

# Brave Little Dragon: Accessible Education in Russia

An Interactive Qualifying Project submitted to the Faculty of  
WORCESTER POLYTECHNIC INSTITUTE  
in partial fulfillment of the requirements for the  
degree of Bachelor of Science



May 13, 2021

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# Abstract

*Brave Little Dragon* is an exercise-based curriculum for cognitively disabled primary school students. We adapted the first portion to a website that includes a framework for future expansion, accessibility features, and data collection to monitor student progress. Noosfera, teachers, and psychologists who use the curriculum evaluated the effectiveness of features in our website and directed our final design. We recommend future groups continue to build upon our framework to establish a fully functional version of the *Brave Little Dragon* website.

# Acknowledgements

Our team would like to give a special thanks to Tamara and Sofia Arzumanyan from Noosfera Education Support Foundation for their enthusiasm and assistance in designing this project. Their information and ideas were invaluable in our process of understanding and designing a solution for educating cognitively disabled Russian students remotely. We would also like to thank Anna Petukhova, Victoria Skobnikova, and Leyli Annageldiyeva from the Financial University Under the Government of the Russian Federation for their unique perspectives and novel impacts on our research. We enjoyed collaborating with them on IQP. Our team would also like to thank Professor John Zeugner, Professor Karen Oates, and Professor Ivan Mardilovich for their consistent encouragement and guidance throughout our project.

# Executive Summary

Throughout history, Russia has faced a lack of accessibility and equal opportunity in education for cognitively disabled children. This prominent issue has recently become a focus of Russian education policy and public attention in modern times, and is therefore a growing field with great need for additional development. Many of the remote platforms that have become a necessity due to the SARS-CoV2 (COVID-19) pandemic are built for typical students, and therefore do not feature sufficient accessibility to allow for the same quality of education that cognitively disabled students are entitled to. However, digital educational programs purpose-built for the cognitively disabled have seen great success on an international level. While accessibility techniques and tools, research, and educational platforms targeted toward cognitively disabled children exist, they have not been applied widely throughout Russian education.

The goal of this project is to create a website framework for the future expansion of the Brave Little Dragon curriculum and to adapt the first few exercises from lesson 1 of the curriculum into the website platform that was created. *Brave Little Dragon* is a book-based curriculum developed by Noosfera Educational Support Foundation that focuses on improving the mental functions of cognitively disabled children ages 6-13 through stories, music, and exercises targeted at specific areas of the brain. A website framework for the curriculum was created, and the first four exercises from lesson 1 were fully adapted into the website to provide the same benefits as the in-person program. The project's development process had four main focuses, and for each of them, the most effective methods were determined based on research, sponsor guidance, and feedback throughout development. These focuses are understanding the problem that our project addresses, development of the front-end of the website, development of the back-end of the website, and testing and gathering feedback on the website design, functionality, and effectiveness for the target audience.

In order to know the significance of the project on the target audience and on Russian society, it was vital that a deep understanding of the problem that the project addresses was grasped. In order to gain this understanding, background and literature research was performed, and meetings and communications with Noosfera Educational Support Foundation occurred. The research and communications allowed for an understanding of the positive impact that the project will have on cognitively disabled children's lives, Noosfera Educational Support Foundation's expectations for the website, and their future plans for the website to be grasped. Through gaining this understanding, the website was developed in a manner that improves the target audience's cognitive abilities, best serves their diverse needs, and impacts their lives. Because a deep understanding of the project and target audience was paramount to a successful project, this understanding was used to model the project and create a

website that aligned with the goals. It is recommended that any future group working on expanding the website gains the same understanding and maintains a constant stream of communication between sponsors, advisors, and students to keep the project on track.

To users of the website, the most prominent part of the experience is the front-end. The front-end includes everything that the students, parents, teachers, and assessors can see. Developing the layout and incorporating adaptation and accessibility techniques were the main objectives that were focused on to create an effective front-end of the website. The website layout included navigation, flow, and aesthetics, while the adaptation and accessibility techniques were implemented to present information to the students in a manner that serves their needs, to collect and assess their response, and to keep them engaged in the lessons. Through research and communications with Noosfera Educational Support Foundation about which type of layout and what accessibility techniques are best for the audience, the front-end design was effective in recreating the feel and aesthetics of the *Brave Little Dragon* book. It is recommended to continue implementing these features in any future work and to use a prototyping software like AdobeXD or Wix Editor to lay out the visuals and website flow before moving on to working on back-end coding.

Equally important as the front-end, although not as visible to the end user, is the back-end. The back-end includes web frameworks, development platforms, and libraries that make up the inner workings of the site. Through using the various types of software, such as Next.js, a successful website back-end with multiple components was created. The back-end can easily support the future plans that Noosfera has for the website, allowing the website to change numerous lives as it is expanded. Overall, Next.js was an effective platform to code the website adaptation, as it is a framework that has a wide range of technologies published to handle user login and authentications. It is recommended for future groups to use Next.js as well for its adaptability and ease of use. Using Next.js will also make it easier for future groups to pick up where the project left off.

There are two main forms of feedback that were received during the website design and testing process. The first form of feedback was the effectiveness of the design, ensuring the website had a simple yet intuitive layout. The second form of feedback that was received was about the overall functionality of the website. It was also important to receive information about any bugs that appeared or any functions that did not run as intended, as well as how easily the children could interact with and understood the exercises. This feedback process involved surveying neuropsychologists, teachers, a librarian, and specialists, and interviewing the librarian. The main way of receiving feedback on the website's visual aspects and functionality was through surveying. A combination of free response and Likert scale questions were used in the survey, which provided feedback on how respondents felt about the website, as well as a chance for

them to give any feedback about aspects that may have not specifically asked about. Sending out surveys early on in the process was important not only for obtaining as many responses as possible, but the earlier the responses came in, the more time the group had to adapt the product. The process was a constant stream of communication toward the end of the project, and as a result, the website was able to be adapted to best fit the needs of cognitively disabled children. By incorporating feedback either into the website or into future recommendations for the website's expansion, the website was able to be improved and ideas on how it can improve were recorded for future use.

# Authorship Page

This project was the joint effort of Natalie Bennett, Ben English, H La Vallee, and Alex Simoneau. Each member provided contributions as listed below, and consensus from the entire group was achieved on every part of the project.

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# Chapter 1: Introduction

Every child, regardless of ability level, needs a proper education in order to incorporate into society and become a well-developed adult when they grow up. Education through early childhood is especially necessary for cognitively disabled children, who often require additional support and resources compared to typical children. Even though education is just as important for all children, the cognitively disabled face a lack of resources that they need to succeed, especially within the Russian educational system. In Russia, the lack of accessibility and equal opportunity in education is a more prominent issue that has only recently become a focus of Russian education policy and public attention, and is therefore a growing field with a great need for additional development (Iarskaia-Smirnova 2015). As the field develops, children in Russia with cognitive disabilities will become more able to integrate into society and find success in employment or higher education.

The SARS-CoV2 (COVID-19) pandemic has had a major impact on education systems worldwide, forcing schools around the globe to move education onto an online, remotely accessible format. Under this new educational environment, teachers and students alike are forced to adapt to new systems and methods to teach and learn. While many students are able to adapt quite well to the major shift in their learning environment, adapting is often more difficult for cognitively disabled students. Most remote platforms designed for typical students do not have sufficient accessibility features to meet the unique needs of the cognitively disabled. Under these systems, disabled students are often left with even less support than in a traditional classroom setting, furthering the divide in educational quality between typical and cognitively disabled children (More & Travers 2013). However, digital educational programs purpose-built for the cognitively disabled have seen great success on an international level. These programs utilize many accessibility techniques and tools that have been developed in order to provide equal opportunities for everyone to use technology, and are based on extensive research into which accommodation techniques and what design features are beneficial to incorporate in technology to address many different types of cognitive challenges (Falloon 2013). By using these programs alongside or replacing a typical remote education, cognitively disabled students are able to get far more support and a much higher-quality education.

While accessibility techniques and tools, research, and educational platforms targeted toward cognitively disabled children exist, they have not been applied widely throughout Russian education. As a result, there is a great need for more accessible remote education for these students. In order to address this need, techniques, tools, and research found in accessibility-focused platforms can be incorporated into the

existing remote education systems used throughout Russia. Implementing these ideas and features into remote education is especially valuable in present times, as numerous schools are providing education through an online format.

The goal of this project is to create a website framework for the future expansion of the Brave Little Dragon curriculum and to adapt the first few exercises from lesson one into the website platform that was created. We created a web platform with a framework that supports future expansion, and we adapted exercises from the curriculum to provide the same benefits as the in-person program. There are four main areas of development we focused on. The first is understanding the problem, which is mainly addressed in the background. It is important to understand the significance of our project to both our target audience as well as Russian society as a whole. Our second objective is to design an effective and visually appealing web app for the children. The front-end design is most important when it comes to capturing and maintaining the children's focus, as well as creating a positive and enjoyable learning environment. The third aspect is to have a solid back-end of the website. In the back-end, we have implemented the delivery of the exercises, tools to gather metrics on student performance, and security features to keep the students' information only accessible to the administrators. Our fourth and final goal is to justify our adaptation methods through continuous surveying and interviews, focusing on different aspects of the design and functionality of the website throughout the development process. We looked to get feedback from neuropsychologists, teachers, a librarian, and specialists to receive valuable and reliable feedback for the project.

