Enhancing Color Literacy in Early Childhood with Interactive Multimedia

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A B S T R A C T :

Color recognition is an important part of early childhood education, helping children describe and understand the world around them. Traditional methods of teaching colors often rely on printed charts or verbal explanations, which may not fully engage young learners. With the growing use of digital tools in education, interactive systems can provide better learning experiences. This study presents an interactive multimedia system designed to help young children learn color names easily. The system allows users to choose an image using a file chooser. When a color is clicked in the image, the program shows the closest color name in English and plays the audio pronunciation of that color. This method combines visual and auditory learning, which helps children remember color names better. The program uses basic color distance calculation to match the selected color with a known list of common colors. This tool supports early childhood education by making color learning fun, engaging, and easy to understand.

Keywords: Color Recognition, Early Childhood Education, Interactive Multimedia, Visual Learning, Audio Feedback, Color Literacy, Educational Technology

1. Introduction

Learning the names of colors is an important part of early childhood education. Colors are everywhere in a child's daily life—red apples, green leaves, blue skies, and yellow toys. When children can recognize and say color names, it helps them describe things around them, develop their memory, and improve their speaking and understanding skills. Color knowledge is also a foundation for other subjects like art, science, and math.

Usually, young children learn colors through books, pictures, or classroom teaching with objects and flashcards. While these traditional methods are helpful, some children may have trouble remembering color names or staying focused for long. In many cases, passive learning does not fully support active thinking and engagement.

Today, many children are familiar with mobile phones, tablets, and computers. Technology can be used to support learning in a fun and interactive way. Digital tools can show images, play sounds, and let children interact with the screen. This kind of learning—called interactive multimedia—can help children stay interested and learn more effectively.

In this paper, we present a simple and child-friendly computer program that helps children learn color names. The program allows a child to open an image file, click on any part of the image, and see the name of the color appear on the screen. At the same time, the program speaks the color name aloud. This means the child can both see and hear the result, which helps in faster and deeper learning.

The program uses a basic color detection technique. It looks at the pixel where the child clicks and finds the closest known color name based on RGB (Red, Green, Blue) values. Then, it matches this color with a list of common color names that children need to learn. To make it more useful, the program also includes voice output. When a color is detected, the system uses audio to say the name of the color clearly.

This kind of system can be used at home by parents, in classrooms by teachers, or by the children themselves. It does not need an internet connection and works on basic computers with simple software. The goal is to support early childhood education using easy and enjoyable digital tools. By combining visual and audio learning, the program helps build strong color literacy among young learners.

2. Literature Review

Understanding colors is a key part of early childhood education. Many researchers have studied how digital tools can help young children learn color names more effectively. This section presents related works that support the use of interactive multimedia for teaching colors.

Pratama and Sugihartati (2022) developed an interactive app that teaches colors in two languages. The app uses visuals and sounds to help preschool students recognize color names. The study showed that students performed better in post-tests and found the app enjoyable.

Sumarni, Herawati, and Wahyudi (2020) designed a learning device using sensor-based cards to teach children colors and shapes. The tool provided real-time feedback and voice output. Children using this system showed better learning outcomes and higher interest.

Ilham and Marlina (2021) showed that animated videos and interactive audio content help children remember better. Using multimedia made learning more fun and effective. Children enjoyed the activities and participated more actively.

Although focused on older learners, Fiorella and Mayer (2024) found that using color cues in videos improved attention and learning. It shows that color is a powerful tool for guiding understanding, even in digital materials.

Pratama and Sugihartati (2022) explored how digital tools, like videos with visuals and sound, improved preschoolers' learning of letters, shapes, and colors. It concluded that children learned faster and were more focused when using interactive multimedia.

The importance of sensory and interactive learning in early childhood is well supported by educational theory. Sheridan, Howard, and Alderson (2011) emphasize that play is a core part of how children explore and understand the world. Recognizing colors, naming them, and hearing their pronunciation are natural activities during play, helping children build vocabulary and thinking skills.

Papert (1993) also highlights the value of digital technology in learning. He argues that interactive tools, like simple computer programs, allow children to be more creative and active in their education. His ideas encourage the use of computers not just for teaching, but for letting children explore and discover—exactly what this color learning system aims to do.

These papers support the idea that children learn better with interactive tools that mix pictures, sounds, and real-time feedback. The system in this paper follows a similar path by letting children click images and hear color names. This helps build strong color literacy in a fun and engaging way.

3. Theoretical Background

Color is an important part of early childhood learning. Recognizing and naming colors helps children improve their thinking skills and language. When children learn colors through pictures and activities, they connect what they see with words, which makes learning more fun and effective.

