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# Design and development augmented reality using OpenCV for primary education

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## Abstract

Children are known to enter a developmental stage between the ages of three and five. It is during this time that they learn how to write letters by tracing them over and making connections between the dots in books. However, this method of involving kids isn't very successful. What if, instead of limiting children to paper and pencil, we allowed them to use the power of air itself to practice writing? Would that bring a magical element to learning? Would it allow children to begin their educational journey? What if education turns into a magical experience that captivates children and turns the ordinary into something fascinating? Computer vision (openCV) with augmented reality (AR). Writing in air has become a evolving yet significant area of research in the field of image processing and pattern recognition. It has led to the development of various applications which have human machine interface. With high quality computers, video cameras and techniques for automatic video analysis, Object tracking has become the most sought out area in the domain of Computer Vision. This study focuses on comparing virtual air canvas built with OpenCV and mediapipe and virtual air canvas built using OpenCV and numpy. Further into the paper, we shall present you our novel idea of integrating Augmented Reality with Computer vision and its impact on teaching and learning.

**Keywords:** Writing in air; Canvas; OpenCV; Mediapipe; Numpy; Augmented Reality

## 1. Introduction

In schools, alphabets are usually taught to kids through text books and chalkboards, emphasizing on written assignments and memorization drills. However, the educational system fails to meet the demand of children who benefit from kinesthetic learning. To tackle these limitations, there is increasing demand for innovative approaches that use conventional methods of teaching with flexibility of modern technology. The rigorous framework of traditional education system fails to fully utilize the potential of personalized and individualized learning, and thus making it difficult for some kids to understand fully.This is where Augmented reality and Computer Vision will emerge as a revolutionary force.Computer vision is an artificial intelligence area that enables machines to analyze and visualize information from the outside world such as photos or movies. It involves tasks like object identification, scene comprehension, image recognition that helps computers to analyze visual information from the outside world without need of explicit programming.In classroom, Augmented Reality improves learning by superimposing digital content over actual environment through the use of 3D models, simulations and interactive components which encourages interactive learning. Augmented Reality elevates and encourages student interaction while offering context of real world context based learning.

## 2. Literature review

Mehta, Soham et al;(1) discussed in the Augmented Reality Books: An Immersive Approach to Learning, and this research work provides a comprehensive overview of Augmented Reality technology in its first section. It explains how

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augmented reality enhances user perception and interaction through smooth integration of digital and real-world data. The foundation for understanding how Augmented Reality can be utilized to enhance education is laid forth in this section. Augmented Reality seeks to address the flaws of traditional education which might have difficulty in conveying complex subjects by adding new levels of knowledge. With just a mobile smartphone or a pair of AR glasses users can access multimedia content, 3D representations, visuals, and simulations related to the book's subject matter. To illustrate the effectiveness of AR books, the article offers a number of case studies from educational institutions that have successfully used AR technology. These case studies demonstrate enhanced student performance, heightened curiosity in the curriculum and affirmative response from teachers and students.


**Figure 1** An interactive learning system

Saidin, et al; (2)discussed in the research work of A Review of Research on Augmented Reality in Education: Advantages and Applications. This paper demonstrates the research conducted by the researchers about AR and VR applications. It provided us with comprehensive understanding about augmented reality focused websites such as Layar, Content Reveal HP and D-3 enhanced. The paper evaluated the response, strength and weakness of every technology. Modern technology has become indispensable in our everyday lives, simplifying everything for us. Now that they have access to all study materials, websites and instructional platforms, students can stop depending completely on their instructors or educators. The study's researcher strongly advises using augmented reality and other technologies in teaching and learning.

Sun et al; (3) described about Augmented Reality Based Educational Design for Children. An important part of the paper is its emphasis on preparing educational content with AR that matches child's developmental stages. The paper talks about how to use interactive elements, age-appropriate graphics and storytelling techniques that effectively engage children in learning. The study considers a user centric approach that takes care of social, cognitive and emotional traits of a target age group. These days a vast amount of data deals with virtual 3D images; interaction between humans and computers is not considered. Conversely, interactive behavior enhances children's learning and piques young people's interest in visually stimulating interactive technology. Thus, this scheme rationally combines the two technologies, in contrast to traditional visual methods that rarely integrate human-computer interaction with augmented reality devices.

