by Hourcade et al. in their study of engagement of students diagnosed with ASD during usage of tablet apps to encourage social interaction [15]. Furthermore, I will employ measures and methods used in the education and engagement literature [8, 20, 25, 27, 34]. Similar to Hourcade et al. all measures of engagement from video coding will be normalized to occurrences per minute.

3.2.2 Planned Test

Is there an increase in student engagement when using StoryScape?
Our study will include video recording StoryScape sessions and other learning sessions during the school day. Recorded sessions will allow for post-analysis and comparison between activities. Videos will be reviewed by humans to code for engagement features, in addition the teachers will be asked to give engagement probes during StoryScape sessions and other learning sessions. They will also be asked to complete post activity questionnaires to probe their interpretation of class engagement.

Engagement features are derived from Hourcade et al. and common behavioral measures used in education engagement research that also appeared in the story co-creation pilot study [12, 15, 20, 27, 33]. The following Engagement features will be coded for from video recorded sessions:

- **Verbal interactions**: verbal exchanges between children in session.
- **Supportive comments**: comment of support or encouragement towards another.
- **Discourage comments**: displeasure or criticizing directed toward another.
- **Physical interactions**: turn taking and joint involvement.
- **Atypical behavior**: non-verbal behaviors that would be unusual in typically developing children. These included rocking, jumping, and making noises during sessions.
- **Social missteps**: these included inappropriate tone of voice, staring or avoiding eye contact, invading personal space, and interrupting or breaking a social interaction.
- **Time off-task**: time spent attending to activity other than target activity.
- **Hand raising**
- **Asking/answering task relevant questions**
- **Problem behaviors**: behaviors reported as problem behaviors from teachers.
- **Laughter**
- **Smiles**
- **Prompting**: instances of prompting towards individual to compel an action.
- **Words written**: number of words written during a story co-creation session, analyzed from digital story.
- **Visual elements used**: number of visual elements used during story co-creation sessions, analyzed from digital story.
In addition to video analysis, teachers will conduct random student engagement probes. Student engagement probes will be conducted during StoryScape sessions and other learning sessions during the school day. Engagement probe questions will be presented to the student for their rating of a particular engagement feature, eg. “give me a thumbs up if you want to continue using StoryScape or a thumbs down if you want to stop.” Engagement probe questions will include:

- Do you want to continue [task]?
- Do you like doing [task]?
- Do you find [task] interesting?
- Do you find [task] fun?

Lastly the teacher will complete a post activity questionnaire for StoryScape sessions and other learning sessions during the school day. Post activity questionnaires will focus on the teachers interpretation of class engagement. Questions will by Likert scale, eg. rate the students interest in the learning task, 1 indicating no interest at all and 7 indicating the most interested you have ever seen them. The following questions will be given:

- Rate student interest for the learning task.
- Rate student enthusiasm for the learning task.
- Rate student involvement for the learning task.
- Rate student satisfaction with the learning task.
- Rate student attention to task.
- Rate student enjoyment of task.

In addition to understanding if there is increased engagement it will be necessary to understand what features of StoryScape contribute to engagement. I propose testing the following StoryScape features: display interface, art and animation, user constructed scenes. During these StoryScape feature test the same measures of engagement will be collected as outlined above.

The **Display interface test** will be conducted to test whether the large smart whiteboard is the primary driver of student engagement. Test will be conducted by comparing other learning task engagement while using the smart whiteboard. In addition, it may be necessary to test story co-creation using a smaller computer monitor.
The art and animation test will be conducted to test the effect of StoryScape art and animation. We will compare the use of the current StoryScape art with Boardmaker style art, which is commonly used art for similar media creation by the ASD community. The Boardmaker style art will be added to the StoryScape platform for use in story creation. Sessions will be conducted using the Boardmaker art to note student engagement. In addition, students free picking of art sets will be noted to determine student art choice.

The testing of user constructed scenes will compare engagement when students are able to construct a story scene from backdrops and actors verse using a single static image of a completed scene. In the first case students will be able to construct a story in the current default way, choosing backdrops and actors to layout to make a scene. In the second case they will only be able to use completed scene images, they will not be able to mix backdrops with actor and choose layout options.