Our project has potential to directly impact the lives of children with cognitive disabilities and their families, bringing them an educational and developmental experience that would not have been possible otherwise. The overall impact of our initial adaptation was created to allow for further implementation in setting the groundwork for further development and distribution. We hope that future IQP groups or other organizations can use our project as a model to adapt the rest of the *Brave Little Dragon* book. Our sponsor's immediate goal is to make the curriculum available virtually for all cognitively disabled (CD) students who need it in Russia. Once Russian children have access to the program, our sponsors at Noosfera aspire to translate the story and exercises so that CD students around the world can benefit from the *Brave Little Dragon* book and program.

# Chapter 2: Background

## 2.1 Preface

In order to understand the importance of this project, its implications on Russian society, and how best to determine methods, extensive background research was performed via the WPI library databases, discussions and recommendations from our sponsors, and other sources of academic literature. From this research, we found the following information to be critically important towards the goal of successfully creating an educational platform for the cognitively disabled in Russia.

## 2.2 Introduction

In order to receive a high-quality education, children must have access to similar opportunities and experiences while also receiving any necessary support to ensure their success. Any child, no matter the severity of their challenges, should be able to tackle everyday activities with their own approach. In Russia, there is a long-standing issue of children with disabilities being unable to join their peers in higher education, the workforce, or society in general. *Brave Little Dragon* is a textbook and curriculum developed by Noosfera, a Moscow-based charity educational support foundation. The *Brave Little Dragon* program was created to develop intellect, emotional intelligence, and motor skills for students with cognitive disabilities, aged 6-13 years. Delivering this education to students in Russia has recently been difficult due to the SARS-CoV2 (COVID-19) pandemic limiting students' ability to learn in-person. Our project is to develop a web platform to deliver the *Brave Little Dragon* curriculum to these students, and to use this platform to digitize exercises within the first lesson of the book into an engaging and educationally valuable format that can be taught to students remotely.

## 2.3 Disability and Russian Education Systems

Before beginning to tackle the problem of digitizing Noosfera's *Brave Little Dragon* curriculum, it is important to understand Russian educational norms and traditions, especially those relating to cognitively disabled (CD) students. In Russia, primary education occurs generally from the ages of 6 to 10 years old, while a general middle level education occurs from ages 10 to 15. These are the equivalents of American elementary and middle schools (Scholaro 2021). Staying true to the traditional mindset of the Russian education system will ensure that students are familiar with the methods used in teaching, and that they are prepared to re-enter the classroom environment once they no longer need to learn remotely. The Russian education system is distinct in its teachings based in tradition, routine, and rigor, putting children

on the spot to come up with answers to tough questions (Hans 2012). It is very much a community experience, emphasizing the importance of fitting in -- social disapproval is considered to be more effective than physical punishment by Russian parents (Sorokina 2018). However, as long as the child respects their elders and traditions, and follows instructions, they are given freedom to play and enjoy the innocent happiness of childhood (Gorman 2015).

However, when Russian children are not able to “fit in” and need additional assistance due to a disability, they are very often not given the same opportunities to succeed as non-disabled children (Iarskaia-Smirnova 2015). This inequality of opportunity was shown in a study by R. Iarskaia-Smirnova in 2015, where their team performed a series of in-depth interviews and surveys of parents, teachers, and students, and looked at employment and higher education enrollment data. They concluded that a lack of inclusivity in society is something that is being actively changed in modern times, but is rooted in Russia’s socialist past where ability to work was considered a metric of normalcy. In those times, disabled people were seen as outcasts, people who took from the system but did not provide anything to it (Iarskaia-Smirnova 2015). This approach led to insufficient support of disabled people, preventing their integration into society. Over time, support has increased greatly for disabled people in Russia. All children have the right to a free education under the Constitution of the Russian Federation (adopted in 1993), and in 2012 Russia ratified the United Nations Convention of the Rights of Persons with Disabilities, which further improved accessibility towards disabled people of all ages (Iarskaia-Smirnova 2015). Since Russia’s education reform of the early 2010s, there has been a push for more inclusive educational practices (where disabled and typical students learn in the same classroom), with supplementary material taught to disabled students extracurricularly. Before this reform, disabled students were educated mainly through segregated and often residential institutions for the disabled, with very little interaction with the outside world. Students in these schools, while often comfortable and open to learning, did not have the experience they needed to integrate with the greater society, and had very low expectations of success on them. A study performed by E. A. Khudorenko in 2011 determined that they were not encouraged to pursue higher education or get a more technical job, and therefore are rarely present in the Russian workforce -- as of 2011, only 15% of disabled working-age citizens were employed. However, 60% of disabled graduates of higher education institutions were employed at that time (Khudorenko 2011). The stark difference shows the importance of higher education on the integration of disabled people into society. Early education, then, must be structured to prepare students for higher education or employment, and so it is important to determine what the best way is to prepare students for a future of integration and accomplishment.

Khudorenko’s 2011 study also shows that inclusive education is beneficial for disabled students and for society as a whole, and inclusivity should be seen as a goal

for the Russian education system. Years ago, inclusive education was an issue, but not one that was dealt with appropriately. As time has passed, Russian culture has started dialogues about inclusive education and are actively working to implement it into their schools (Personal communications, Tamara Arzumanyan, February 18, 2021). Working towards the goal of more acceptance and inclusion in a Russian child's education are groups such as Noosfera, that have created curricula that can be used to supplement a child's in-class learning. Noosfera is a charity education support foundation that educates the youth in the spirit of tolerance. They were founded in 2003 by Elena Baturina, and the work of the organization focuses on designing and organizing educational projects and events for children. They have a variety of projects that reflect the goal of educating children in tolerance, and they cover topics such as science, business, history, fine arts, religion, astronomy, foreign language, and more. Each year, Noosfera delivers over seventy educational projects across Russia and worldwide (ABOUT NOOSFERA 2013).

## 2.4 Brave Little Dragon Program

In 2017, Noosfera created *Brave Little Dragon*, a curriculum that educates Russian cognitively disabled primary school students (ages 6-13) through stories, artwork, and songs, and specifically tailors to the needs of these students (Brave Little Dragon 2018). By creating *Brave Little Dragon* and a corresponding program at Noosfera's center that teaches it to students, Noosfera is working to improve the lives of children with cognitive disabilities, further addressing the issue of a lack of education and integration into society that this demographic faces. *Brave Little Dragon* is structured as a fairy tale with a storyline, making it enjoyable to young students. The disabilities that the textbook was developed for include autism spectrum disorder, attention deficit disorder, mental retardation, and Down syndrome, along with many other disorders. These disabilities are types of cognitive disorders (CDs), which are conditions that begin at birth or an early age and hinder or delay normal development (Cognitive disability 2011). For example, autism spectrum disorder (ASD) is a CD because those affected typically have challenges developing social skills, repetitive behaviors, and speech and nonverbal communication (What is autism 2021). People with attention deficit disorder (ADD) typically have difficulty following and listening to instructions, focusing on tasks or assignments, keeping up with assignments, and completing tasks, assignments, and social interactions (Logsdon 2020). Those affected by mental retardation often face limitations in their communication and social skills, self-care, self-direction, and intellectual ability (Emory University 2019). Down syndrome is a condition that results from an error in cell division, causing an extra twenty-first chromosome. People with Down syndrome face limitations in their cognitive abilities and physical growth, and may also experience developmental delays (MediLexicon International 2017).

In order to educate children with these disabilities, the *Brave Little Dragon* textbook contains 300 exercises that work to develop ten important functions of the growing brain (see Figure 1). As a result, the student's academic performance is improved. Sofia Arzumanyan, the director of Noosfera, reported a 100% success rate in improving the child's cognitive abilities after working through the curriculum. The exercises within the book are presented and taught by a neuropsychologist, teacher psychologists, speech therapist, or a parent outside of normal classes. While delivering the exercises from the textbook, the provider monitors factors like the student's reaction time and quality of their work to assess their development (Personal communications, Tamara Arzumanyan, February 18, 2021).



**Figure 1: Types of Exercises in Brave Little Dragon.** There are ten different types of exercises in each chapter of the book that each work to develop a different function of the brain (Brave Little Dragon 2017).

Each exercise in *Brave Little Dragon* focuses on a variety of cognitive skills and brain functions (see Figure 1). For example, exercise one from the first chapter of the book works to develop the auditory attention function of the brain by having the student listen to a section of *Brave Little Dragon's* storyline and answer questions about that story. Exercise three works to develop visual, auditory, and speech memory, as seen in Figure 2. In the exercise, the students look at food that the dragon's mother brought to him, they describe the food to him, and they then have to remember the food by helping him find it in his refrigerator on the next page of the textbook (see Figure 2).





