Enhancing Human-Computer Interaction on Educational Websites: Color Preferences for 7-8 Years Old

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ABSTRACT For any application development first impression will always be a matter to attract users. User Interfaces (UI) will be the first handshake of an application with the user. This concern brings more impact when creating applications for children for educational purposes. In that case, having a vibrant and playful UI will be supporting to spark joy in every click of an application. The study aims to evaluate the impact of the effective selection of colors in educational website UI designs. Initially, the study conducted a comparative analysis of color preferences among 7-8-year-old students, aiming to identify the most preferred colors. A systematic color selection process was employed by gathering data from both primary and secondary data sources, resulting in 220 data from primary and a sample population of 323 data from secondary. Based on the findings, the most preferred colors among 7-8-year-old students were identified as red, yellow, green, blue, and purple. Then, the obtained color preferences were used in designing an UI for an educational website. The newly created design was then compared with three existing websites to evaluate the attractiveness of UI as an educational website. Finally, the study has concluded that a successful color selection in the UI design will enhance the UI, as it was proven by identifying the newly created UI design with the most preferred colors of the 7-8 years old as the most liked with 52.9% of positive feedback during the post surveys conducted to validate the aim of the study.

INDEX TERMS Applications for children, Color preferences, Human Computer Interaction, UX/UI designing

I. INTRODUCTION

"*It's not enough that we build products that function, that are understandable and usable, we also need to build products that bring joy and excitement, pleasure and fun, and, yes, beauty to people's lives.*" - **Don Norman**

User interface (UI) is where human-computer interactions (HCI) take place and it includes all user-interactive elements, such as buttons, pages, screens, icons, and more. A positive user experience can only be achieved with a well-designed user interface. To give a better user experience color combinations on an interface can be influential, especially when creating interfaces for young children. To design effective user interfaces that satisfy children's wants and preferences, it is essential to comprehend children's color preferences and their potential influence on user engagement and interaction. This study intends to investigate how youngsters between the ages of 7 and 8 feel about color preferences and User Experience (UX) for UI designs.

The concept of e-learning is a dominant point of current centuries. Student Content Interaction (SCI) is a major part of the HCI. It helps to keep the student interaction for the e learning platforms in the educational domain. User satisfaction is the final output which expect from any product. This is belonging to the Web UI concept as well [1].

The importance of color associations and their impact on children's emotional and cognitive responses have been addressed in earlier research [2]. The study has stated for instance that, yellow has been proven to be both highly favoured by 7-year-olds and to have a calming impact on kids with respiratory disorders like asthma. Additionally, fourth graders have been identified color yellow with honesty, demonstrating the complex nature of color preferences in many settings. Red color, on the other hand, has been associated with improved motor skills as well as elevated blood pressure and respiration rate. Girls respond to color red more favourably than boys do, evoking sentiments of exhilaration and passion. Children with sensory impairments may benefit especially from blue color, which is a popular color among 7 to 11-years-old and well known to have a soothing effect on the respiratory and cardiac systems.

Children prefer hues like red, yellow, green, blue, purple, violet, and orange, according to UI evaluations and research [3-5]. Age-related differences in color preferences have been observed, with color orderings for various age groups. For instance, blue is the color that 7-year-olds enjoy most, followed by red, yellow, violet, orange, and green colors [4].

Cool hues like purple, blue, and green have been proven to affect attentiveness similarly, but red has a detrimental impact on children's attention [5]. Hence, the influence of colors on student attentiveness has been investigated through numerous studies as explained above. Moreover, gender distinctions have been observed to possess a relationship with color preferences. In the study [6], the above factor has been proved as it has identified girls rating for colors such as pink and purple whereas boys do the opposite.

By understanding these color preferences and their psychological associations, UI designers can create interfaces that are visually appealing, engaging, and tailored to children's needs.

This research paper contribute to the existing body of knowledge by investigating the specific color preferences and their potential impact on children's UI experiences. The study has aimed to evaluate the impact of the effective selection of colors in educational website UI designs rather than designing UIs without considering the color preferences. The authors

evaluate the color preferences to keep the interaction of 7- to 8-year-old student for educational websites. Sample population and the educational websites are selected from the Sri Lankan context.