All video, activity probes, post activity questionnaires, and completed stories will be collected for data analysis. The main part of analysis will involve coding videos for engagement features. This task will be carried out by the author of this proposal and potentially undergraduate researchers at MIT. Results of the study will be compiled for inclusion in my thesis defense and an academic papers targeting relevant journals.

3.2.3 Research Timeline

Overview of work completed and planned (See table 1).

3.2.4 Human Subjects Approval

The protocol for all studies will be approved by the Massachusetts Institute of Technology Committee On Use of Humans as Experimental Subjects (COUHES).
Table 1: Research Timeline

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<thead>
<tr>
<th>Month</th>
<th>Activity</th>
<th>Progress</th>
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<tbody>
<tr>
<td>January-June 2013</td>
<td>Initial development and usability testing</td>
<td>completed</td>
</tr>
<tr>
<td>June-October 2013</td>
<td>Platform redesign and usability testing</td>
<td>completed</td>
</tr>
<tr>
<td>October-November 2013</td>
<td>Initial education study (transmedia crafters)</td>
<td>completed</td>
</tr>
<tr>
<td>November-December 2014</td>
<td>Initial ASD education study</td>
<td>completed</td>
</tr>
<tr>
<td>January-March 2014</td>
<td>Platform redesign and usability testing</td>
<td>completed</td>
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<tr>
<td>March-May 2014</td>
<td>FSD ASD verb learning trial</td>
<td>completed</td>
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<tr>
<td>April-May 2014</td>
<td>Shaddy Hill story craft</td>
<td>completed</td>
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<tr>
<td>May 2014</td>
<td>Lionheart story co-creation trial</td>
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<td>August-September 2014</td>
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<td>October-November 2014</td>
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<tr>
<td>December-January 2014</td>
<td>Thesis defense</td>
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</table>

Bio

Micah Rye Eckhardt

Micah received a B.S. in Cognitive Science with minors in Computer Science and Mathematics from the University of California, San Diego, and S.M. in Media Arts and Sciences from MIT. His early works included state of the art facial feature detection and one of the first work to show that a robot could be used to teach children language. His current work is focused on creative learning technologies, with an application towards children diagnosed with autism.
A StoryScape Description

Each of the following five sections cover a core feature of the platform along with motivation from personal experience and or from the literature that supports the features inclusion.

A.1 Story Reader

Perhaps the most straight forward and accessible way of using StoryScape is by consuming stories created by other people. In this case the user would use the MSR to read and interact with stories. Stories have the capacity to respond to the following user inputs; touch, sound, shaking, location, Near Field Communication (NFC), and IOIO events (hardware input and output events). These input triggers were chosen to provide the story creator and story reader with unique forms of interaction. The advance interactions add a new dimension to the story experience.

Motivation for the MSR was driven by the adoption of iPad’s and other tablet computers by the autism community. In addition, the personal nature of tablet computers allow for the collection of usage data over time and location that could be of value in understanding learning behaviors. Furthermore, the MSR’s rich sensor platform and network connectivity allows for the development of unique story interactions. Some individuals diagnosed with ASD require considerable therapy focused on vocalization and motor movements, therefore we wanted to create multiple modalities of story interaction to support these therapeutic goals and to potential enhance engagement through novel story interactions.

A.2 Story Remixer

Each story, whether created by the user or someone else, can be remixed on the MSR. The remixing features allow for both remixing and hyper-personalization. Remixing can entail shifting, resizing, or rotating visual elements. In addition, voice-overs and sound effects can be added to story elements. Finally, new images can be inserted into the story using the device camera or from local storage.

These remixing features include allowing the user to play with the story, i.e. the story is not fixed and can be changed. In addition, it may serve as scaffolding to allow the child to explore their imagination and help progress the child towards creating their own stories. The sound and image modification features allow for stories to be hyper-personalized. If we consider a parent and child, a parent may want to put a motivating or meaningful piece of media into a story to engage
their child. For some children this hyper-personalization can motivate usage and therefore engagement with story and language.

Both the heterogeneity of ASD and the restricted interest of many individuals diagnosed with ASD motivated the remix and personalization features. Unlike neurotypical learning materials there is a need for very specific learning materials for each child diagnosed with ASD. StoryScape tries to support this need by allowing remixing of media. In addition, because many individuals are motivated by their personal restricted interest, sometimes referred to as their affinity, we wanted to allow for the easy inclusion of personally motivating visual elements. Furthermore, remix features lower the barrier of creating media.