### Exercise 3.

Mother invited the Draggy to eat. Look at what she has treated the Draggy to. He does not know anything about these products yet. Describe them for the Draggy: what is their shape and size, what do they taste like and what do they feel like? Remember them.



The Draggy liked the food so much that he asked for more.  
Turn the page and help the Draggy to find the same products on shelves of the refrigerator.

**Figure 2: Exercise 3 from the first chapter of *Brave Little Dragon*.** This exercise works to develop the students' visual, auditory, and speech memory skills by having them look at, describe, and find the food in the image (Brave Little Dragon 2017).

As a result of the recent novel coronavirus SARS-CoV2 (COVID-19) pandemic, schools around the world have had to adapt to remote learning strategies. Schools in Moscow, Russia were forced to close in March 2020 (reopening in January 2021), and many schools in smaller or more rural regions remain closed as of the time of writing (Coronavirus in Russia 2021). Working to bring aspects of a traditional education into a remote learning platform will help these students readjust when they continue their academic career and return to the classroom. However, curricula such as Noosfera's *Brave Little Dragon* cannot be adapted as easily due to their focus on one-on-one teaching and monitoring of many different factors. The issue of accessibility in digitization is not one unique to *Brave Little Dragon*, but is a larger problem that encompasses all digital learning material, many with their own sets of challenges. Due to these difficulties, there are not as many remote platforms available for CD students as there are for typical students (More & Travers 2013). The development of a virtual

learning environment for this curriculum will be beneficial because it will allow the students to learn from home while getting the extra support and monitoring they need in a virtual setting. By tackling these challenges, CD students in remote Russian areas and beyond can have access to high-quality educational material specifically tailored to their needs.

In adapting *Brave Little Dragon* into a web app, every student's needs must be addressed and met in order to promote learning. Therefore, general and adaptable accessibility is vital to the website. There are multiple well-documented strategies that can be applied to platforms that provide widespread accessibility to CD students (Chmiliar 2017). These strategies have influenced all decisions regarding the *Brave Little Dragon* website's presentation. Adapting a curriculum designed for CD students requires additional considerations for accessibility and assessment strategies. General accessibility features such as valid HTML tags are guidelines intended to allow for broader use of technology. Screen readers will use the formatting of web content to differentiate between sections and emulate natural speech patterns. Further features like dyslexic-friendly fonts and image 'alternate-texts' give students a chance to better perceive the material they are being taught. Assessment for CD students on remote learning platforms needs to mimic the assessment they're used to. By keeping accessibility and strategies such as these in mind, a platform can easily meet the student's needs.

Over recent years, there have been several studies on CD-focused online learning platforms and what techniques make them most effective. Understanding accessibility techniques and strategies used to meet the needs of CD individuals is essential to understand while digitizing the *Brave Little Dragon* curriculum. One of these studies, performed by Falloon in 2013, determined that app design and content should focus on communicating objectives, instructions, and lessons in ways that are understandable and accessible to the students. It also argued that apps should incorporate positive and corrective feedback, provide a distraction-free way for students to complete goals, have a balance of lessons and interactions or games, and incorporate interaction parameters that meet the students' needs (Falloon 2013). A different study, performed by Fernández-López, discusses an app called Picaa that is targeted toward CD students. This study includes information on how the developers of Picaa adapted the app toward specific impairments. These adaptations have proven beneficial to the target audience of users with visual, hearing, mobility, and cognitive impairments. While the visual and hearing adaptations are of great importance to Picaa, they are not significantly relevant to the target audience of *Brave Little Dragon*. However, mobility and cognitive adaptations are relevant, as individuals with autism and Down syndrome face challenges in these issues. The adaptations for mobility within Picaa include adapted input and output devices, an alternative selection of components, adjusted time for scrolling and user selection, and adjusted time for the overall use of

the application (Fernández-López 2013). The cognitive adaptations within the app include developing a simple interface without distracting elements and prioritizing the use of graphics (Fernández-López 2013). By considering these strategies used to meet the needs of the target audience in the digitization of *Brave Little Dragon*, the platform was created to cater to students with a diverse range of needs.

## 2.5 Strategies for Adaptations

While accessibility strategies are vital to implement in an accessible platform, these strategies need to be optional due to the variety of challenges that each student faces as a result of their age and disability. For example, a kindergarten (age 6) child with visual processing challenges may need significant support in the form of audio narration, descriptions of objects, and less overstimulating visuals. They require much more accommodation than a 10-year-old student in their fifth year of studies with attention deficit disorder, who may need more stimulating visuals but would be much more independent and would understand common user interaction (UI) elements like an on-screen back button. The psychologist and parent could work together before the start of the curriculum to determine how to configure the website so it is optimally and uniquely teaches their child. Due to this wide range of ability and needed support, it is important that a website designed for this group has a large amount of customizability and optional elements to cater to the needs of each individual student. In developing our solution, we researched many of the most effective techniques and options for the age and ability range seen by the students in Noosfera's program. Together with Noosfera, we determined which exercises would benefit most from which technique and how to best implement them into the website.

## Chapter 3: Methodology

In order to complete the *Brave Little Dragon* project, we determined the most effective methods for meeting our project goal. To accomplish the goals of the *Brave Little Dragon* project, we divided the goals into smaller objectives, and then found methods to meet those objectives and determined their effectiveness. By using this process, we were able to develop methods for all parts of the development process.

### 3.1 Project Goal

The goal of this project is to create a website framework for the future expansion of the *Brave Little Dragon* curriculum and to adapt exercises from lesson 1 of the curriculum into the website platform that was created. This objective involves adapting and digitizing the first chapter of *Brave Little Dragon* into a digital format that can provide the same benefits as the physical book to children ages 6-13 with cognitive disabilities. In order to adapt the curriculum onto a digital format, we aimed to determine the most effective approaches to teach these students through a remote platform. This objective can be broken down into major sections of focus for the development process:

1. understanding the problem,
2. development of the front-end,
3. development of the back-end, and
4. testing and gathering feedback on the design.

### 3.2 Understanding the Problem

The first stage in our development process is understanding the criteria of the website. Through significant background literature research and weekly meetings with our sponsors at Noosfera Educational Support Foundation, Moscow before and throughout the design process, we learned the significance of our project and how it aims to benefit society, the sponsor's expectations and requirements for the finished product, and their plans for the product beyond the scope of our project. These weekly sponsor meetings had the additional benefit of ensuring their views continuously aligned with our work. To assess the effectiveness of this stage of development, we held weekly video discussions throughout April and May with our sponsors, where we discussed the status of the project and our plans for the near future (see Appendix C for dates and summaries of these nine meetings). We also kept up regular email communication with any questions or concerns regarding their goals for the project's development.

## 3.3 Front-end Development

To the end users, the most prominent part of the experience is the front-end. The front-end includes everything that the students, parents, teachers, and assessors can see, and its effective implementation is important to the success of the project. This section is broken up into two major objectives: the layout of the website on a macro level, including navigation, page layout, and aesthetic; and the adaptations and techniques used to present information to the students, collect and assess their response, and keep them engaged in the lessons so they do not become disinterested or frustrated. Achieving these goals involved creating a user interface that is intuitive for all users, accommodates each individual student's needs, and effectively captures the educational value of the *Brave Little Dragon* curriculum into a web app that students can use to gain the same benefits as the physical, in-person system.

### 3.3.1 Website Design and Layout

The first major objective in this section is designing an intuitive high-level structure and flow to the web app. It is very important that users do not get lost when trying to navigate the systems of the website, or unexpectedly navigate to another page and lose progress due to misunderstanding how to move through the website. Therefore, research into the design of a simple web app, and especially how children interact with technology, was a crucial method to creating a valuable and effective final product. This was done via the WPI library database and other peer-reviewed literature sources. Additionally, scheduled interviews and questionnaires with neuropsychologists, teachers, a librarian, and specialists were used to gauge the effectiveness of our solution, as this audience was either familiar with the curriculum, had experience teaching cognitively disabled children, or will be using the web app. See *Feedback and Effectiveness Assessment* below for more information on how we gathered this information.

### 3.3.2 Adaptations and Accessibility Techniques Incorporated into the Website

The second objective in this section is creating a system that can effectively deliver the *Brave Little Dragon* program to the students. Because of the vast nature of this objective, smaller goals within it were created and are discussed as categories in the following paragraphs. Through online research and discussions with Noosfera, we gathered information on how we can produce a web app that can meet this objective for every student and adapt to their individual needs. Once we determined we had gathered sufficient information on the techniques needed to develop the website, we began researching specific software packages or programming techniques to implement them into our product. This process involved more online research as above.