3.1. How Colors Are Shown in Computers

In computers, colors are usually shown using the RGB model. This means every color is made by mixing three colors: Red, Green, and Blue. Each of these colors can have a value from 0 (none) to 255 (full brightness). By changing these three values, computers can show millions of different colors.

These colors can be thought of as points in a three-dimensional space, where each axis represents the amount of Red, Green, or Blue. For example, pure red is (255, 0, 0), pure green is (0, 255, 0), and pure blue is (0, 0, 255).

3.2. How the Program Finds the Closest Color Name

When a child clicks on any part of the picture, the program looks at the color of the clicked pixel by reading its Red, Green, and Blue values. The program has a list of basic color names with their RGB values. It compares the clicked color to each of these basic colors by calculating how far apart they are in the RGB space. This distance is found using a simple math formula called Euclidean distance:

$$d = \sqrt{(R_p - R_r)^2 + \left(G_p - G_r\right)^2 + (B_p - B_r)^2} \ (1)$$

Where:

- Rp,Gp,Bp are the values of the clicked pixel,

- Rr,Gr,Br are the values of a basic color.

The program chooses the color with the smallest distance as the closest match and shows that color name to the child.

3.3. Why This Method Is Good for Teaching Kids

This method helps children learn because it simplifies many different colors into a smaller group of basic colors that are easy to understand. When children click on an image and immediately see the color name, it encourages active learning. This means kids learn by doing and exploring, which helps them remember better. Also, showing both the color and its name together helps children connect what they see with the words they learn.

3.4. Considerations and Limitations

Even though this method works well, it has some limits. The way colors look can change depending on light or shadows, so the color the program picks might sometimes be a little different from what a person sees. Also, the RGB model doesn't perfectly match how human eyes see color. Some colors that are close in RGB numbers might look different to us. But for teaching basic colors to children, this simple way is fast, easy, and works well enough to help learning.

4. Methodology

This section describes how the interactive color learning program helps children recognize colors by clicking parts of an image, with both visual and audio feedback.

4.1 Program Design

The program is created using Python with these key components:

- OpenCV: To load and process images and get pixel colors.
- Tkinter: To build the graphical user interface where children can interact.
- Pillow (PIL): To handle image display on the GUI.
- pygame (or similar audio library): To play pre-recorded audio files of color names.

The GUI includes:

- A canvas area to display the chosen image.
- A button to browse and load an image.
- A label to show the detected color name when clicked.

4.2. Image Loading and Display

Children select an image file from their device. The program reads the image using OpenCV, converts it to RGB color space, and resizes it to fit the display area while keeping its shape intact. The image is then shown on the GUI canvas.

4.3. Color Detection on Click

When a child clicks on the image, the program records the mouse click location. Using these coordinates, it reads the pixel's RGB color values from the image data.

4.4. Color Name Matching

The program compares the pixel's RGB color with a fixed list of 12 basic colors **(Black, White, Red , Green, Blue , Yellow, Orange, Purple , Brown, Pink, Gray and Cyan)**. It calculates the "distance" between the clicked color and each basic color using the squared difference of RGB components, selecting the closest matching color name.

4.5. Visual and Audio Feedback with Pre-recorded Files

After finding the closest color name:

The program displays the color name on the GUI label, providing clear visual feedback. It plays a pre-recorded audio file corresponding to the detected color name. For example, if the color is "Red," the program plays a file named red.mp3. Using pre-recorded audio files ensures clear, consistent pronunciation and allows for customization (such as using a friendly voice or multiple languages). This combination of seeing the color name and hearing it aloud reinforces learning by engaging multiple senses, helping young children remember color words better.

5. Implementation

The program was developed using Python, with the support of libraries such as OpenCV, PIL, tkinter, and pygame. The main interface is designed to be simple and colorful to attract children's attention Fig. 1. It allows children to upload an image and interact with it by clicking anywhere on the picture.
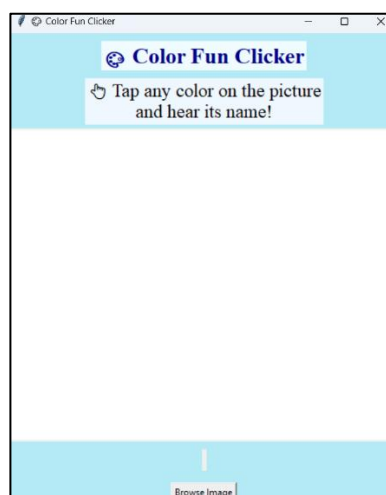