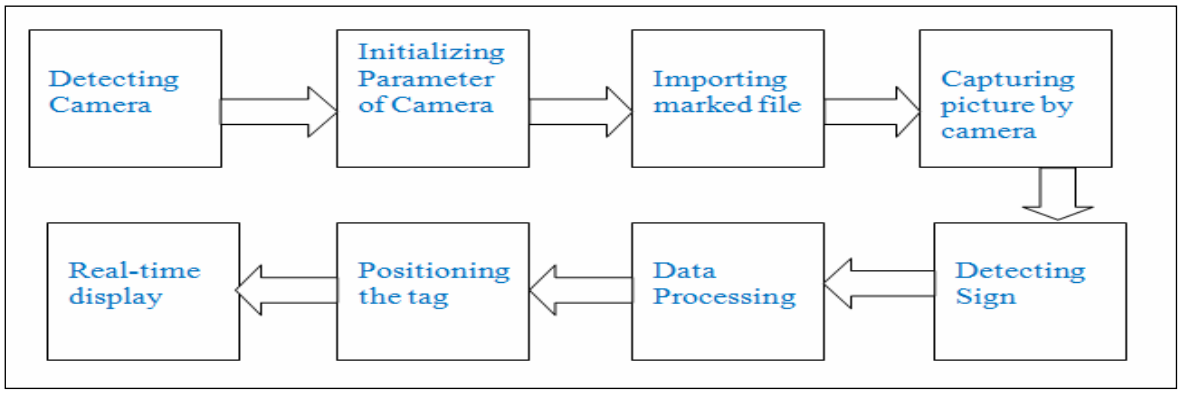


**Figure 2** The process used by this paper.

(4) discussed in the article Hand Gesture Recognition Based on Computer Vision. The paper's main focus is a methodical analysis of hand gesture recognition algorithms. It includes a variety of methods, ranging from more complex ones like deep learning and machine learning to simpler ones like rule-based and template matching techniques. The study examines the benefits and drawbacks of each method, providing a thorough understanding of how each might be applied in different circumstances (5). For example, the primary disadvantage of employing a wearable glove-based sensor approach for gesture recognition was the skin infections that resulted from the sensor coming into contact with the hand, even though the expected results were achieved (6). Thus, the application of Open CV, a computer vision-based system, for gesture recognition was born. Algorithms based on computer vision techniques have been developed to detect hands using different types of cameras. The algorithms try to segment and detect hand features like skin color, appearance, motion, skeleton, depth, 3D model, deep learn detection, and more(7).

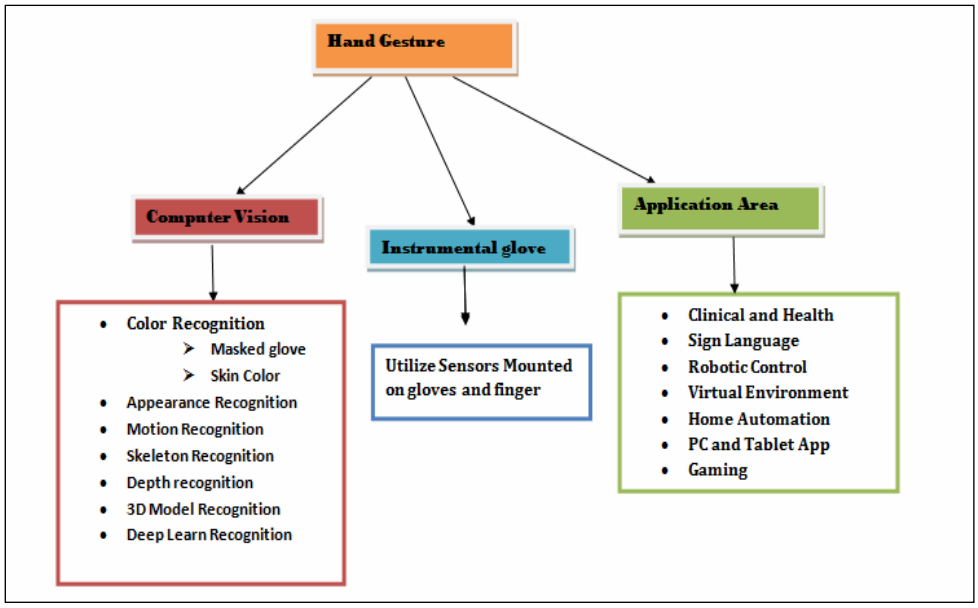


**Figure 3** Various hand gesture techniques used**.**

Kaur et al;(8) discussed in the A Comprehensive overview of AR/VR ,In this article Skeletal tracking is a feature of the Leap Remote Control that tracks each individual finger within the contact area of the device. This results in the skeletal joint coordinates of the finger being retrieved, and the Leap Motion Controller sensor is used to obtain the distal micro lading socket coordinates of the human hand(9). The software chooses the primary points that will represent each stroke from a set of points that make up each stroke. Key points are identified by the constant direction change. To determine the appropriate range for slope n in order to obtain the important points, three tests were conducted. Tolerance is the lowest allowable value of the shift between slopes n(10).