Through our extensive research into specific adaptation techniques, we compiled a list of features that we verified with our sponsors and implemented into the website. An in-depth description of each of these features and how we assessed their effectiveness is given in Appendix A. There are three major categories that these features fall into based on how the student interacts with the feature. These three categories are based on presenting information to the student, recording their response, and providing the student with feedback on their performance, respectively.

Communicating instructions and information from the *Brave Little Dragon* book in a manner that CD students will understand on the website is another goal of this project. This objective's success was measured by determining if the students understand the instructions, understand the information portrayed, and remain attentive and engaged with the website. To achieve this goal, numerous features that provide accessibility and comfort in the use of the website were implemented. These features include narration to allow the students to understand instructions and information portrayed, image descriptions that allow the students to understand the images from the curriculum, and attention-retention features that keep the students engaged with the website.

A smaller goal of ours within the larger objective of creating a system that can effectively deliver the *Brave Little Dragon* program to the target audience was to construct the website in a manner that considers the wide range of different skills challenged by the exercises. To accomplish this goal, a wide variety of different input methods were incorporated into the website to best suit each question. We incorporated features into the website that provide a wide variety of input methods for the students' answers to the exercise questions, including clicking on the answer, clicking on the correct image, and selecting the correct multiple-choice answer.

Another goal of ours is providing reinforcement for answers that students provide for the exercises. Positive reinforcement features incorporated into the website provide feedback for answers (correct and incorrect) to motivate the student with pop-up cards, small sounds that make inputs feel more tactile and satisfying, and hints to provide aid when the student is struggling.

After we determined which methods are most valuable and implemented them, we created a system through which the website can be tailored for each student's needs. Creating this system was accomplished by including layers of options within the website that can be attached to each student's account (as described in *Chapter 3.3: Back-End Development* below) and can be assigned to a student by a Noosfera teacher or psychologist prior to the beginning of the course.

### 3.3.3 Front-end Software and Tools

The front-end was primarily developed using React, a framework built to provide interactivity and responsiveness to a web page. Through the use of a virtual document object model (known as a virtual DOM), it can interface between the webpage and the

underlying code to create a responsive website. This allows for interactive elements like buttons, as well as locale/translation support. React is part of the Next.js ecosystem, which is described in more detail in section 3.4. Additionally, a library of standard styles called Bootstrap was implemented to speed up development. It includes common elements like buttons, pop-up cards, and grid layouts that can easily be added to the web page, and a simple way to modify those elements to fit the design of the web page. React and Bootstrap ultimately create HTML, CSS, and JavaScript, which are languages that are read by the web browser to render the web content to the users.

### 3.3.4 Student Metrics Tracking

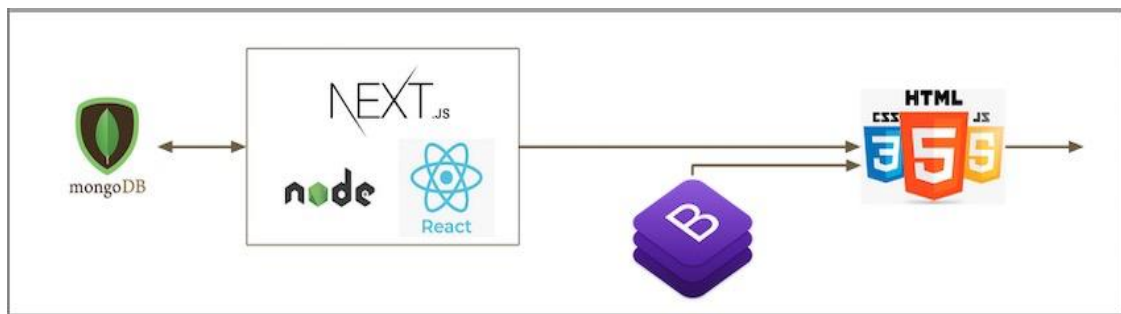
In order for Noosfera to track students' progress, it was essential to ensure that useful assessment metrics on each student's performance are sent to Noosfera, their teachers, and psychologists. To accomplish this task, the information sent from the web app to Noosfera was discussed with our sponsors, who determined if it was sufficient and effective in measuring the progress of the students as they complete the *Brave Little Dragon* curriculum. To allow this information to be easily accessed by Noosfera, an effective and intuitive system for the assessors to access the student's data was incorporated into the website. Providing assessment metrics to Noosfera and their teachers or psychologists was accomplished by creating a separate entry point in the website for assessors through an assessor login. The separate entry point leads to a display of the database of student responses, and the assessors are able to navigate through to see how each student responded to each question. In order to provide Noosfera with information that is valuable in assessing the students' progress, collecting the correct data is key. To have the website collect data that is beneficial to Noosfera, the team discovered what specific statistics Noosfera uses to evaluate the students' progress, which include timing and accuracy testing. These parameters will be incorporated into the website through specific features that track time and incorrect attempts at a question.

## 3.4 Back-End Development

Equally important as the front-end, although not as visible to the end user, is the back-end. A website back-end includes web frameworks, development platforms, and libraries that make up the inner workings of the site. To develop an online adaption of *Brave Little Dragon* curriculum, our web app backend was needed. The goal of this objective was to create a stable and extensible platform to build out curriculum infrastructure. This framework is designed to support further localizations of the *Brave Little Dragon* book and more exercises, as Noosfera aims to use the website to adapt each exercise in the book onto a remote format in the future. The framework facilitates

the delivery of book materials and lessons to students, as well as the delivery of responses and metrics data to psychologists at Noosfera.

The content delivery system is the first major challenge of this web application. We chose Next.js for our web framework, as it allows us to use a multitude of techniques to render content dynamically and efficiently for end users. Next.js is bundled with Node, a server framework; and React, which handles animations, styling, interactive elements, and translation. These three components make up the “core” of our website. This core interfaces with a database (we used mongoDB) to save user data and account information. Figure 3 is a visual representation of how the aspects of back-end development relate to each other.



**Figure 3: Diagram of the frameworks and tools used for the website.** This figure shows a diagram of the frameworks and tools used for the website. The core of the site (framed in a box) is the Next.js ecosystem, which interfaces with mongoDB, the database. The core produces HTML, CSS, and JavaScript, used to render the website in the user’s browser. Additional CSS styling is provided by Bootstrap, a CSS library of common elements.

Besides content delivery, the backend will also be responsible for user accounts, tracking metrics, and progress on a per-student basis. The nature of this application necessitated logins for standard user accounts for CD students and their parents, as well as Noosfera neuropsychologist. The data of children with cognitive disabilities is incredibly sensitive and should be protected with appropriate cybersecurity techniques. The use of this framework ensures a strict standard of security in the application.

For statistics tracking, our users do not notice what is collected. Through further discussions with Noosfera, we learned the exact data to collect. This data and tracking involves information such as how long it takes a student to complete a task, how many times they attempted a question, and their answers to the exercise questions. A simple lesson dashboard is visible on a student account, while in-depth statistics are shown to just the psychologist.



### 3.5 Development Cycle

To accomplish these objectives, we followed a modified version of the popular Agile development cycle used commonly for software development and adopted it as our method to complete our project goals within a timely manner. This method involves weekly cycles with three phases. The first phase involves studying existing literature and apps that were developed for a similar audience, and/or evaluating user feedback from the week before. The next stage is where we add the feature's functionality to the web app. The final stage collects feedback from relevant experts or people who are close to the target audience. This feedback determines if the objectives are effective in reaching their goals, whether the week's progress was beneficial to the goals of the project, and what changes could be made to improve it further. The feedback was received through the methods described in the functional effectiveness tests below, including an interview with a librarian and survey responses from the librarian, neuropsychologists, teachers, and specialists.

### 3.6 Feedback and Effectiveness Assessment

The main form of feedback received during the design and testing process was about the effectiveness of the design. Our initial prototype included the general layout and visual aspects of the website, and by showing this prototype to our sponsors, interviewing a librarian, and sending surveys to neuropsychologists, teachers, a librarian, and specialists, we could get feedback on the aesthetics and flow of the website. The goal of receiving this feedback was to help us reconfigure our design as we moved towards making the website.

In order to get feedback quickly from the end users and from our sponsors, we utilized prototyping software to be able to quickly generate a semi-functional version of our web app. This prototype showed the overall look and feel, the navigational structure, interactive elements of the app, and included adaptations of all ten exercises from the first lesson of the curriculum. We used Adobe XD as our prototyping software. While this prototype was not fully-functional, it was created to be modified quickly in response to sponsor or user feedback, and is therefore valuable in determining an aesthetic design and navigational system that suits the expectations of the sponsors, and is clear and usable for the end users and the target audience.

The librarian, neuropsychologists, teachers, and specialists who provided feedback received a prototype, and were asked through a survey to rate both the ease of use and the clarity of the website. They were also asked to describe any difficulties that the students had with navigating the website and completing tasks. In addition, they were asked how useful the data received was to assess the student's performance. The survey included questions such as "Does the app look interesting and appropriate to the target audience?", "Is the navigation easy to follow?", "Do the children understand the

exercises in the website as well as they do from the book?”, “Do the children understand how to answer the questions?”, and “What other data, if any, would be valuable to collect to measure student progress?”. The full list of survey and interview questions is in Appendix B. An interview was conducted with a librarian who used to work with the *Brave Little Dragon* program. We asked the same questions as the survey, but we opted for the interview to receive more detailed and concrete feedback.