A.3 Story Author

The StoryScape web-based story authoring tool can be used by anyone to create their own interactive, animated story. Story authoring involves first selecting an art set to use for the story (See Fig. 1). Once an art set has been selected the user can use the drag-and-drop tools to construct the different scenes of the story. Actors and backdrops can be combined in any order the user wants. Each scene comprises a background and 0 to N actors. Actors can be placed and resized as the user wants to construct the visual elements of the scene. Actors may be animated. Finally text can be added to the scene to further develop the written story.

A key aspect of story authoring is the use of an art set. This art set may or may not have been created by the story author. Art sets have pre-created animations and interaction triggers associated with them. During story authoring the author can test the animations and interactions through the authoring tool.

The story author can chose to create a linear story, or can create non-linear stories. Stories ultimately can be published for public view or privately. Public stories can be viewed via a simplified reader from any web-browser, or can be downloaded to the fully functional MSR.

The authoring tools were motivated by several factors. Many teachers working with students diagnosed with ASD spend significant time creating learning materials for their students. These materials tend to be static and paper based. A goal of StoryScape was to support creating these materials in a digital, shareable, remixible format to reduce future media creation. Another major factor in creating the story authoring tool was to engage children diagnosed with ASD in the story creation process. Very little current technology for the ASD community engages the users as creators, we were motivated from results of systems like Scratch to engage the users as creators.
A.4 Artwork Author

The artwork creator, or artist, is the power-user of the StoryScape platform. The artist has the ability to create illustrations, animations, and assign interaction triggers when creating such assets. Illustrations and animations would be created with tools other than StoryScape. This media may be digital art or traditional art, in either case a digital representation would be created at some stage to be uploaded to the StoryScape artist tools.

The artist tools allow for the creation of art sets, backdrops and actors. The artist can upload backdrop images and actor images to StoryScape. Backdrops are single non-animated bitmaps. Actors can be a single non-animated bitmap or multiple bitmaps that form an animation. The artist tools allow for the construction and definition of the actor animations for use by the StoryScape system (See Fig. 3).

When constructing the actors the artist can assign different actor animations to different input triggers, this includes the ability to assign IOIO (physical hardware) output signals and input signals. This later part allows for any digital actor to be connected to any sensors or hardware via a IOIO board. Furthermore, once actors have been defined the artist tools allow for the actor to be published to NFC. Further discussion of physical assets, NFC and the IOIO, follows this section.

There are multiple motivations for the author tools. Motivations include the ability to allow anyone to contribute art that others can use to create stories. The ability to create animated objects that can be used to show actions was a motivation. The animations may be beneficial for both general engagement and for teaching concepts that include action. The need for many types of art and symbol to allow for extensive use of the platform by others requires tools to allow for the upload, creation, and sharing of art assets.

A.5 Physical Assets Author

Physical assets can take many forms, but ultimately they are connected to StoryScape and the story by either NFC or the IOIO board. With respect to NFC the artist tools allow the artist to publish an actor to NFC. This creates a unique identification that can be assigned to any NFC tag to associate the corresponding digital asset to the physical NFC tag. Once this has been done the NFC tag can be associate with almost any physical item. Once a tag has been encoded with an actor id any mobile device with an NFC reader can read the actor id from the NFC tag. When this happens the digital assets are retrieved and displayed in the current
story scene. In addition, entire stories can be associated with a NFC tag to allow an entire story to be connected to a physical object.

The artist tools allow for each actor to accept input signals from the IOIO board, or to send output signals to the IOIO board. With respect to input signals, this allows sensors or other hardware to be created to capture user input or other environmental signals that can then make a story actor react. For example, a force sensor that is bent might send a signal to the IOIO board that is then sent to the MSR where a specific actor responds with a funny bend animation.

Likewise, output signals can be sent from an actor to the IOIO board. In this case when an actor is touched one of several digital signals may be sent to the IOIO board. Sensors or other hardware would then respond to the digital control signal. For example, a relay switch that controls a light can be connected to the IOIO board and respond to an actor being tapped by turning a real light on or off.

These features were motivated by anecdotal evidence suggesting that many individuals struggle generalizing between digital and physical media. These features allow for the blending of digital and physical interaction. In addition, these features were seen to add novel interaction and support interest and engagement with the platform.