**Figure 4** Air Canvas and Mask.

P. Rai et al; (11)discussed in the Virtual Canvas for Interactive Learning using OpenCV .This paper focuses on the architecture and design of the Virtual Canvas system. It explains how the system records and analyses motions, gestures, and objects instantly by integrating OpenCV. An immersive and dynamic learning environment is produced when users interact with graphical elements in a virtual canvas. The project creates a motion-to-text converter using object-tracking techniques that could be used as instructional software to enable teachers and students to write in the air. The project generates letters on the screen by tracing the path of an object or finger using computer vision. The generated text can be utilized for a variety of tasks, including the resolution of graph-related issues. Math problems requiring logical thinking, formula writing or derivation work, teaching kindergarteners the alphabet, replacing chalkboards and chalk with dust-free classrooms in offline classrooms, etc. For the deaf, it will be a useful communication tool. The paper explains how to use the virtual canvas and shows how to draw, manipulate shapes, and experiment with different image processing algorithms in real time. It highlights the interactive elements of the platform, which encourage a more dynamic and engaging learning environment by allowing users to receive immediate visual feedback in response to their inputs.

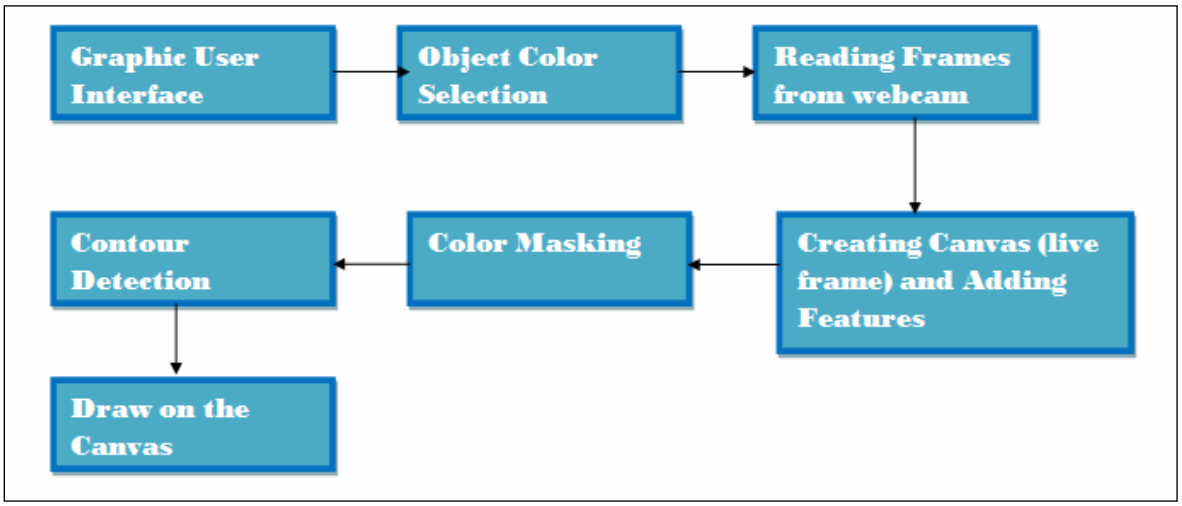


**Figure 5** Methodology used for virtual air canvas

V. RamachandraH, G et al; (12)described in the article about Virtual Air Canvas

Using OpenCV and Mediapipe.”Virtual Air Canvas Using OpenCV and MediaPipe" demonstrates a creative application of computer vision technology by fusing OpenCV's image processing capabilities with MediaPipe's hand tracking capabilities. The study opens up new possibilities for interactive technology and artistic expression in the fields of education and the arts, and it furthers the study of gesture-based interaction. Novel Deep Learning techniques along with the latest developments in computer vision application scenario design were considered in the studies. You will learn how to use Hand Tracking through this project (13). As soon as the user's hand is captured up by the webcam, the program begins to automatically create a bounding box around it. In order to enter sketching mode, users can expose their index finger. The user must spread their middle and index fingers to use the various functions. MediaPipe is an open-source, cross-platform machine learning solution for streaming and live video from Google. Put another way, MediaPipe provides users with access to a wide variety of trustworthy Machine Learning models that were developed with consideration for the limitations imposed by mobile hardware. MediaPipe provides basic machine learning models for everyday tasks such as hand tracking, thereby lowering the current development barrier. The workflow stage of this system is the most fascinating component. There are many purposes for which drawing is used. As a result, the number of gestures and activities required to operate this particular system are equal. A specific area of the image can be highlighted by using the masking technique. In order to highlight only the non-zero portions of the image, it entails giving nonzero values to particular image pixels, such as those in the pink, green, and blue color spaces.


**Figure 6** Inverse Mask**.**

Reddy, G. Manoj et al.(14) discussed in the AIR SCRIPTING USING OPENCV. This has a very similar design to the one we will be using for our project. After reading every frame initially, the colors that are readily identifiable are converted to their HSBV values. After creating an Air Canvas and attaching all necessary buttons to it, the mask is pre-processed by going through a set of steps that include identifying every contour in the frame, selecting the largest contour, figuring out its center coordinates, and storing them in an array (deque). The points were drawn using this deque data. The system's effectiveness was evaluated under various lighting scenarios. They discovered that, in order to get the best results, the lighting condition should be medium; otherwise, the system is more likely to malfunction.

| Sl.No | Test Conditions | System Behavior |
|---|---|---|
| 1 | High Intensity of Light | Not able to Detect Mask Properly |
| 2 | Medium Light Intensity | Able to Detect the Mask |
| 3 | Poor Lightening Conditions | Sometimes detects, sometimes fails |

**Figure 7** Test conditions and System Behaviour

Feher, Peter and Aknai, et al(15) described about Augmented Reality applications from Kindergarten to secondary school Classroom.

This paper makes use of augmented reality, which has gained popularity across all educational levels in recent years. It offers digital skills and creativity to create a link between the physical and digital worlds, encourage experiential learning, give kids visual aids to help them comprehend the lessons, and create an engaging, real-world learning environment(16)t.

