

The Design and Implementation of Inclusive Astronomical Website for Visually Impaired and Autistic Kids

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Abstract. In the era of the rapid development of the Internet and science and technology, more and more children get knowledge from the Internet. Many children hope to learn some astronomical knowledge from websites. However, some of them may have some degree of disability. This article will focus on children with autism or visual impairment, because hearing or physical impairments often do not have a big impact on reading the web. This article will describe how to design a website that is more suitable for children with disabilities by comparing the author's website step by step with the various parts of some existing representative astronomy websites. To get an inclusive website that makes it easier for children with visual impairment or autism to read and focus on. Lower the learning threshold of children with disabilities, so that those who are "different" children better acquire knowledge and integrate into normal life, and thus improve their interest in learning and self-confidence.

Keywords: Astronomy; Website; Visual Impaired; Autistic; Kids.

1. Introduction

With the gradual popularization and development of the Internet, an increasingly number of people spending a lot of time online to visit some websites and it is worth noting that the proportion of kids' users had doubled from 2014 to 2022 in China, according to China *Internet Network Information Center* (CNNIC). Furthermore, some of them have some degree of disabilities, this article focuses on two types of them (visually impaired and autistic). Kids who have one or two types of these disabilities face to two main dilemmas. One is that most of websites are not target to children. Kids' cognitive and physical limitations present many challenges to them when they surf the Internet. [1] Many Web designers did not experience the popularity of the Internet when they were young, Ways they get information in their study or life is mostly paper materials, maybe books, magazines, or newspapers. By either way, they are free to control the rate of access to information. They get into a mindset, and they get annoyed waiting for some web pages to load. However, children of this era live in an environment where the Internet is the main source of information so they have a completely different mindset about the Internet than most web designers, thus very few web designers have empathy for children's abilities and thinking[2].

Another problem is that very few web pages are designed for people with visual impairment and autism. Firstly, focusing on people with visual impairment, and there are many types of visual impairment, but concentrating on two of the main ones, color blindness and blindness. After interviews with many color-blind people, some of the key information on many websites is almost invisible to them because of some color contrast reasons, although these pages are very clear and even very colorful to us. Although current browsers usually have the ability to read web pages, this is not enough to meet the needs of blind people, for example, some forms are difficult to understand. When the author interviewed blind people and showed them a website where they could order sushi, and asked them to customize their own sushi, the responses were devastating. On the site's home page, there are images of sushi that, when read by a browser, turn into a series of long, impossible numbers. The interviewees are very confused about them. Even if they overcome this and find a menu interface, they still find much of the information in the form that appears on the menu interface difficult to understand, like birth year, month and date, they don't know what they're filling in. An interviewee is also a programmer, he said: 'The screen reader user can never tell a developer, what they can not see.'

If this happens to children, they are likely to become more frustrated. So it makes sense to design and implement some web pages for children with visual impairment.

Secondly, focusing on the autistic kids. Children with autistic tend to have an affinity for digital technologies, often preferring computer-assisted learning to human-assisted learning[3]. Low-cost systems (i.e., smartphones) can be used to increase the independence of people with intellectual disabilities or mental disorders who suffer from cognitive impairment[4]. Furthermore, the author also interviewed children with autism and showed them regular astronomy websites (such as the NASA homepage) to see what they thought of them. The interview found that most children with autism have difficulty understanding some conventional web pages or are not interested in them because of their intellectual disabilities[5].

This research is based on the above survey and interview feedback of people with these two types of disabilities and Designing Web Interfaces For kids mentioned guidelines to implement an astronomical website for children with visual impairment or autism, or both. This study will compare the design implementation of a conventional astronomy website with the design of an inclusive astronomy website for children with disabilities The purpose of this study is to improve the interest of children with two kinds of disabilities in reading web pages by using appropriate codes, so as to acquire knowledge more intensively and help them improve their confidence and interest in learning.