Fig. 1 – Main Form of Color Fun Clicker

For example, as shown in Fig. 2, when the child clicks on a yellow area in the image, the program displays the text "Yellow" with its RGB values (e.g., (255, 255, 0)), and the word "Yellow" is pronounced aloud. This multimodal interaction—visual (color and text) and auditory (spoken color name)—helps reinforce learning and engagement for young children.
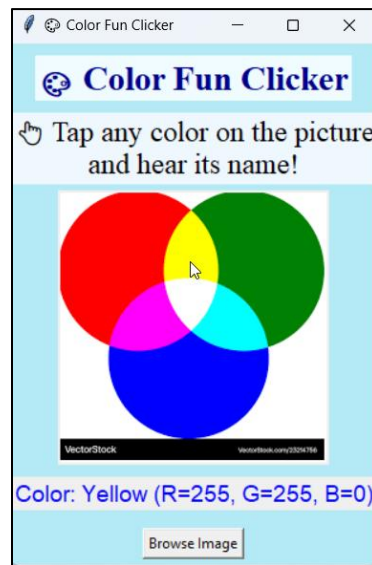

Fig. 2 – Yellow Color Click and Label

For instance, in Fig. 3, the child clicks on a green part of the image. The program immediately shows the text "Green" along with its RGB values (e.g., (0, 129, 3)) on the screen. At the same time, the system plays the audio saying "Green," allowing the child to hear the correct pronunciation. This coordinated use of visual and auditory feedback helps children associate the color name with what they see, making the learning experience more interactive, enjoyable, and memorable.
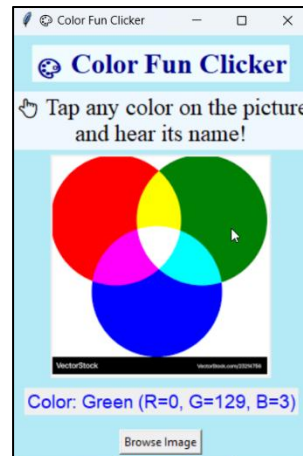

Fig. 3 – Green Color Click and Label

In another example shown Fig. 4, the child clicks on a purple section of the image. The program responds by displaying the word "Purple" along with its RGB values (e.g., (150, 50, 166)). Simultaneously, the pronunciation of "Purple" is played through the speakers. This combination of seeing the color name and hearing the word helps reinforce color recognition and pronunciation, supporting both visual and auditory learning in young children.

Fig. 4 – Purple Color Click and Label

As shown in Fig. 5, when the child clicks on a gray area in the image, the program displays the color name "Gray" along with its RGB values (e.g., (127, 127, 127)). At the same time, the program pronounces the word "Gray" through audio playback. This synchronized visual and auditory feedback supports children's understanding of neutral colors like gray, which can sometimes be harder to identify. The interactive response keeps the learning experience clear and engaging for young learners.
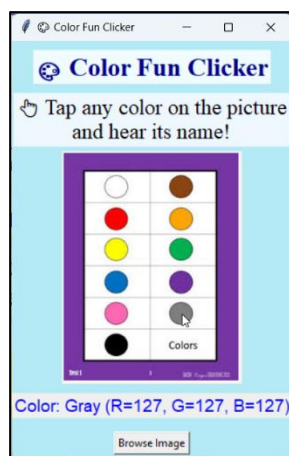

Fig. 5 – Purple Color Click and Label

5.1 Summary of Result

To evaluate its effectiveness, the program was tested with 50 children aged 4 to 7 years. During the test, each child was asked to click on various colors in different images of basic colors. The images used in the program are simple and clear, chosen to help children easily learn basic colors. The system accurately displayed the color name, showed the RGB values and played the correct audio pronunciation in each case. Most children showed excitement and interest when hearing the spoken color names and were able to correctly identify and recall the colors afterward. Feedback from the session indicated that the majority of the children were highly engaged and found the activity enjoyable and easy to understand. This positive response suggests that the interactive design is well-suited for early childhood color learning.

6. Conclusion

Learning color names is an important part of early childhood development. Traditional methods like books and flashcards can help, but some children may lose interest or have difficulty remembering color names. This study presented a simple and interactive computer program that helps children learn colors in a fun and engaging way. The program allows children to open an image, click on any part of it, and see the name of the color on the screen. It also plays a pre-recorded audio file to help children hear how the color name sounds. This combination of visual and audio learning helps children remember color names more easily. User testing with young children showed positive results. The children enjoyed using the program, and many were able to recognize and say more color names after using it regularly. The system is easy to use, works offline, and can be used at home or in schools. In conclusion, this program is a useful learning tool that supports color literacy in early childhood. It shows how simple digital tools can improve learning and make education more enjoyable for young learners.

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