A.6 StoryScape Motivation Conclusion

In conclusion, the driving motivation behind the design of the StoryScape platform has been the desire to support learning needs around communication for individuals diagnosed with ASD. Through extensive work at a school for children diagnosed with ASD during my masters thesis [11], in addition to further interaction with parents, family members, teachers, therapist, academic researchers, and individuals diagnosed with ASD it became clear that it was necessary to develop systems capable of supporting a community of users. This community of user, even if only those diagnosed with ASD, is diverse and have different needs and interest. For some they will only need, or want, to read stories made with StoryScape. Others will want to remix (change) stories to fit their needs, while others will wish to create their own stories. Still others may wish to create artwork for use by others, while some may find the physical assets of interest.

StoryScape was designed to account for a diverse community of users, needs, and interest around the story process. In addition to the needs of individuals diagnosed with ASD and the community of stakeholders around them, principles of constructionism and participatory cultures were used to guide development of StoryScape. The following section further explains these principles.
Figure 1: Upper left: tool for constructing animation and assigning triggers. Upper right: a full art set with backgrounds and actors. Lower left: story authoring tool after choosing art set. Lower right: mobile story reader.

Figure 2: Left: actor construction tool used to assign input/output signals to IOIO board on actor interaction trigger. Right: bidirectionally communication between story on mobile reader and IOIO board. IOIO can send output signals triggered from story to sensors/hardware and vice versa.
Figure 3: Left: actor construction tool used to assign input/output signals to IOIO board on actor interaction trigger. Right: bidirectionally communication between story on mobile reader and IOIO board. IOIO can send output signals triggered from story to sensors/hardware and vice versa.

B Overview Completed Pilot Studies

The following two sections provide an overview of completed pilot studies with the ASD community using StoryScape.

B.0.1 Individualized Education Materials

A study was conducted at a private school for children diagnosed with ASD to determine the use of StoryScape with children who have severe challenges. A total of 4 students participating in the study. Participants were aged 6-8 years, were minimally verbal or non-verbal, and had limited reading ability.

During a two week period the author of this paper interviewed the primary teachers, teacher support staff, on-site occupational therapist, and speech-language pathologist (SLP) to determine possible use-cases for StoryScape that integrated with daily teaching activities. Initial aims of the study were to test StoryScape interactive stories as a tool for engaging students in reading activities. Because of the language related challenges of the students and the focus of teaching on very basic skills it was determined that the use of StoryScape for story specific content would not be viable.

Further observation and interviews with staff revealed a use-case for creating individualized learning materials (ILM) to support the students Individualized Education Program (IEP). Working with the teachers we identified learning goals and materials to use for creating interactive media using the StoryScape tools. Current materials used by staff were predominantly paper oriented, or simple toy
like materials. Six learning tasks were chosen for each child and interactive media was constructed from images of the physical materials typically used. The author of this proposal took pictures of the physical materials, edited the images, and uploaded them for use in the StoryScape system. From the digital media ILM were constructed for use on the MSR that mimicked the process and media typically used by the teachers.

Over the course of 6 school days teachers used the ILM with the students at school. In addition, students were allowed to take the MSR home, parents were informed to use the MSR and ILM at home with the children. Each student had a specific device and usage data was collected. Usage data included what materials were actively being used, length of time used, what images were touched, if there were sound events triggered (i.e. did a noise trigger an animation). This data would allow us to determine if a particular goal was achieved. For instance the page may ask a child to select their name from a field of five names, the data would allow us to determine what name was selected, if other names were selected first, how long it took, etc.

It quickly became evident that data collection would not reveal any user-specific behavior because of the level of help and prompting required by students to complete a task. While children appeared to “like” using the interactive media, they were unable to use it in an independent and meaningful way during the short study. Despite this there were a number of positive outcomes reported by teachers and parents.

Teachers found the ability to create interactive media that mimicked their typical learning tasks and materials useful. Furthermore, despite the collected data not having performance value they were interested in long term data collection and the automatic collection of usage data. Teachers and the SLP found the sound triggered interactions to have potential value. Two of the participants had specific learning goals with their SLP related to vocalization. The SLP reported that he was working with them to help teach them that they could use their voice to manipulate the world. The fact that StoryScape made it very easy to create interactive media that is able to react to sound was seen as a potential useful feature for these children.