2. User's Personas

The author conducted some interviews with children with autism or visual impairment. Here are three classic examples

Table 1. Three classic examples

Name	Kaori	Cuyler	Thea
Age	12	8	14
Gender	Female	Male	Female
Location	GA,U.S.	GA,U.S.	Seattle,U.S.
Disability	ASD	Color blindness	Blindness
Intrest	Science(especially astronomy),math, soccer	His parents often take him to watch stars at night. His room is decorated with planets, also crafts such as rockets, airplanes, and cars. He likes to play with legos and watch Marvel movies with his family.	Listen to music
Goal	She hopes to learn science outside of the classroom. She loves nature and the universe. As she describes: 'My favorite thing is to watch the night sky and to imagine what exactly do stars look like	Gain knowledge related to stars and planets. Text on the website should be easy to understand. Instead of reading text, he prefers images/visual representations on the website.	To be able to acquire some knowledge on the website more easily and quickly.
Frustration	Many websites explain science-related topics with terminologies that are too difficult for her to understand. It's hard for her to stay focused on one page	Many astronomy websites have blurred text in some parts due to color blindness, and some free websites always have a lot of advertisements, so he often clicks on the advertising interface to waste time, and finally lose patience	When using the reader function of the browser, the structure of some websites is not obvious, it is difficult to catch the key point, which is confusing

3. The Design and Implementation of Common Astronomy Websites

NASA was the first thing that came to mind when most people asked about astronomy websites, When most of the interviewees mentioned astronomy websites, the first thing they thought of was NASA, and most of them had visited NASA and raised some problems. They also searched astronomy websites for children, and PlanetsForKids was the first one. The author will take these two websites as examples to describe in detail

3.1 Homepage

3.1.1 Header

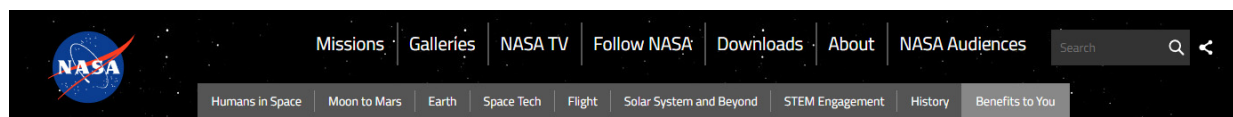


Fig 1. Nasa's header (www.nasa.gov)

The header on NASA's homepage consists of three parts: logo, navigation and search. The whole header part's html code is

The NASA's homepage developer implements the header part as a div and give this div an ID name 'navbar'. Then put the three parts into this div tag.

The logo part is in the left of header and it takes up a very small area of the header. Besides, the logo was implemented as a hyperlink that, when clicked, would return the user to NASA's homepage. 'NASA' will be displayed when the logo image is not displayed thus it is accessible for some blind people.

There are two navigations in the middle of header and they are implemented as unordered lists.

In the end, there is a search bar in the right of the header. It's worth noting that when kids type some words into the search bar, they don't get any word associations or prompts.



Fig 2. PlanetsforKids' header(www.planetsforkids.org)

Like NASA, the header section of the site is implemented as a div, but with the class name 'header'.

But unlike NASA, the logo section of the site's header takes up significantly more space because children tend to prefer larger shapes. This is especially true for children under the age of 10, who rely more on larger ICONS to navigate the site as their precision motor skills are not fully developed. And like NASA, the developers also made the logo a hyperlink, allowing users to click on it and return to the homepage.

The navigation section is also done by an unordered list, but you can see that the navigation text is smaller. And the entire header section has a completely black background, without NASA's star background.

3.1.2 Main

The main part of NASA is implemented by grid, in addition, the entire main section is done with a div, and the table section inside is done with a section tag.

In the NASA Events section on the right, there are a lot of text hyperlinks, this is not child-friendly, especially for children with autism. A 2-year-old can't control a mouse or a trackpad, but they can navigate on a tablet. Most 6-year-olds can use a computer mouse, but for the past three years of their lives, they've mostly been playing with tablets. So, they are used to buttons being the main navigation triggers. Again, the mental models they developed early on affect the way they perceive interface [1].