Most students prefer using online materials for learning. Among these, websites are a popular medium used by 7- to 8-year-old students for their educational activities. Therefore, creating websites with colors that appeal to children can further enhance their use of educational sites.

II. LITERATURE REVIEW

The relationship between UX/UI and color in creating rich interfaces has been evaluated in many aspects through existing works. Further, this study has been conducted as a part of the previously conducted work by one of the authors. In that study [7], the author has conducted an overall study about several factors such as color, fonts, user behaviour, user interactions, and gestures affecting the UX/UI designing under the field of HCI. In this section, the previously conducted study of the author and a few existing works will be highlighted.

In [7], the authors have investigated the user interactions for educational websites for the age group of 7-8 years old. The study has investigated about five factors namely as color, fonts, user behaviour, user interactions and gestures. Three existing local websites were considered, and the factors were evaluated. As the results, the study has concluded when designing interfaces for children to keep them engaged and to enhance the UX, designers should properly identify the preferences for each factor for the targeted audience. Hence, the study has emphasized the room for further studies to investigate about these factors one by one.

The study conducted by C. Llinares et. Al [8], has focused on the usage of colors, and warm and cold hues in the virtual classroom environments and the impact of that for education. The investigation has been conducted in two main aspects through psychological and neurophysiological methods. Psychological testing has been conducted with attention and memory tasks where neurophysiological methods have been monitored through heart rate variability and electroencephalogram. Hence collected factors have been analysed to relate to the cognitive functions. Through the study, authors have found that cold hue colors not only improve attention and memory function but also raise arousal and facilitate the formulation of design principles. Furthermore, correlations between the psychological and neurophysiological measures were discovered, which represents a remarkable advancement in the field of neuroarchitecture. Moreover, the study has emphasized the use of the impact of colors properly in architectural designs for educational environments will be a crucial factor in learning settings.

In [9], the study has discussed about the term ‘color symbolism’. It has shown the impact the colors in thinking and decision making. Further, the study has shown that color preferences often reflect gender significance. The study shows that some colors were categorized as girls’ colors and some as boys’ colors which clearly defines the gender significance. Moreover, the study has shown that color impacts for the society, preferences, performances, environment, and emotions. This clearly shows that having suitable colors in the learning environments are highly impactful.

The study [10], has discussed about color as one of the essential elements of design as it has a direct impact on children's psychology and behaviour. The authors have selected a color range as orange, yellow, green, blue, purple, and pink, and have investigated about the preferences of grade 1 and 2 students. As results, study has observed blue and orange colors as the most favourable impacts on children. With blue color creativity and artistic skills were found to be improved while orange and yellow colors were identified to support logical rational thinking associated with mathematics. Moreover, purple color has been identified as a balanced color in both logical and creative aspects with the research. Another significant finding of the study was that blue color had an impact on attendance. Hence, the study overall shows the impact of the colors in the learning spaces including environment, materials, and resources.

In [11], the study has discussed the role of colors in establishing a visual hierarchy within a design. The study has cleared stated that the colors are not just only an aesthetic element, and it also can be used as a strategic tool in communication and emotional resonance. Further, the study has emphasized that users can easily learn and navigate through a clear visual language which is supported by a well-defined color scheme. Warm hues like red and yellow, according to the study, can arouse feelings of urgency and energy, which makes them appropriate for aspects that call for user action. Additionally, colder colors like blues and greens can have a calming impact. This makes them useful for backgrounds or spaces where people are supposed to unwind and take in information. Authors have also stated that utilizing color psychology can be instrumental in designing compelling and successful user interfaces that evoke feelings and actions from users is a valuable technique. In concluding remarks, the study has shown that utilizing color to highlight the most significant and pertinent aspects of the user interface is important, and a visual hierarchy and contrast should be established. Also, the colors can be used to evoke strong feelings in users and to build an emotional connection with the design. Further, making use of color to appeal to the target audience and establish cultural and personal significance and using it to make users happy is also important in UX/UI designs.