# Chapter 4: Results

The main goal of this project is to create a website framework for the future expansion of the Brave Little Dragon curriculum and to adapt exercises from lesson 1 into the website platform that was created. The following results sections provide information used to create the *Brave Little Dragon* adaptation.

## 4.1 Understanding the Problem

Through significant background literature research and meeting with our sponsors from Noosfera Educational Support Foundation, our team was able to achieve the following:

1. Gain a deep understanding of the significance of our project to Russian society.
2. Learn and understand Noosfera's expectations and requirements for the finished website adaptation of *Brave Little Dragon*.
3. Understand Noosfera's plans for the website beyond the scope of our project.

### 4.1.1 Results from Gaining an Understanding of the Significance of *Brave Little Dragon* Project

Through weekly sponsor meetings and literature research (explained in chapter 3.2), a deep understanding of the significance of our project to Russian society was gained. The results from the research and meetings conveyed similar information, specifically revealing that there is a lack in providing inclusivity, accessibility, and equal opportunities in education for cognitively disabled (CD) children both in Russia and worldwide (More background information is found in chapter 2.3 and 2.4). As a direct result of this lack of inclusivity, accessibility, and equal opportunity, it was also discovered that there are less remote educational curriculum programs available for CD children than there are for typical children (More & Travers 2013). The *Brave Little Dragon* project directly addresses both of these issues by providing an educational curriculum for CD children in a remote platform and has potential to positively impact numerous lives as a result.

### 4.1.2 Results from Learning About Noosfera's Expectations and Requirements for the Project

Through frequent communication with our sponsors at Noosfera Educational Support Foundation, we were able to understand their expectations and requirements for our website. As a result of these communications, the following list of expectations and requirements that our sponsors had for us was created by our team.

1. Adapt exercises in the first lesson of *Brave Little Dragon* onto a website format in a manner that is very similar to the book and works to improve the CD student's cognitive abilities.
2. Ensure that the website framework allows the website to be expanded upon in the future by Noosfera or another developer.
3. Ensure that the website incorporates numerous accessibility techniques and features for CD students that can be tailored to each student's individual needs.
4. Maintain the theme and aesthetics of the original *Brave Little Dragon* textbook on the website format.
5. Provide the final website in the Russian language.
6. Format the website in a manner that is easy for CD children to understand and navigate.
7. Incorporate assessment metrics into the website to ensure that useful data on the student's progress is sent to Noosfera.

#### 4.1.3 Understanding Noosfera's Future Plans for the *Brave Little Dragon* Website

Through frequent communications with Noosfera, our team was able to learn about their future plans for the *Brave Little Dragon* website. We learned that they plan to use our website to adapt all thirty lessons from *Brave Little Dragon* onto an online format. We also learned that they plan to spread the *Brave Little Dragon* program throughout the world, so they needed the website to support translations of the original book into other languages. These future plans facilitated a need for a web-based adaptation of the physical book.

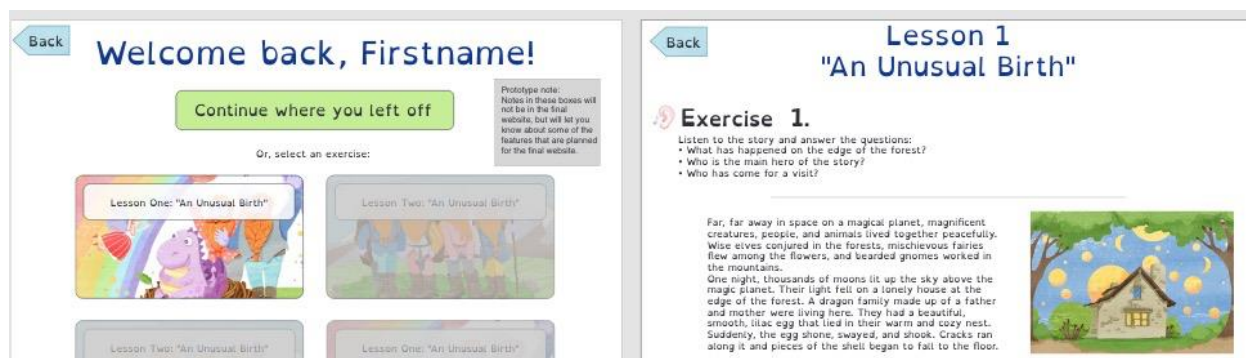
## 4.2 Results Leading to Front-End Development

Utilizing the methods outlined in Chapter 3.3, our team developed the front-end portion of the website. The front-end development included the creation of the website design, aesthetics, and layout, as well as adaptations and accessibility techniques.

### 4.2.1 Website Aesthetics and Layout

As a result of doing significant background and literature research as well as communicating with our sponsors, our team was able to understand how to best design the front-end portion of the website so that it serves the needs of our target audience. We learned that a simple yet colorful front-end with easy navigation and a lack of distracting or overwhelming elements is best for our audience. From this understanding, we were able to determine which design features would be best to incorporate into our website. We created a front-end that is easy to navigate, and we included menu buttons, continue buttons, and back buttons within each page of the website to prevent

the students from getting lost in the website. A prototype of the front-end was made using Adobe XD, which included simple navigation buttons and displayed the theme, colors, and aesthetics of the website (as seen in Figure 4). We also sent out surveys regarding the clarity, comfort, and ease of flow of the website. This information is discussed in *4.4 Feedback and Effectiveness Assessment*.




**Figure 4: Navigation within Brave Little Dragon Prototype.** Within the front-end prototype of the Brave Little Dragon website, our team incorporated the aesthetics of the Brave Little Dragon book and included navigation features. These features include buttons such as “back” or “continue where you left off”.

#### 4.2.2 Adaptations and Accessibility Techniques Incorporated into the Website


Through research and communication with our sponsor (explained in chapter 3.2), our team was able to discover and implement appropriate adaptations and accessibility techniques in the website to fit each CD student’s needs. These adaptations and accessibility techniques involved features that were incorporated into the website, all of which accomplish the goal of either presenting information to the student, recording their response, or providing the student with feedback on their performance. To allow our target audience to understand information and instructions from the exercises in *Brave Little Dragon*, narration, image descriptions, and attention-retention features were implemented into the website. For example, if a student has trouble reading and understanding text, narration is an option for the students to listen to when any instructions are given or when they are expected to read a story. For students who have sight problems or difficulties interpreting images, our team included image descriptions for every image in the online exercises. To hold the students’ attention, we made a simple user interface while also including fun illustrations with bright colors. In case some students in the target audience have dyslexia and would benefit from a dyslexic-friendly font, our team also incorporated this font into the website.

To provide multiple methods in the website for the students to easily and comfortably answer exercise questions, we included clicking on the answer or the

correct image, selecting the correct multiple choice answer, and text input as ways for the students to record their responses. An example of a multiple-choice method of answering exercise questions is shown below in Figure 5.

 **What has happened on the edge of the forest?**

- Draggy's parents gave the gnomes new gifts.
- Little Draggy hatched from his egg.
- The leader fairy had a smooth, pink egg.
- Draggy visited his neighbors and knocked on their doors.

 **Who is the main hero of the story?**

- Draggy's Parents
- The gnomes
- The leader fairy
- Newly-hatched Draggy

**Figure 5: Multiple choice questions from Exercise 1.** Throughout Lesson 1, there are numerous methods used to allow students to answer exercise questions. In exercise 1, there are multiple choice questions that easily assess the student's understanding of the story.

To motivate the students and to keep their focus maintained on the *Brave Little Dragon* curriculum, the method of implementing feedback and reinforcement strategies into the website was completed. These feedback and reinforcement methods included positive reinforcement for correct and incorrect answers, as well as hints to motivate students when they got stuck. An example of a positive reinforcement feature implemented in the website prototype is shown below in Figure 6. The effectiveness of every feature was further determined through surveys and is discussed in *4.4 Feedback and Effectiveness* in further detail.

Back

## Exercise 6.

In the meadow in front of the house, Draggy saw little gnomes. It turns out that the gnomes adore dancing. Stand up and get ready to move!

b) Another gnome in front of the house is dancing on one foot, and put your hands on the ground. Click the correct gnome.