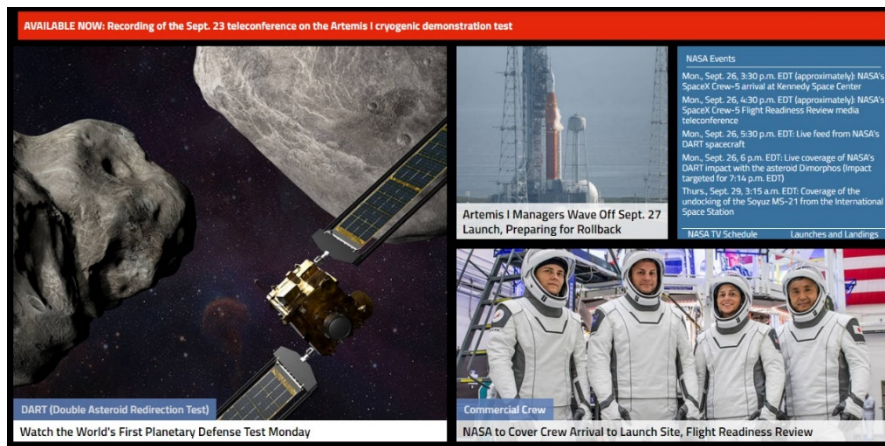


Fig 3. Part of Nasa's main part(www.nasa.gov)

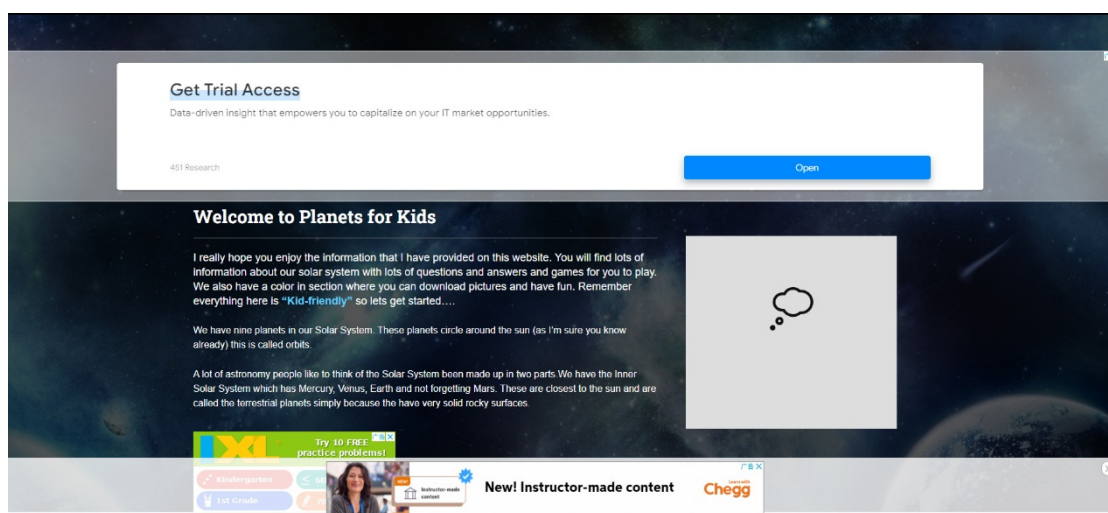


Fig 4. Part of PlanetforKids' main part (www.planetsforkids.org)

It is noticeable that the main section of the site has a large portion of advertisement inserts. The author will discuss this in a later section. In addition to the problems with the ads, it is clear that there is too much text in the middle of the top and bottom ads. As with NASA's text hyperlink above, a lot of text is stacked in the center of the page, which is very harsh for them. In addition, the 'Welcome to Planets for Kids' sentence uses the h2 tag, while the following paragraph uses the h5 tag.

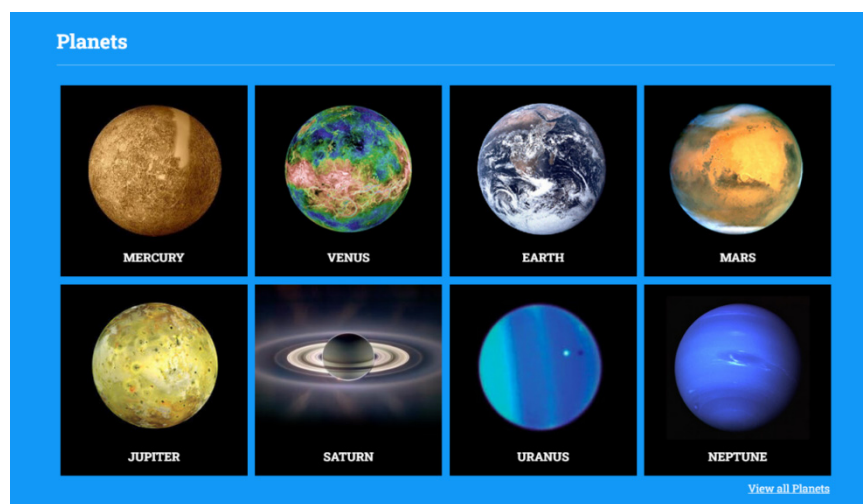


Fig 5. Rest part of PlanetforKids (www.planetsforkids.org)