The study [12], has directly discussed colors in UIs. The study has shown that the main factor to be considered when selecting colors to the designs should be to make user-friendly interactive interfaces. That is because color is a powerful tool that a designer can use and influence the user with easy visuals. The study also stated that colors will support to distinguish and separate objects. Hence, the study has concluded that color plays a vital role in UX/UI design and it a highly challenging resource to utilize.

The article [13], has discussed color psychology. The author has stated that UI/UX designers may use color psychology as a potent tool to craft memorable and compelling digital experiences. Through a proper understanding about the colors and the emotional effects the UIs can be designed to arise the favourable feeling and encourage user interactions. The article has discussed about colors and user engagement and color associations with UX. In user engagement, it has been identified that color is a direct impact, and the vision can be attracted easily with good and pleasing colors. In terms of user experience the behaviours of the users and satisfaction can be impacted with colors. Overall, the article has clearly shown the importance of colors, and using it to promote psychological aspects in a UI design is tactful.

Hence from the above highlighted works, it has clearly identified that colors play a vital role in human life impacting the psychological aspects of humans. In designing UI to provide a rich UX colors can be used as a powerful tool. With the psychological impact of colors, it is efficient to use it, especially in educational aspects. Overall, the review has emphasized that the effective use of colons in educational application UI design will play a pivotal role.

III. METHODOLOGY AND EXPERIMENTAL SETUP

This study's primary goal is to investigate how color affects educational websites, with a particular emphasis on kids between the ages of 7 and 8. This age group is perfect for the research because they consider a lot about the looks and comfort of their learning environment. These kids also possess improved memory and the mental capacity to classify items according to their size, shape, and color. Understanding color's impact is crucial for creating captivating and educationally useful websites that may improve learning and promote cognitive development in this delicate age group since color plays a significant part in a child's visual environment [7], [14-15].

The overall methodology has been done following several sub-processes including data gathering, data analysis, UI designing, validation, and the result analysis as shown in Figure 1 below.

As a beginning of the methodology, data gathering was done in two methods as primary data gathering (pre-survey) and the literature review. It was observed that depending only on primary data will not be sufficient to make the decisions. Hence, the study also conducted a sound literature review referring to the existing work regarding the color preferences of the targeted student groups.

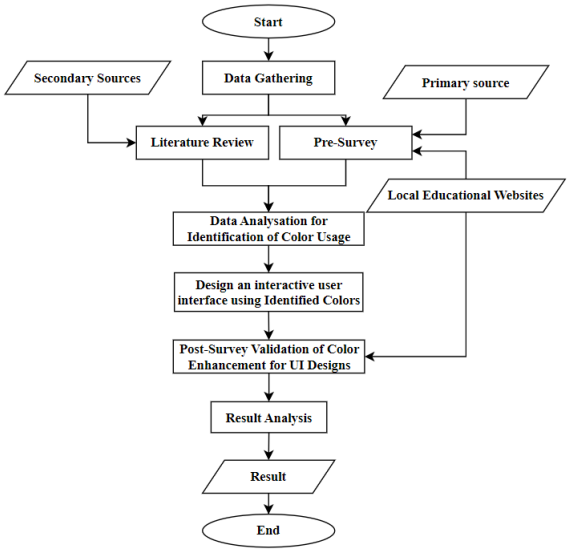

Figure 1. Methodology of the Study
Source: Authors

A. Data gathering and preprocessing.

1) Primary data gathering (pre-Survey): In the study, a pre-survey has been conducted to gather the data to identify the impact of colors on user experience and preference changes. Structured interviews were conducted as questionnaires with the selected participants of the age group 7-8 years old in identifying their color preferences. The questionnaire was used to learn in-depth about how children of the age group interact with instructional websites and to get their opinions on color components in existing websites. To ensure uniformity and comparability, a common operating protocol was adhered to during each data collection session. During the interviews, audio-visual recordings were used to guarantee reliable data acquisition. The comments, gestures, and nonverbal clues made by the participants were reviewed and analyzed later with the recordings. 45 existing colors were identified from the secondary data sources as shown in Figure 2 below. Evaluating the identified colors the questionaries were generated with the support of the selected 3 websites.