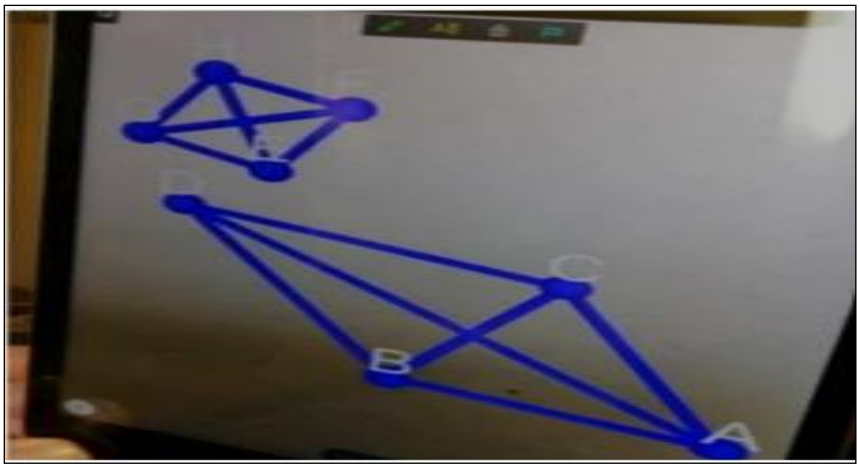


**Figure 8** Example of Geo AR.

**Table 1** Comparative study of Literature Reviews

| Authors | Title | Remarks |
|---|---|---|
| Mehta,Soham Jain,Pratish and Vora, Aayush i andJoshi,Abhijit andDalvi,Harshal | Augmented Reality Books: An Immersive Approach to Learning | This paper aims to investigate the potential of augmented reality in books. The work encourages the development of a lively learning environment. |
| Saidin, Nor and Abd halim, Noor, Yahaya, Noraffandy | A Review of Research on Augmented Reality in Education: Advantages and Applications | The researchers gave us insights on how to infuse quality of training in education |
| Sun, M., Wu, X., Fan, Z., and Dong, L | Augmented Reality-Based Educational design for children | Interactive elements and age appropriate contents are developed for kids |
| Oudah, Munir and Al-NajiAliAbdulelahandChahl, Javaan | Hand Gesture recognition based on CV: review of technique | Different approaches for hand gesture recognition are developed. |
| Kaur, Harneet, Reddy, Busireddy and Sai, Guna and Raj, Akula. | A Comprehensive overview of AR/VR by Writing in Air | The leap Remote Control has a skeletal tracking system that focuses on the individual fingers throughout the device's contact region |
| P. Rai, R. Gupta, V. Dsouza and D. Jadhav | Virtual Canvas for Interactive Learning using OpenCV | The paper describes the functionalities of the virtual canvas, demonstrating real-time drawing, shape manipulation, and algorithm experimentation image processing |
| Reddy, G. Manoj | Air Scripting using OpenCv | Air Canvas is created for writing and learning |
| Feher, Peter and Aknai, Dóra Orsolya | Augmented Reality applications from Kindergarten to secondary school Classroom | In this paper they use augmented reality which has become popular in recent years all the level of education. It provides creativity and digital skills and to connect the real and digital world |
| Ramachandra H Balaraju Deepika, Navya, Sebastian | Virtual air canvas using open cv and mediapipe | Air Canvas is created for writing and learning |

### 1.1. Proposed application in the field of education

A big step toward providing all students with a dynamic, welcoming, and enjoyable learning environment is the incorporation of augmented reality and computer vision using OpenCV in the alphabet learning domain. By utilizing these tools, educators can solve the drawbacks of conventional approaches and guarantee that learning becomes a customized experience that meets each student's unique needs and learning preferences (17). The combination of technology and education has the potential to completely change the way we teach the alphabet, thus changing the face of education as we know it today.