The h5 tag is not appropriate here, the developer probably just wanted to bold the paragraph and the H5 tag font size was just right. If a blind child was visiting this page, he would be confused as to where the point was, because the browser would read it and the blind child would probably see it as an insignificant part. If really want to emphasize the paragraph, the H3 tag can be used, and if just want to bold the paragraph or change the size of the text, you should set them in CSS. These will meet the requirements of the heading hierarchy and make this page more accessible. This is a very easy part to implement, just use the flex box with the blue background. This section has the outstanding advantages of very large ICONS and very little text, which is very suitable for children to browse, and the contrast between the stars and the background is very high, even the color-blind children can see very clearly.

3.1.3 Footer

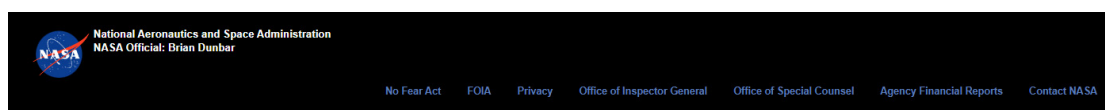


Fig 6. Nasa's footer (www.nasa.gov)

Like the header section, the NASA footer section is still a div with the ID 'footer'.

The left side of the footer is still a logo that can be clicked back to the homepage, and the right side is some hyperlinks related to NASA.



Fig 7. Planets for Kids' footer (www.planetsforkids.org)

It can be seen this site footer part is the comparison of the existed obvious mistake, first of all, the most obvious is the hyperlink below there are some parts have been blocked by advertising, when children browse here is very easy to point into the interface of advertising, especially on under the age of 10, has yet to grasp precision motor ability of children, are more likely to happen to this problem. Another problem is that although the Footer's layout is similar to NASA's, with logo and hyperlinks, it can't be clicked back to the homepage.

3.2 Other Pages

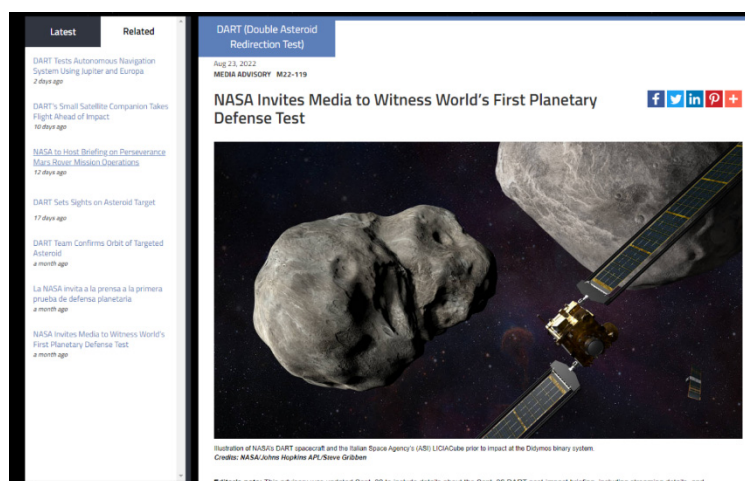


Fig 8. One page of nasa (www.nasa.gov)

It can be seen that there are still a lot of text hyperlinks on this page, so NASA astronomy site is not suitable for children, there is still a lot of text information under the picture.

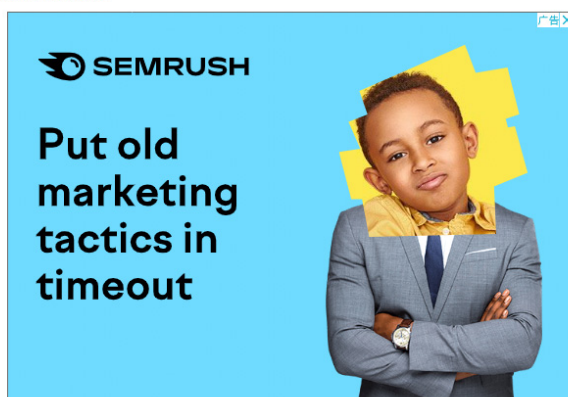
But beyond that, in terms of visual impairment inclusiveness, there is another problem.