#F642FD	#1FD249	#D94924
#A047B3	#2BD353	#F82F75
#A26AFE	#65DA5A	#FB0101
#7974FE	#7FD33F	#C54667
#707AD4	#86CC49	#D35F63
#423376	#4CB23E	#FD0002
#6E60A0	#A0ED82	#C33825
#395B98	#26B594	#6D1416
#2DC5FB	#E8F56B	#ff0000
#0178F1	#E0BF5C	#E77D67
#3FBCF3	#F9F022	#847231
#3343C7	#FFFB02	#ECB4A4
#0000FF	#F79A01	#B98AA6
#72B2F8	#E9610E	#000000
#FFFFFF	#FDFEFE	#EAEAEA

Figure 2. Identified colors from the secondary data gathering.
Source: Authors

Data collecting was facilitated by a data gathering scale, as Grade 3 students had weak writing abilities. This Likert scale, as shown in Figure 3, was included in the questionnaire to gather the responses from students. Students responded by identifying their choices on a five-point rating scale: 5 for excellent, 4 for good, 3 for average, 2 for terrible, and 1 for extremely dissatisfied. A color-coded method was implemented to improve clarity even further. A green picture was allocated to a question that received a higher preference rating from students (5 out of 5). A standardized evaluation of the student's preferences and perceptions was made possible by the constant application of this approach to all their replies. Further, for an additional clarity the websites' interfaces were shown with a few selected similar activities through a largely visible screen devices.

Figure 3. Likert scale [16]

Overall, the interview was conducted by focusing on three local educational websites. The websites were selected based on their different usage levels according to a previously conducted work by one of the authors of the study [7]. "Website 1" from the most used category, "Website 2" from the moderately used category, and "Website 3" from the least used category. Altogether 220 responses were gathered through the pre-surveys to identify the most preferred colors through the websites.

2) Secondary data gathering (Literature review): Among the various studies reviewed, a study has selected the three most suitable research papers. These papers were focused on the color preferences for educational interface backgrounds, colors related to their emotions, and color combinations to keep students attentions [4-6]. The studies were referred to collect a sample population for the preferred colors. By considering each paper, 6 sample groups were identified together creating a sample population of 323 for this study for the selected age categories from both private and public schools from both genders.

Table 1. Selected Sample populations from selected research papers
Source: Authors

Sample group	Sample population	Study
1	62	[4]
2	62	[4]
3	34	[5]
4	44	[5]
5	20	[6]
6	20	[6]

Group 01 and Group 02 consisted of 62 students each, representing the 7-year-old and 8-year-old categories, respectively. The students were asked to express their preferences for single colors, including violet, green, blue, yellow, orange, and red. The researcher recorded the students' 1 to 6-order of color preferences.

Group 03 and Group 04 comprised 34 and 44 students, respectively, from state and private schools in the 8-year-old category. These students were also asked to express their preferences for yellow, red, purple, blue, and green colors. The researcher recorded the average color preference percentage for each student.

Group 05 and Group 06 consisted of 20 boys and 20 girls, respectively, in the 7-8-year-old age range. The students were asked to indicate their happy preferences for red, orange, yellow, green, blue, purple, pink, white, brown, and black colors. The researcher recorded the average color preference percentage for each student.

B. Data analyzation

The core objective of this analysis was to identify the most suitable colors for the target age categories. Hence, the JASP tool was used to analyze the primary data as well as the secondary data. Data about 11 colors from the secondary data gathering and data about 36 colors from the primary surveys were analyzed.