In the branch of artificial intelligence known as computer vision, visual data from the outside world, like pictures or movies, can be interpreted and understood by machines. It involves activities like object detection, scene comprehension, and image recognition, enabling computers to comprehend visual input without explicit programming. In education, augmented reality (AR) improves learning by superimposing digital information over the physical environment (18_. Through the use of 3D models, simulations, and interactive features, it encourages immersive and engaging learning experiences. AR alters conventional teaching strategies by increasing student engagement and giving them access to practical, context-based learning opportunities. Thus, the proposed project aims to address these challenges by introducing an innovative approach to alphabet learning. Through the integration of OpenCV and augmented reality (AR), the project seeks to create an air canvas where learners can practice writing alphabets in the air, combining the benefits of kinesthetic learning with the engagement of AR-based visualization (19).

## 3. Methodology and way forward

So far to achieve this progress, we have built a web application which has a part dedicated for OpenCV using MediaPipe. Where kids can write in air and practice alphabets. Going forward we are aiming to integrate Augmented Reality into the website where kids can read books and enhance their learning.

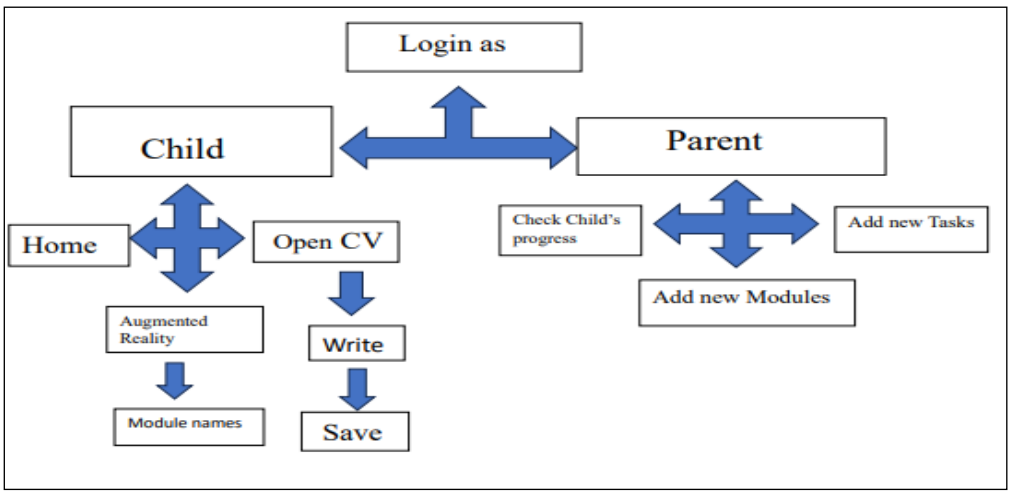


**Figure 9** Workflow designed for the web application.

Air canvas using open CV: To develop this project, the technology used would be OpenCV's computer vision methods. Python is favored because of its extensive libraries and simple syntax, but by grasping the fundamentals, it can be implemented in any language that supports OpenCV(20). Here, the goal is accomplished by using color detection and tracking. A mask is created after the color marker has been found. It also comprises the subsequent morphological processes of erosion and dilation on the finished mask. Erosion removes the impurities from the mask, and dilation further repairs the main mask that has been eroded.