In the part of the picture with white text on the blue background, the author checks the color contrast and finds that the text in this part is difficult to be recognized by some people who are color blind or color weak, the results are as follows:



Fig 9. Color contrast

Each time you look up to the sky and see a star you are looking at a sun in another galaxy. If you were on another planet looking back at our solar system, you would see our sun as a star. It's believed that every sun has planets orbiting it.



Our Milky Way galaxy has more planets than it has stars. In our solar system we have eight planets: Mercury, Venus, Earth, and Mars are the inner rocky planets.

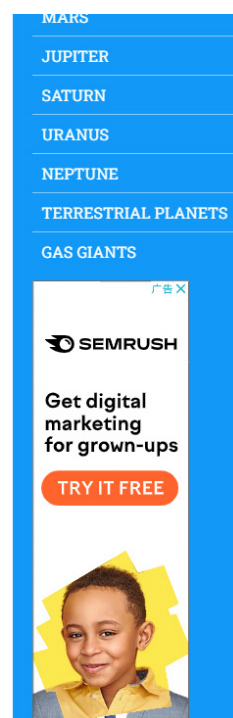


Fig 10. One page of Planets for Kids (www.planetsforkids.org)

Then it is another page of PlanetsforKids:

Like the home page, this page still has a lot of ads inserted, but it seems to be more than the home page, and the proportion of ads even exceeds the proportion of valid messages. It's an astronomy site for kids, but according to Trine Falbe, it is not a good site for children.

4. Design and Implementation of the Author's Astronomy Websites for Visually Impaired and Autistic Kids

The name of the author's website is Kids' Universe (Hereinafter referred to as KU) This website is an inclusive website designed and realized by the author according to their needs after interviewing people with visual impairment and some autistic children.

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4.1 Homepage

4.1.1 Header



Fig 11. KU's header

This is the header section of the homepage of Kids' Universe. It consists of two parts. The left part is the logo of the website, which occupies a large part of the space of the header. On the right side of the header is the search bar, just like the search bar on NASA's home page, but it is different from NASA. The author will show the difference in the next section. Since the website is aimed at children with visual impairment, it has more stringent requirements on contrast. The author has tested the background color between each color and the background color, and they are all accessible for these disabled children. In addition, the header part is implemented by the header tag:

Just like the NASA logo section, each subpage has a logo that, when clicked, will return the user to KU's home page. In addition, KU's homepage omits the navigation section because many children with autism report that they are confused by the navigation of many websites and prefer graphics [1]. In addition, noting that NASA's search bar does not have a prompt function, the author also added an automatic association function to the header search function, since children may have some difficulty with typing. This functionality is implemented using the data list tag.



Fig 12. KU's search column

4.1.2 Main

This is the main part of KU, which is first implemented using the main tag

A section tag is used inside the main tag. At the top of the section is an h1 tag, so that more users can find the author's webpage by searching solar system through search engine, and blind children can quickly know what the topic of this website is [6].