1) Primary data analysis: Data gathered from the survey was analyzed using the JASP tool to identify the highest preferences of the students. The process of analysis was able to produce more than 80% valuable feedback for 24 colors. *The Figures 4 to 6 given below shows the analysed preferences by the primary data.*

#Code	%	#Code	%
#1FD249	92.73	#3343C7	81.82
#395B98	92.73	#C54667	81.82
#D94924	92.73	#A0ED82	80
#65DA5A	89.09	#7974FE	80
#F642FD	89.09	#F79A01	80
#E8F56B	89.09	#D35F63	80
#707AD4	89.09	#ECB4A4	76.36
#7FD33F	87.27	#B98AA6	69.09
#A26AFE	87.27	#6E60A0	69.09
#2DC5FB	87.27	#847231	67.27
#0178F1	87.27	#6D1416	66.55
#F82F75	87.27	#000000	60.91
#FFFFFF	87.27	#F9F022	60
#FB0101	85.45	#0000FF	60
#4CB23E	81.82	#E9610E	60
#26B594	81.82	#C33825	60
#A047B3	81.82	#72B2F8	59.39
#E0BF5C	81.82	#EAEAEA	45.45

Figure 4. Analysed feedback of primary data – Overall
Source: Authors

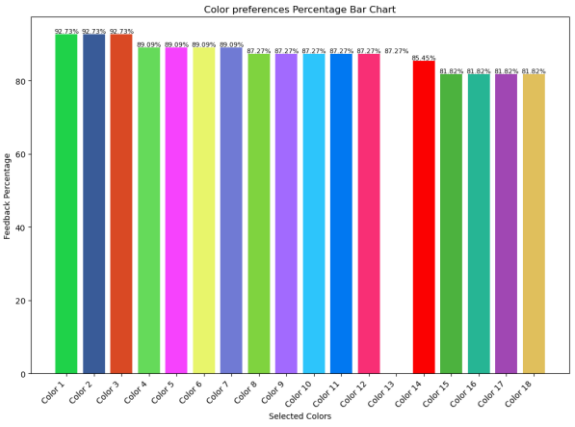

Figure 5. Analysed feedback of primary data – part 1
Source: Authors

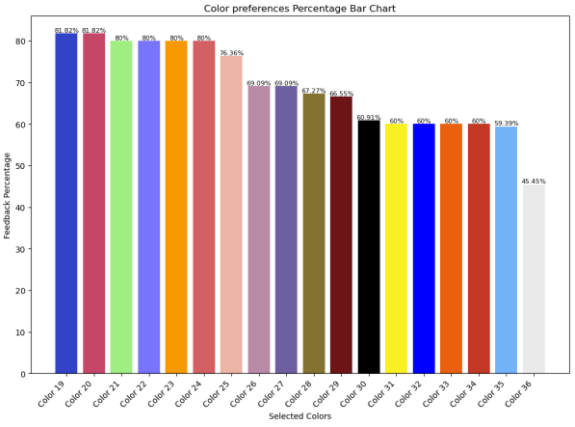

Figure 6. Analysed feedback of primary data – part 2
Source: Authors

2) *Secondary data analyzation:* The collected data from the sample groups were analyzed by grouping them based on similarities in available colors. Sample Group 1 and Group 2 were combined, and the average percentage for each 1st, 2nd, 3rd, 4th, 5th, and 6th color preferences was calculated. Sample Group 3, Group 4, Group 5, and Group 6 were also combined to calculate the average percentage of color preferences. Study [4] evaluated the color preference for the age 7- and 8-years students using 6 colors (Violet, Green, Blue, Yellow, Orange, Red). Both age categories have the highest color preference for both blue and red colors than others [4]. Table 2 given below shows the obtained results from [4].

Table 2: Color ranks for age 7- and 8-years students [4].

Color	Age	Violet	Green	Blue	Yellow	Orange	Red
Rank	7	5	3	1	6	4	2
	8	4	6	1	3	5	2

In [5], they have used 5 colors (Purple, Blue, Green, Yellow, Red) to test the relation between attention and colors for the students' educational processes. According to the result of this study purple, green and blue colors can be used to keep a highest students' attention for their studies than red and yellow [5].

According to the study [6], six feelings, three complicated emotions: proud, envious, and nervous and three fundamental emotions: happy, sad, and love were concentrated. Females provided more effective responses regarding both happy and negative emotions, and gender had a major effect on the appropriateness and quality of the emotional responses. Nevertheless, there were no appreciable variations in the replies for happy and negative feelings, nor were there any appreciable interactions between gender and categorization. The Munsell method of color notation was examined in the study; there were no appreciable variations in the orange, yellow, purple, or pink ratings between boys and girls. Blue was ranked as joyful, whereas black, white, red, green, and brown were more frequently rated as unpleasant hues. There were no discernible gender differences for orange, yellow, black, white, blue, or green [6].