- Step1: Convert the collected frames to HSV color space and begin reading the frames.
- Step2: Put the appropriate ink buttons on the canvas frame after it has been prepared.
- Step3: Adjust the track bar values for finding the mask of the colored marker.
- Step4: Preprocess the mask with morphological operations (Eroding and dilation).
- Step5: Find the largest contour's center coordinates and maintain saving them in the array (arrays for painting points on canvas) for all the subsequent frames.
- Step6: Finally draw the points stored in an array on the frames and canvas.

## 4. Results and discussion


**Figure 10** Air Drawing

Figure 10 shows the Air drawing of letter A.

Furthermore, we have also conducted a comparative study on various ways to implement augmented reality. The study is represented in the below table.

**Table 2** Comparative study on various ways to implement augmented reality

| **Feature** | **A-Frame** | **Unity3D** | **ARKit** | **ARCore** | **Vuforia** |
|---|---|---|---|---|---|
| Platform Support | Web-based (VR/AR on browsers) | Multiple platforms(PC,mobile) | iOS(Apple devices) | Android | Cross-platform |
| Ease of use | Beginner-friendly | Intermediate to advanced | Advanced | Intermediate to advanced | Beginner to Intermediate |
| Development Language | HTML,javascript | C#,UnityScript(JavaScript) | Swift, Objective-C | Java,C++,Unity,(C# for Unity) | C#, C++, Java |
| Community and Support | Active community, good documentation | Large community, extensive resources | Apple developer community | Active community, developer resources | Active community, extensive documentation |
| Integration with AR Features | Limited native AR features | Integrated AR foundation package | Native AR support | Native AR support | Native AR support |
| Performance | Web-based performance(may vary) | High performance | High performance (iOS devices) | High performance (Android devices) | Good performance |
| Learning Curve | Quick learning curve | Moderate learning curve | Moderate learning curve | Moderate learning curve | Beginner friendly |
| Cost | Free and open source | FREE(unity Personal),paid(Unity Pro) | Free(iOS development)Apple developer program(required for distribution) | Free (Android development),Licensing for distribution | Free(limited features),paid plans available |

| | | | | | |
|---|---|---|---|---|---|
| Marker-Based AR | Limited Support | Yes | No(primarily tracking) | No(primarily surface tracking) | Yes |
| Markerless AR | Yes(primarily scene based) | Yes | Yes | Yes | Yes |

*Abbreviation*

- AR- Augmented Reality
- VR-Virtual Reality
- OpenCV- Open Computer Vision Library

## 5. Conclusion

After surveying the existing methodologies and techniques which incorporate open CV and Augmented reality for educational purposes separately, it would be a novel idea to integrate both these features into one web application which will foster easy access and better learning environment for kids. The development of an Augmented Reality and Open CV based learning platforms offer a promising solution to improve interaction systems. The traditional method of learning can often be passive and monotonous, but this can empower children to learn and practice letters independently, making learning more engaging and self-directed.

## Compliance with ethical standards

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*Disclosure of conflict of interest*

The authors declare that there is no conflict of interest.

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*Authorship contribution*

- Conceptualization: Dr Smitha Sasi
- Data curation: Mrs Rajeswari P
- Formal analysis: Dr Smitha Sasi
- Acquisition of funds: Mrs Rajeswari P
- Research: : Dr Smitha Sasi
- Methodology: : Dr Smitha Sasi
- Project management: Mrs Rajeswari P
- Resources: Mrs Rajeswari P
- Drafting - original draft: Dr Smitha Sasi
- Writing - proofreading and editing: Dr Smitha Sasi

*Statement of Ethics approval*

This study does not contain any studies with human or animal subjects performed by any of the authors.

*Data availability*

Data sharing is not applicable to this article as no new data were created or analyzed in this study.

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