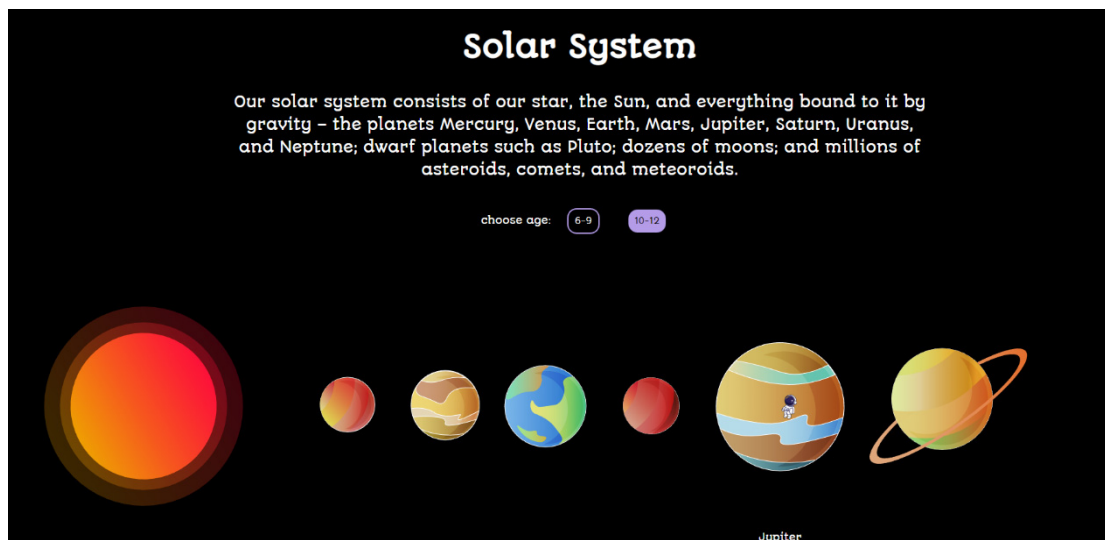


Fig 13. KU's main part

After that comes a solar system made up of a few words, and these words are relatively easy for children to grasp the basic vocabulary. Then in the paragraph below is two option buttons, children are free to choose their own age group, the group if they are six to nine years old, the show in front of them web literal will be less, and vocabulary will also be more easily, this change not only appeared on the homepage, other pages in the subsequent will also have the same effect. The most important thing is that if children chose six to nine years old age group, so he faced the header part of the web page will not have a search bar, because children before the age of ten precision motion ability has not development [1], a child before the age of ten even if only one finger to type some words also need a very long time and not more than ten years old children. This may frustrate these younger children, so they will not see the search bar.

Below these two age buttons are cartoon images of the eight planets of the solar system made up of flex boxes. First of all, they are set in the cartoon style that children like, and they all meet strict contrast standards, so that every child who is color blind or color weak can see them clearly. And then when you hover over these patterns the names of the planets will appear below them. At this point, if the user clicks the mouse, it will enter the planet's introduction page.

It is worth noting that when the user hovers over the empty space of Main (the black universe), the cursor will change to an astronaut piloting a rocket, and when the user hovers over the stars, the cursor will change to an astronaut who has landed.

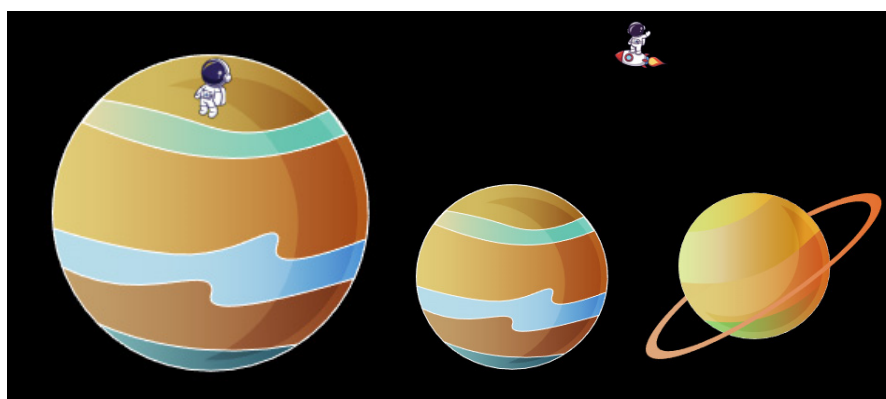


Fig 14. The cursor on different parts

The code to achieve this effect is an attribute called cursor. Just add this attribute to the selector.

But it makes a big difference, because the vast majority of children with autism are graphically sensitive. But it makes a big difference, because the vast majority of children with autism are graphically sensitive. They'll be more interested in gamified content, and if the cursor looks like this, they'll be more interested in the site [1]. So, it's a better way to get kids with autism's attention and keep them going,

4.1.3 Footer



Fig 15. KU's footer

The Footer section of KU is similar to NASA and PlanetsForKids, except that it is implemented with the Footer tag.

4.2 Planet Introduction Page

This is the planet introduction interface for the ten to twelve age group of KU. The logo above can still be clicked back to the home page. The interface more than six to nine years old age group the interface of some words and some difficult words, but no matter what age group of the page, there will be some words are highlighted, because it is easier to grab the attention of children with autism, when they see some color contrast words, they are more likely to finish reading. And when they mouse over the text, the text becomes highlighted in a contrasting color. Of course, these are the colors that tested color blind people can see clearly.