According to the above analysis eleven colors, namely as: Violet, Green, Blue, Yellow, Orange, Red, Purple, Pink, Black, White, Brown were identified and among them seven colors, Blue, Red, Purple, Green, Orange, Pink could be highlighted as the most suitable colors for age 7- and 8-years students.

C. User Interface Design

After conducting a sound data gathering and analysation, the study's aim was to evaluate the suitability of identified color preferences at a newly created UI for the desired scope in educational websites. Therefore, a new website interface was designed as a sample that can be used for any educational website based on the identified color preferences. Then along with other three websites which were identified from study [7] during the data gathering were compared with the newly developed website among the age groups of 7- and 8-years old students by conducting a post survey. Figma tool was used to draw the User interface design. *The Figure 7 given below shows the newly created UI design by the authors based on the identified highly preferred colors by the age group.*

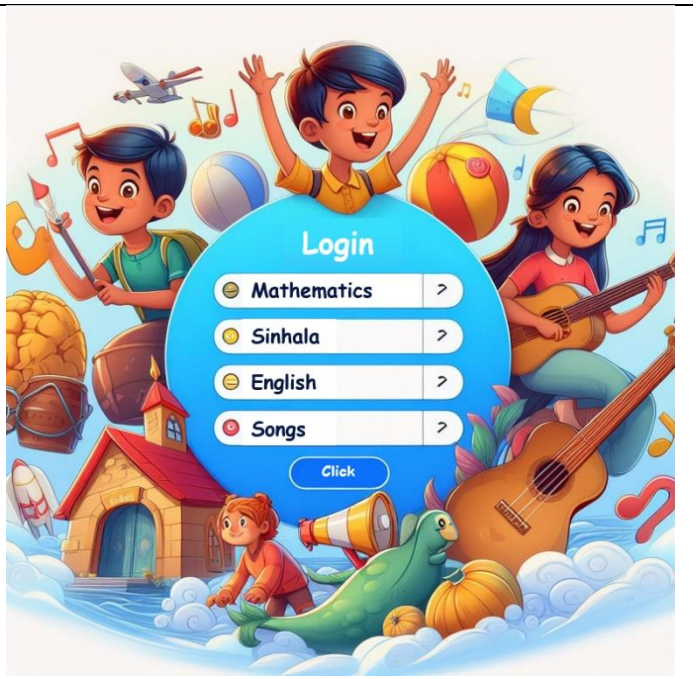

Figure 7: Interactive UI design created with the identified colors
Source: Authors

IV. TESTING AND VALIDATION

Due to privacy and ethics, the names and UIs of the other three websites have not been revealed in the study. Nevertheless, the study conducted an open-ended detailed interview as a post-survey to identify the impact of colors on a website for students. During the interviews, students were shown the four websites, three existing, 'Website 01', 'Website 02', and 'Website 03' along with the website UI designed by the authors with the identified colors. 34 detailed interviews were conducted, and records were taken to a Google form to present the results. Post surveys were supportive in validating the impact of colors in the enhancement of UI in the selected domain for educational websites. The results discussed in the section below will validate the findings.

V. RESULTS

During the post surveys, authors let students choose the most preferred website image considering the appealing nature for them and colors from the included images of four UI designs. The image of the newly created web interface design was considered as "Image 01", selected Website 1 as "Image 02", Website 2 as "Image 03", and Website 3 as "Image 04" in the post surveys. Table 3 and Figure 8 given below shows the results recorded to a google form from the detailed interviews conducted as the post survey.