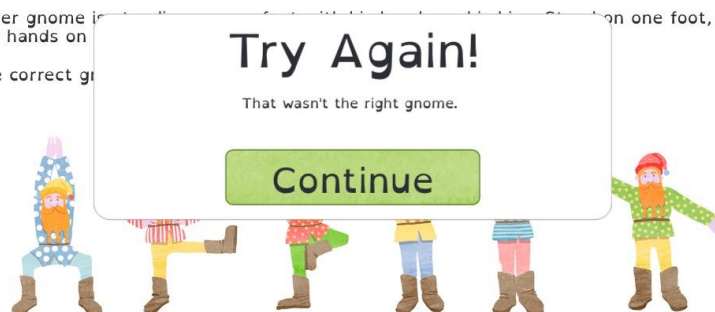


Back

## Exercise 6.

In the meadow in front of the house, Draggy saw little gnomes. It turns out that the gnomes adore dancing. Stand up and get ready to move!

b) Another gnome in front of the house is dancing on one foot, and put your hands on the ground. Click the correct gnome.



**Figure 6: Positive Reinforcement in Exercise 6.** In the exercise 6 prototype, positive reinforcement is used to motivate students and provide feedback. This reinforcement includes pop-up windows on the website that state “That’s correct! Good job! You found the right gnome!” in the case of a correct answer, or “Try again! That wasn’t the right gnome.” in the case of an incorrect answer.

### 4.2.3 Student Metrics Tracking

Access to student metrics were provided to Noosfera, their teachers, and psychologists by creating a separate entry point in the website for assessors through an assessor login. These types of data and metrics include the time it takes for a student to complete an exercise, the number of attempts on an exercise, and the incorrect answers, if any, that the student submitted on an exercise. The website front-end of the assessor page is shown in Figure 7 below.



**Figure 7: Student metrics tracking.** This figure shows a website page that displays the assessor view of the website. The assessor can view student data and performance in the website.

#### 4.2.4 Agile Development Cycle

By following the Agile development cycle, the project work was structured through weekly cycles with three phases. These three phases are shown below.

1. The first phase involved researching and studying existing literature and apps that were developed for a similar audience, and/or evaluating user feedback from the week before.
2. The second stage was where we added the feature's functionality to the web app.
3. The third stage involved the collection of feedback from relevant experts or people who are close to the target audience.

Through following these phases, the methods in chapter 3.3 were conducted and achieved the desired result. This result is the creation of a website adaptation of *Brave Little Dragon* that fits our target audience.



## 4.3 Back-End Development

As a result of developing the back-end of the website, a stable and extensible platform to build out curriculum infrastructure was created. By completing this task, a successful online adaptation of the *Brave Little Dragon* book was made. By using Next.js for the website framework and React to handle animations, styling, interactive elements, and the translation framework, the website was able to deliver the content adapted from the *Brave Little Dragon* book. The back-end was also successful in storing student and teacher/assessor accounts, tracking metrics, and student progress, as well as keeping the data from the users secure. The effectiveness of the website's back-end was evaluated through surveying our sponsors, teachers, a librarian, and neuropsychologists, and it is discussed in further detail in *4.4 Feedback and Effectiveness Assessment*.

## 4.4 Feedback and Effectiveness Assessment

To achieve an understanding of how effective our product was, we created a survey that was sent out to neuropsychologists, teachers, and specialists here in the United States. This survey was a google form with questions in both Likert scale and open response formats. The survey mainly asked questions about the visual aspects of the design and the effectiveness of our product towards the target audience. The feedback from the survey is reported in section 4.4.1. We also conducted an interview with a librarian who uses the *Brave Little Dragon* story for her library's story time to receive feedback about the prototype and website's effectiveness. The feedback from the interview is also discussed in section 4.4.1

### 4.4.1 Website Design and Layout: Survey and Interview Results

Within the survey, our team included a functional prototype of our website so that neuropsychologists, teachers, and specialists could evaluate the prototype's aesthetics, ease of use, giving of information, how students input answers, feedback and reinforcement, and the overall effectiveness of the exercises. Three complete survey results were obtained, and the qualitative results for each of these categories are shown below.

**Aesthetics** - The feedback on the aesthetics of the prototype was overall very positive. The responses to our survey indicated our strongest aspect was the overall visual appeal, while the one part that received more neutral responses was the aspect of retaining student attention. The visual appeal to a child and professionalism of the website were also rated highly. The only suggestion made for aesthetics was the idea of adding animations into the prototype to hold the children's attention.

**Ease of Use** - The ease of use received unanimous positive reviews. The intuitiveness received all "strongly agree" votes on the Likert scale question. One comment stated that the user loved the "continue where you left off" button.

**Giving Information** - Survey participants agreed with the text being easy to read, while the potential student's ability to understand exercise instructions were split between two positive reviews and one negative review. Answers to follow-up questions suggested either splitting up the story into multiple pages or condensing an exercise for easier understanding.

**Student Input** - The consensus of the responses related to the student input were positive. Multiple suggestions involved simplifying exercise 2 of the chapter, with responses focused on simplifying the exercise or making the instructions clearer.

**Feedback and Reinforcement** - Survey respondents disagreed with the statement "students would easily lose interest in the app", and agreed with the positive reinforcement aspect, leaving positive reviews for the encouragement aspects we implemented. One responder mentioned the pop-up style works well. There were varied responses about the students potentially being frustrated when they answer incorrectly. Some agreed that the students might become frustrated when getting an answer wrong, while some thought the students would be fine. One responder suggested more animations as well as adding a "hint and retry" button to help keep the children from getting stuck.

**Effectiveness of Exercises** – Overall, the survey respondents thought the exercises in the prototype would be as effective as the exercises in the book. One survey response indicated that the reading comprehension questions were especially impressive, effectively targeting the skills needed.

Through interviewing the librarian, detailed feedback about the prototype aesthetics, ease of use, manner of giving information, and reinforcement was provided. Feedback about the website style and functionality was also obtained. These results are shown below.

**Aesthetics** - The librarian thought that the design of the prototype was visually appealing. She also commented that it would catch the attention of a child, and that the simplicity of the design is especially important given the target audience.

**Ease of Use** - The librarian thought that the prototype was easy to navigate. She accessed it both on a PC and an iPad, and both devices worked well with the prototype.

**Giving Information** - The librarian thought that the information and instructions provided in the prototype were clear and that children would understand them. She also commented that the text was easy to read and that the font fit well with the story.

**Feedback and Reinforcement** - The librarian commented that the encouragement provided through the feedback and reinforcement pop-ups is a great feature to include, especially because the target audience is children.

**Style and Functionality of Website** - After showing the librarian the website, she commented that it looks appealing, and that the simplicity of the front-facing portion of the website will keep the children engaged. She also commented that the website fits the theme of the original book and that the website felt very familiar because of her experience reading the original book.

# Chapter 5: Discussion and Recommendations

This chapter discusses and provides recommendations for the adaptation of the *Brave Little Dragon* curriculum. The methods and results of understanding the problem, developing the website front-end, developing the website back-end, and feedback and effectiveness were critical to the project. These methods and results are discussed, and recommendations are also given. This section is organized similar to the previous chapters, starting with understanding the problem, then moving proceeding to the front end and back-end development, and finishing with the feedback and effectiveness assessment.

## 5.1 Understanding the Problem

### Discussion

To understand the problem that our project addresses, our team grasped a deep understanding of the significance of our project, our sponsor's expectations for our project, and their future plans for our project. The significance of these topics on our project, our sponsor, and on our target audience is discussed below.

Our project has potential to directly help the lives of children with cognitive disabilities and their families by providing them with an easy-to-access education supplement that accommodates their needs. One goal of Noosfera's is to make their *Brave Little Dragon* program more accessible than it is now. Currently, students must attend the program at Noosfera's center in Moscow. However, there are families who are unable to send their children to Noosfera's center for many different reasons. By providing the *Brave Little Dragon* curriculum to children remotely, this project is going to hopefully help families by providing them with an opportunity to improve their children's cognitive abilities and change their lives.

Our weekly sponsor meetings and consistent correspondence via email were an important part of our understanding of the problem we were tasked to solve. The goal of these communications was to ensure that our approach to every human-facing part of the web app agreed with our sponsor's expectations of our project. By meeting their expectations, our team was able to deliver a product to them that they are proud of and can use to change the lives of numerous cognitively disabled children.

Noosfera plans to expand upon the *Brave Little Dragon* website and use it in other nations, so our team created a framework that can be expanded upon to be accessible to people not only in Russia, but throughout the world. The setup of the website code allows for easy translation of exercises, making the website have potential to be accessible to anyone with a computer or tablet and connection to the internet. Through this accessibility, our team is confident that the website will change lives worldwide in the future.

## Recommendations to understand the problem more thoroughly

- Always keep the target audience in mind
- Make project so that it can easily be built upon
- Communication is key, so establish a constant stream of communication with all parties involved

## 5.2 Front-End

The front-end of the website includes website design, aesthetics, layout, adaptations, and accessibility techniques. The effectiveness and impacts of these features are discussed below.

### Discussion on the front-end design of the website

Overall, the front-end design was effective because we used the same images and a similar format as the *Brave Little Dragon* book, along with incorporating accessibility techniques. Noosfera reports a 100% success rate in *Brave Little Dragon's* ability to increase children's cognitive abilities, so we wanted to model our front-end design exactly after the book and include adaptations and accessibility techniques so that it has the same success rate.