Fig 16. KU's introduction page

Finally, there is a quiz button at the bottom, which will take you to a small quiz screen.

4.3 Quiz Page

This is a simple quiz page. The reason why this page is set up is that autistic children like interactive websites very much. Moreover, if the quiz is correct, the reward can effectively make them feel happiness and reduce the symptoms of autism [2]. So, when they got it wrong, the correct answer would appear at the bottom of the question and they would be allowed to do it again [7]. If they get it right, they will be sent to dynamic fireworks display [8]. This fireworks page is done with some JavaScript code

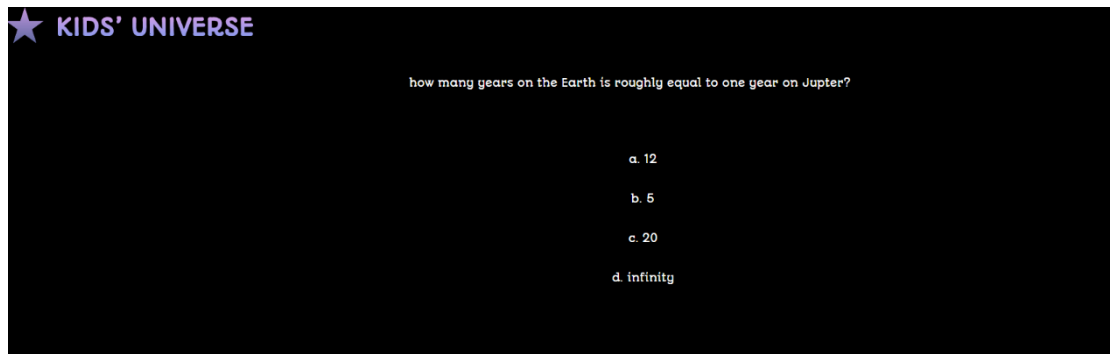


Fig 17. KU's quiz page

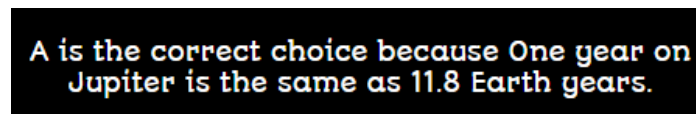


Fig 18. Situation after answer the question wrongly

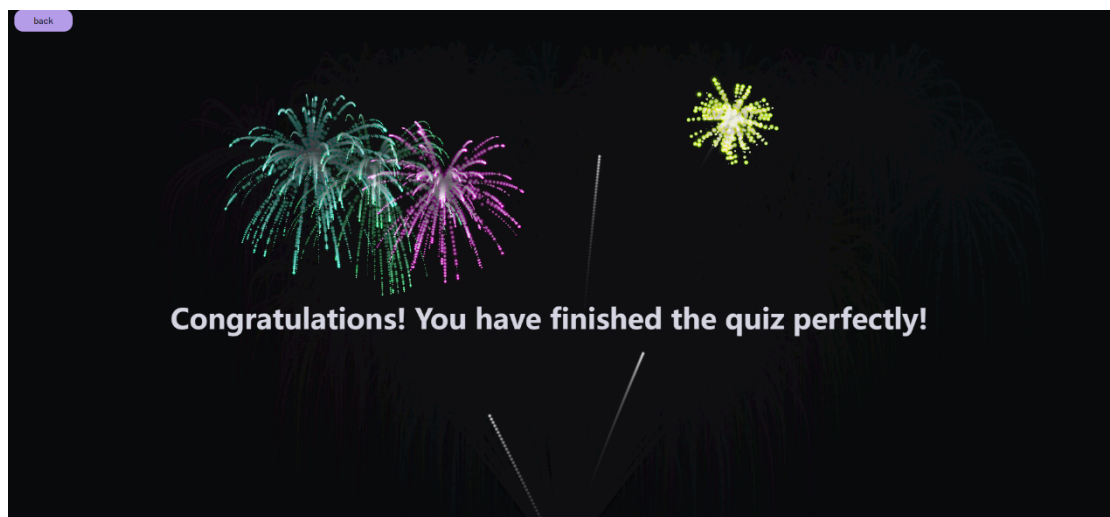


Fig 19. Situation after answer the question correctly

5. Discussion

5.1 Header

The most notable part of the header section is the search bar. It was mentioned in section 2.1.1 that when you type the prefix of some words into the search bar of NASA, there is no prompt or auto-complete of these words. However, in fact, children, especially autistic children, need this function very much, because they can master reading much faster than reading and writing. That is, while they will know how to read a lot of words, spelling those words is a very different matter. Allison Druin, a researcher in the field of human-computer interaction and new technology for children, has found that kids experience many problems when searching. For instance, if a search field doesn't have auto-completion, young kids (and non-native speakers) have a very difficult time searching properly. If they are searching by themselves (with no one nearby to help), then success is even harder to come by [1].