Table 3: Results of the post-survey
Source: Authors

Website	Selection Criteria	Image Name
Newly created UI design	Used Identified Colors	Image 01
Website 01	Most-used category	Image 02
Website 02	Medium-used category	Image 03
Website 03	Least-used category	Image 04

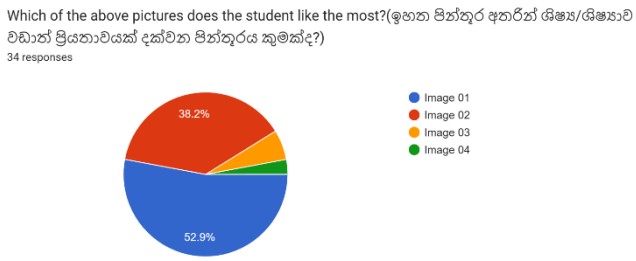

Figure 8: Post survey responses
Source: Authors

As shown in above Figure 8, 34 responses were gathered from the students of the respected age group 7-8 years old from private and public schools. According to the results, 52.9% of the sample preferred Image-01 which was created by the authors using identified colors. 38.2% of feedback was obtained by Image-02 of Website 1 which was from the most used category. 5.88% of feedback was taken from Image-03 which represents Website 2 and 2.94% of feedback for Image-04 which was Website 3. Overall, 31 responses from the 34 were taken by Image-01 and Image-02.

As per the results of the post-survey which was conducted to validate the impact of considering the color preferences in UI designs, it was identified the students preferred the website created by the authors with the colors identified as the highest preferred by age group as the most preferred educational website design among the considered four interfaces.

Hence, the results clearly have shown that even though there are existing websites which are highly used, students will be most likely to get attracted to an UI design which has successfully selected the colors according to the preferences of the user age, gender or any other relevant criteria. Hence, the results conclude that the colors can be considered as an important factor in UI design enhancement.

VI. DISCUSSION AND CONCLUSION

The study was conducted with a balanced experimental setup, where there is more room to succeed. This section hence discusses the limitations, drawbacks and successful facts that the study has flown through. During the data gathering process, it has been limited only for the local educational websites to balance the scope. Hence, the study has only reached to the Sri Lankan educational context and produced the results related to it. Moreover, another critical challenge that study has experienced was to gather the correct feedback from the age 7- and 8-years students. In that aspect, school teachers' and parents' support were taken to get most accurate preferences and to simplify the questions to the student audience. Also, the data-gathering process was limited to only 34 students due to the above-mentioned situations. The selected age category has no experience and much knowledge for scaling their preferences as a presentation or ratio. To avoid this matter, the Likert scale was used to gather the correct preferences. Secondary data sources were also reviewed to make the color selections accurate. Further, three factors were observed when identifying the color preferences based on the specific scenarios such as: gender, keeping attention, and initial feelings. Various lists of colors were identified through this study and both colors identified from primary and secondary data gathering were analyzed to interpret the most suitable colors. Equal size samples were taken from the population to avoid color preference ratio based on gender. Moreover, the privacy of the selected websites had to be preserved. The website names had to be processed anonymously due to ethical considerations. Hence, a study has addressed them as Website 1, Website 2, and Website 3.

In conclusion, the study has proved that there is an impact of color on educational websites. According to the overall process from requirement gathering to the result interpretation, a study has identified different colors from the existing educational websites, emotional preference, attention, and initial feelings. The study emphasized the direct impact of gender and emotional preferences on colors. Also, developers need to focus more on ways to keep the students' attention on the educational web pages. As the final output of this study, it can be highlighted that the created UI design got the highest preference (52.9%) from the students over the existing websites selected from all three categories, highest-used, moderately- and lowest-used. Color may affect the attraction for educational purposes. The study can hence conclude that the colors do impact the UI designs and proper selection of colors can be used as a greatly impacted element to enhance users' interaction with UI designs and create a rich user experience.

Concluding the work, the authors emphasize that as a part of the overall process of education with the educational websites, enhancing the knowledge of the future world holders can also be dependent on color selection that a designer chooses. Hence it is compulsory to keep suitable and preferred color combinations and consistencies when designing user interfaces to keep the interaction.

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VII. FUTURE WORKS

The study has room to expand the work in many aspects in the future. Many other elements in a UI design can be evaluated to check the impact of them in enhancing the UI design. Further, factors such as fonts, user behaviour, user interactions, and gestures, etc can be evaluated in enhancing the user interfaces and user experiences.

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ABBREVIATIONS AND SPECIFIC SYMBOLS

UI - User Interface

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