Every student is different and faces a diverse set of challenges, so needs vary greatly within our target audience. By incorporating adaptations and accessibility techniques such as narration, image description, attention-retention techniques, dyslexic-friendly fonts, multiple methods of answer input within the exercise questions, and reinforcement to motivate the students, our team was able to make the website accommodate a wide variety of student needs. Our team discussed all of these features at length with Noosfera, who confirmed that these techniques provide accessibility and comfort for each student, as each technique addresses challenges faced by our target audience. We built in an assessor side to the website so a neuropsychologist or teacher can set the accessibility settings for each student. This way, a student does not need to configure the app for themselves. When the students open the app for the first time, they will be met with an optimal learning environment for them personally. If these settings need to be configured after the beginning of the course, the child's teacher or psychologist can do so easily via their administrator account, or the student can toggle simple accessibility features on or off if needed.

The student's ability to answer the questions given in the exercises is vital to their success in the *Brave Little Dragon* curriculum. The questions within the curriculum cover a wide range of topics and were intentionally crafted to require many different response methods in the printed book, from making poses to drawing pictures to describing the smell of foods. As each exercise was made to build a different function of the brain, each exercise challenges the student to respond in a way that best represents

their skills with that function. Building in positive reinforcement was also an important part of our design. By providing reinforcement for the students completing the curriculum, they will be motivated to continue their studies and not give up, and they will feel that their inputs are being received and have meaning to the web app.

Student metrics tracking is an important feature we included in the website that allows Noosfera, teachers, and psychologists to track the student's progress in the curriculum. What matters most for metrics tracking is what Noosfera, teachers, and psychologists require to properly assess the students, since they are the end user of this information. From discussions with Noosfera, we determined that it would be most beneficial to include data such as the time it takes for a student to complete an exercise, the number of attempts on an exercise, and the incorrect answers that the student submitted on an exercise. By including this information, Noosfera, teachers, and psychologists are able to view students' progress and know how to specifically help them with the curriculum so that they can improve their cognitive abilities.

The agile development cycle was an effective way to structure our work. It allowed us to consistently update our goals for the weekly "sprints" of work that we did.

## Recommendations for the future

- Continue to use AdobeXD or similar software for prototyping chapters
- Maintain consistent visual style with the book and with the rest of the website
- Use a work cycle that involves constant feedback for optimal results
- Add drag-and-drop input and animations
- Use web design service (Wix Editor, etc) to quickly style website to best match prototype
- Add tutorials and/or walk through steps to make instructions more clear

## 5.3 Back End

### Discussion on the development of the back-end of the website

We found that Next.js was an effective platform for our adaptation. Next.js has built in support for internationalizations and locale translations based on information the web browser sends to the server. When connecting to a website, modern browsers send a piece of information with the webpage request called the 'Accept-language' header. The Next.js server reads this header and will provide the correct page if it is translated in that language, or often English as a default. For future translations or lessons of the *Brave Little Dragon* book, the text on the page can be in any language, but it will always be formatted the same way across languages. The consistent formatting is because of techniques such as data fetching and server side rendering. We utilized these techniques to load data into the web server before the client could see

it and turn React JavaScript into plain HTML. This will optimize loading pages for people on low bandwidth connections because we are reducing the footprint of our outgoing data bundle. Next.js also uses a popular industry tool called Webpack that will further reduce the size of the web pages being served to end users. The reason we considered this optimization is that some students in remote parts of Russia could have very low bandwidth connections and will still require reactive and responsive website loading.

Next.js is built on top of the Node.js server framework, which has a wide range of technologies published to handle user login and authentications. Early in development, simple username and password security sufficed, but a stretch goal for any future development would be to implement two-factor authentication. This consideration for future work should be taken seriously as the platform grows its user base and more data is generated. If the website is ever deployed in a region that is not geographically close to Moscow, where Noosfera and likely the server will be located, it is possible for the responsiveness of the website to be degraded.

#### Recommendations for the future

- Continue to use Next.js and MongoDB for consistency throughout the project
- Implement two-factor authentication as the platform grows its user base

## 5.4 Feedback and Effectiveness Assessment

### Discussion on receiving feedback and the effectiveness of our project

We found that receiving feedback through surveys was an effective way to receive feedback and opinions from specialists about the website. The survey included questions on the prototype's aesthetics, ease of use, giving of information, how students would input answers, feedback and reinforcement, and the overall effectiveness of the exercises. From the feedback on these topics in the survey, we were able to implement changes into our website to improve its quality and effectiveness. We also were able to gather recommendations for the future based off feedback we could not implement within the course of our project.

#### Recommendations for the future

##### Recommendations about surveying:

- Send the survey out early on in the project to allow time to implement changes suggested from feedback into the project

- Include questions regarding aesthetics, ease of use, giving of information, how students input answers, feedback and reinforcement, and the overall effectiveness of the exercises and the website in the survey

Recommendations about the website from survey feedback:

- Simplify instructions
  - Make instructions in Lesson 1 Exercise 2 more simple and clear
- Split story in exercise one onto two pages
- Condense exercises onto the same page for ease of understanding, unless exercise is supposed to be split into separate pages
- Continue using pop-ups for feedback and reinforcement techniques throughout the exercises
- Implement a “hint and retry” button to prevent students from becoming frustrated



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# Appendix A: Planned Features for Exercises

Following is a list of possible features that we planned to implement into our web app. These features cover a wide range of abilities and situations, and aim to cover every aspect of how the user interacts with the exercises in the app. They are broken into three categories: information presentation, input from students, and feedback from the app in response to a student's actions.

- Category 1: Giving Instructions / Presenting Information
  - The goal of features in this category is to provide the information in the lessons to the students in a clear and understandable way. This goal is met if the students understand the instructions given and remain attentive and engaged.
  - Feature 1.1: Narration
    - This feature provides narration of the story in *Brave Little Dragon* and narration of the instructions of each exercise, and will be accomplished by getting recorded audio of both the story and instructions from Noosfera and incorporating these into the remote platform.
  - Feature 1.2: Image Descriptions
    - This feature provides audio descriptions of images on the *Brave Little Dragon* remote format, and will be accomplished by including a text description of the image as alt text that is compatible with accessibility tools such as screen readers.
  - Feature 1.3: Animations / Attention-Retention Methods
    - This feature provides animations and attention retention tools within the web app that allow for students to be engaged in the exercises, and would be accomplished by including animations, images, bright colors or pulsating that draws the student's eye to a specific part of the screen; and designing elements of the web app and exercises in a playful manner. Animations were not implemented into the web app within the time frame the team had to complete the project, so it is recommended that future groups implement this feature into the web app.
- Category 2: Getting Input from Students
  - The goal of features in this category is to allow the students to input their answers into the web app in a clear and effective way. This goal is met if the students are able to easily and intuitively input their response to a question.
  - Feature 2.1: Clicking on things



## Appendix B: Survey/Interview Questions

This appendix includes all approved survey and interview questions we have used to collect feedback. They are broken down into categories, relating to the type of question and the area of feedback they are designed to address. Likert scale-style questions use a five point scale, with results ranging from “Strongly disagree” to “Strongly agree”. Open-ended questions allow the interviewee to provide more in-depth feedback with an open text response.

- Question area: Meets Goals
  - This section involves questions designed to assess whether or not the project meets the goals set by the sponsors.
  - Open-ended:
    - *How well does this portion of the app meet your expectations?*
- Question area: Aesthetics
  - This section involves questions designed to assess the visual clarity and appeal, both to a general audience and to our target audiences.
  - Likert scale:
    - *The app is visually appealing and interesting.*
    - *The app’s visuals would appeal to a 6-13 year-old student.*
    - *The app looks professionally made.*
    - *The app feels professionally composed.*
    - *The app’s visual design would hold the student’s attention.*
    - *The student would be interested in the visual design of the app.*
  - Open-ended:
    - *Would children age 6-13 seem interested by the app’s designs?  
Would it hold their attention?*
- Question area: Ease of Use
  - This section involves questions designed to assess if the website is free of bugs, and behaves smoothly and as expected.
  - Likert scale:
    - *It was intuitive to navigate between screens within the app.*
    - *Everything in the app behaved as expected.*
  - Open-ended:
    - *Did you encounter any bugs or strange/unexpected behaviors?*
- Question area: Giving Information
  - This section involves questions designed to assess if the app’s information delivery would be clear and effective to the target audience.
  - Likert scale:
    - *A student using the website would be able to understand the instructions for every exercise.*



- *The narration was audibly easy to understand.*
    - *The text was visually easy to read.*
- Question area: Input
  - This section involves questions designed to assess if the app's student input methods would be clear and effective to the target audience.
  - Likert scale:
    - *The student would understand how to input their answer into the app for every exercise.*
    - *The text entry system was intuitive to use.*
    - *The audio recording system was intuitive to use.*
  - Open-ended:
    - *Would the student have difficulties inputting their answer into the app? If so, what would be difficult for them?*
- Question area: Reinforcement
  - This section involves questions designed to assess if the app's reinforcement methods would be clear and effective to the target audience.
  - Likert scale:
    - *A student might become frustrated if they answer an exercise incorrectly.*
    - *The student would feel happy when they complete an exercise.*
    - *The student would lose interest easily in the app.*
- Question area: Effectiveness of Exercises
  - This section involves questions designed to assess if the website's exercises would have a similar impact to the target audience as the physical curriculum.
  - Open-ended:
    - *Do you think the lessons are as effective as they would be if presented normally from the book? If not, please explain aspects that you think are less effective.*
- Question area: Quality of Data collected
  - This section involves questions designed to assess if the data being collected by the website is useful to assess student ability and progress.
  - Likert scale:
    - *The data being gathered from these exercises is useful to measuring student progress.*
  - Open-ended:
    - *What other data, if any, would be valuable to collect to measure student progress?*

- *Is there data that is presented which is not relevant to your measurement of student progress?*

## Appendix C: Notes from Noosfera Meetings

This appendix includes summaries of all meetings between the team and the sponsors (Tamara Arzumanyan, art director, and Sofia Arzumanyan, director) from Noosfera.