5.2 Tags

Both NASA and PlanetsForKids use a lot of div tags to implement their headers, footers and main, which means that they don't use semantic tags as much as possible. And every part of KU is semantic tags (e.g.: header tag, main tag, footer tag). If you don't use words, because some blind people can not see web page, and when reading web browser will not read the label ID name, so the blind man may be a bit confused, I don't know this web page layout and key, when developers use these labels as soon as possible, the blind will solve these problems.

5.3 Main

The hyperlinks in the main sections of NASA and PlanetsForKids are mostly text, and children are apparently more receptive to hyperlinks in the form of logos and images because even if they can't read the text, They can also click on ICONS to manipulate web pages based on their experience with various applications. And KU is more hyperlinks in the form of cartoon patterns to present, which can greatly attract children's curiosity [9].

One of the key issues on the NASA website is the color contrast problem, which is the area that children who are color blind or achromatic can't see clearly, and the colors in every part of KU are completely validated for children who are color blind or achromatic.

The main section of PlanetsForKids is even more problematic: This problem seems to be relatively easy for adults to solve. If they don't want to see it, adults may choose to press the close button or automatically skip it. However, it may be a very difficult challenge for children, because no child has the ability of abstract thinking before the age of twelve. The ability to think abstractly is crucial because it allows a person to predict the consequences of their actions and to reflect on those consequences. if a 10-year-old clicks on an ad that takes them to a new website, they will get annoyed because the goal has been delayed. What the child cannot predict is how much damage it could do to the computer[1]. As a result, KU's design implementation is completely free and ad-free.

6. Conclusion

KU through interviews with using a lot more to keep visual impairment or autistic children understand or concentration of the code, make web pages more inclusive, These changes will increase the level of concentration of children with both types of disabilities on the web, make them more efficient, more interested in completing the acquisition of knowledge, and improve their confidence in learning. but the current page is very simple, there are some functions need to be perfect, the back-end functionality, for example, can realize the user login or the user can communicate with other friend platform. The author will continue to study this direction in the future and implement these interactive functions.

References

- [1] Trine Falbe, Designing Web Interfaces for Kids, 2015.
- [2] Jonathan Evans, how to balance design guidelines for children, 2015.
- [3] Aurora Constantin, Hilary Johnson, Dr Elizabeth Smith, Denise Lengyel, Designing computer-based rewards with and for children with Autism Spectrum Disorder and/or Intellectual Disability, 2017.
- [4] Resta, Emanuela, Brunone, Lucia, D'Amico, Fiora, Desideri, Lorenzo, Evaluating a Low-Cost Technology to Enable People with Intellectual Disability or Psychiatric Disorders to Initiate and Perform Functional Daily Activities. 2021.
- [5] Jihad M. Alja'am, Samir A. El-Seoud, Masoud Udi Mwinyi, Design and Implementation of a Multimedia-based Technology Solution to Assist Children with Intellectual Disability to Learn. 2017.
- [6] A. De Bildt, S. Sytema, D. Kraijer, S. Sparrow, R. Minderaa, Adaptive functioning and behaviour problems in relation to level of education in children and adolescents with intellectual disability. 2005.

- [7] Aurora Constantin, Hilary Johnson, Elizabeth Smith, Denise Lengyel, Designing computer-based rewards with and for children with Autism Spectrum Disorder and/or Intellectual Disability, 2017.
- [8] Grzegorz Szumski, Maciej Karwowski, School achievement of children with intellectual disability: The role of socioeconomic status, placement, and parents' engagement. 2012.
- [9] James M. Kauffman and Li-Yu Hung, Special education for intellectual disability: current trends and perspectives. 2009.
- [10] N. Jacques, K. Wilton, M. Townsend, Cooperative learning and social acceptance of children with mild intellectual disability, 2002.