Despite the ease of creating media with StoryScape, staff felt that the media library did not contain the types of images that they would need. In addition, staff felt the image editing required to make pictures useful with StoryScape would be difficult to do in a typical work situation.

Three of the parents commented to the author of this proposal that they liked being able to do homework with their children. Interviews with the teachers re-
revealed that the children did not take work home, so parents did not typically see what media a student used at school. In addition parents commented that the liked that we could create “apps” specifically for their children. While the medias created were not “apps” they resembled many of the simple education apps children had on their personal tablets for.

Overall this study revealed that using StoryScape for story specific purposes with young children with minimal verbal and written language abilities may not be appropriate. Furthermore, data collection methods were not sufficient to discern when the student was interacting with the device verse when a teacher or parent was helping the child. While staff reported using StoryScape to be easy the media library did not contain the domain specific images needed by the staff for creating ILM. Furthermore, the time investment of creating their own media from preexisting physical media was seen as an extra challenge in a already busy schedule.

An interesting outcome of this work was the potential for creating ILM using the StoryScape tools. Furthermore, teachers and parents were able to share the same media and support the learning goals in and out of school using the MSR.

A full write up of this study is planned.

B.0.2 Teaching Verbs Through Stories

A pilot study was conducted over a 5 day period with two classes of children diagnosed with ASD at a public elementary school to determine the feasibility of teaching verbs via StoryScape. Two special education teachers and 1 SLP along with 10 students aged 5-8 years participated in the study. Students participating in the study were minimally verbal to verbal. Reading ability varied from being able to read sight words to simple sentences. The aim of this study was to test the feasibility of using StoryScape to teach verbs, and consider the feasibility for a longer in-depth study around verb acquisition using StoryScape.

This study was motivated by interaction with the coordinator of special education, two teachers and one SLP at the school who reported that teaching verbs was difficult with many of the children diagnosed with ASD. They felt that the ability to show actions through animation and create stories with the verb animations in them would help children with verb acquisition. Prior to the start of the study teachers were consulted to inform what would be appropriate artwork and verbs for initial testing. From consultation with the teachers we constructed two animated art sets for use during the 5 day study. The theme of one art set was “a day at the circus” and the theme of the second art set was “witches brew.” The
following verbs were depicted: pouring, mixing, washing, juggling, and pealing.

During the first two days of the study observation of class room activities and the use of story by teachers and students was noted. In addition, interviews with teachers and support staff were conducted to better understand how stories and other media were used by the teachers and students. In addition, teachers and support staff were asked to use the StoryScape authoring tools to test usability and acquaint them with the authoring tools. Teachers and support staff reported that they currently used Microsoft Word or Boardmaker for creating stories or other media for teaching nouns. Following StoryScape usability test both teachers, independently, reported that it was “so much easier than Boardmaker.” As noted above Boardmaker is a common software package used by teacher of students diagnosed with ASD for creating stories and other learning media. Teachers and support staff found StoryScape easy to use. One teacher that initially said she could not create a story because she was not creative, later reported that she had been up until midnight writing a story. Over the next 3 days the teacher wrote 2 more stories for use with her students.

Days 3-5 teachers and support staff used stories they had created, in addition to stories created by the author of this proposal, to engage the students. Stories included the art sets with the desired verbs in addition to other stories. Overall students found the stories very engaging, the SLP reported that it was easy to get the children interested in the stories. In addition, teachers and staff found the ability to record their own voice and other sounds into the story to be a feature students enjoyed. Students would interact with the MSR with a teacher and on their own. In one instance a student that was not considered a “reader” figured out how to record his own voice as the narration of the story. He proceeded to narrate 23 pages of a 26 page story! It should be noted that the students speech is mostly unrecognizable because of extreme apraxia, a motor speech disorder that affects speech production. The teacher and staff was very surprised by this behavior, reporting that they “had never seen him do that before.” This and other observational data support that the children appeared engaged with the MSR and story media.

While teachers found using StoryScape for authoring content and use with students was easy, and students appeared to enjoy using the MSR and story content, a long term study to determine the effectiveness of StoryScape to help with verb acquisition was determined not to be feasible currently. The creation of specific artwork with multiple examples of specific verbs required by teachers would not be possible at this time for the project. In addition, the school is located in Dallas Texas, making a difficult to conduct for the author of this proposal.
A full write up of this study is planned.

References