- Meeting 1: 2/22/21
  - Introduced ourselves and our project
  - Discussed Noosfera's goals and vision as an organization
  - Discussed impact of *Brave Little Dragon* curriculum on cognitively disabled children's lives
- Meeting 2: 3/1/21
  - Discussed how to receive future feedback from the sponsors and other relevant parties
    - Developing a prototype will let us get quick feedback and make changes in a visual program, rather than having to make the changes in code which will take longer
    - The sponsors would be able to test the prototype/website with children and report back to us by answering questions<sup>1</sup>
  - Ran through each exercise from the book, comparing our plans for adaptation with their ideas and expectations
    - Exercise 1
      - Important to ask questions to the child before they read the story
      - Show the text, but also include narration (already recorded)
      - Could include animations / movie with subtitles
      - Audio recording of child's answers is promising
    - Exercise 2
      - Want child to learn to follow instructions, don't completely walk them through the steps
      - Visual hint to assist child if they are stuck
      - Step-by-step progression (not going back) important
      - Following the line and going in order is important
      - Important to see the whole table at once
      - Manually circling flowers is not important, can use click input

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<sup>1</sup> This was not ultimately used in the project, as we are unable to survey the children directly. They, and all other people surveyed, answered questions based solely on their past experiences working with these children.

- OK to make mistakes, they are learning and this is the first exercise. They should have feedback on if they made a mistake or not, but not be expected to do it perfectly
- Goal is visually inspecting the table and following instructions
- Exercise 3
  - All about memory
  - Don't show the second page while the first is open
  - Items in the refrigerator should light up when clicked
  - Not an examination, just a way for them to show what they know about each thing: no correct answers<sup>2</sup>
- Exercise 4
  - Highlight/select images when they are clicked
  - Maybe images could move from the larger image into a collection area when found
- Exercise 5
  - Complicated in real book, will be especially complex here
  - Don't expect them to draw with their mouse
  - Could separate image into pieces and slide them into place
  - Record accuracy of mouse movements as a metric
- Exercise 6
  - Can not use image recognition to determine if child is in correct pose
  - Options are to either have the student submit a video of themselves for manual review or have them make the pose described, then pick the correct gnome
  - This is a good break in the lesson for physical activity to keep focus
- Exercise 7
  - Dragging the food into the correct basket seems like the best way to adapt this
- Exercise 8
  - Should use different method from exercise 7 (no baskets)
  - Maybe drag a person or a fairy to each transport mode, or click each one then click "human" or "fairy"

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<sup>2</sup> This question was changed significantly based on later feedback and discussion.

- Exercise 9
      - All about reasoning and logic
      - Can provide a hint if the child gets stuck
    - Exercise 10
      - Remember the story and what happened
      - Can tell teacher/parent or type and answer, or use multiple choice
      - Providing free input for the story recall is important so the child can show off new vocab, etc.
    - General Exercise Discussion
      - Do not allow child to skip, rather add hints or make question easier
      - Psychologists eager to start using the website
      - Send prototype just to psychologists and teachers, send actual builds to the students<sup>1</sup>
  - Meeting 3: 3/30/21
    - Showcased the prototype to the sponsors, walked them through navigation and exercises.
      - Generally positive feedback on the design of the prototype, some tweaks on some exercises were made or requested for the final version. Notable changes:
        - Many of the text input options were replaced with multiple choice, as it will be hard to tell immediately if the student got a question correct with text input.
        - Exercise 3 was completely changed: instead of text input for describing each food, only a few foods are to be focused on. Each one will have several multiple-choice questions about different aspects of the food, like “is a watermelon big or small?”. Afterwards, students will find the foods in the fridge as before.
        - For Exercise 5, color was suggested: instead of dragging shapes, color the image from a color bank (like a coloring book). Possibly implement a combination of both?
    - Discussed the English version: while we are not providing an official English version to Noosfera (as we will have no English audio), we should polish the translation up for presentation to our advisors and others.

- Received the following feedback based on the questions in Appendix 2:<sup>3</sup>
  - Is this style interesting and appealing to children?
    - Yes
    - The first page can be in the style of the book cover
    - Landing page with name and story of the app before login
  - Do you think this style will hold their attention?
    - Yes
  - Is the navigation easy to follow?
    - Yes
  - Do you think the children will understand this format?
    - With both sound and text record this will be better
    - Some children are better at listening/speaking, and some at reading/writing
  - Do you think this exercise is effective compared to the book version?
    - We hope it will be as effective
    - It is different and will be different
    - Different spirit of involvement, like at home vs in a cinema.
    - This will encourage different skills and advantages
    - They will still gain knowledge and skills
- Meeting 4: 4/6/21
  - Discussed audio narration: We can get recordings from the original narrator, but we will need to compile a list of everything that needs to be translated.
  - Sponsors shared an anecdote: a child that came into the center who was missing part of their brain, who still saw significant improvement from the Brave Little Dragon program along with other therapy over a 3 month period
  - Sponsors asked us to send our research, they can help supplement it with some experts / literature in areas we don't have as much research on
    - They can provide us figures from the psychologists they worked with to develop the program initially

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<sup>3</sup> As these questions were asked verbally and not in a written survey, the method was modified to not use the Likert scale, as the sponsors could provide any additional information verbally.

- Discussed the first survey: we can send them the prototype and survey in English, and they can translate the survey into Russian to get more responses
  - They won't be able to translate the prototype, so we think it may be best to only get English-speaking people's responses to the survey
- Meeting 5: 4/20/21
  - Discussed giving students certain number of attempts to discourage clicking on every option
  - Showed Russian translation, database, teacher view
  - Tamara is getting us in contact with librarian in Denver, CO who worked with BLD program
  - Going to write down survey questions more interview style to be translated and answered by Russian specialists
  - Sent sounds, going to use them throughout the website
- Meeting 6: 4/28/21
  - Showed progress on website
  - Discussed survey to get team more feedback
  - Tamara offered to reach out again to librarian from Denver, CO
- Meeting 7: 5/4/21
  - Showed progress on website
  - Discussed interview with librarian from Denver, CO
  - Discussed how team will only be able to adapt first few exercises of lesson 1
- Meeting 8: 5/11/21
  - Showed progress on website
  - Discussed transfer of website to Noosfera for development
- Meeting 9: 5/13/21
  - Discussed transfer of website to Noosfera for development

# Appendix D: Approved IRB

## WORCESTER POLYTECHNIC INSTITUTE

100 INSTITUTE ROAD, WORCESTER MA 01609 USA

### Institutional Review Board

FWA #00015024 - HHS #00007374

#### Notification of IRB Approval

**Date:** 31-Mar-2021

**PI:** Oates, Karen K

**Protocol Number:** IRB-21-0422

**Protocol Title:** Brave Little Dragon

**Approved Study Personnel:** English, Benjamin~Simoneau, Alexander~La Vallee,  
H~Bennett, Natalie~Oates, Karen K~Mardilovich, Ivan P~

**Effective Date:** 31-Mar-2021

**Exemption Category:** 3

**Sponsor\*:**

The WPI Institutional Review Board (IRB) has reviewed the materials submitted with regard to the above-mentioned protocol. We have determined that this research is exempt from further IRB review under 45 CFR § 46.104 (d). For a detailed description of the categories of exempt research, please refer to the [IRB website](#).

The study is approved indefinitely unless terminated sooner (in writing) by yourself or the WPI IRB. Amendments or changes to the research that might alter this specific approval must be submitted to the WPI IRB for review and may require a full IRB application in order for the research to continue. You are also required to report any adverse events with regard to your study subjects or their data.

Changes to the research which might affect its exempt status must be submitted to the WPI IRB for review and approval before such changes are put into practice. A full IRB application may be required in order for the research to continue.

Please contact the IRB at [irb@wpi.edu](mailto:irb@wpi.edu) if you have any questions.