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# Clever Zone – An Interactive Mobile Learning Aid for Advanced Level Biology Students in Sri Lanka

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***Abstract*** **- This research paper discusses the mobile application developed as a learning aid for A/L Biology students to enhance their learning experiences in the field of biology, specifically focusing on microbes, animal classification, and human body systems. The main feature of this includes an Artificial Intelligence (AI) chatbot that utilizes natural language processing and image recognition technologies to help students understand key biological topics. Extensive research was conducted to align the app's content with the Advanced Level Biology syllabus, ensuring its relevance to the curriculum. The app offers a user-friendly interface with engaging visuals and a carefully curated knowledge base, allowing students to explore and study independently. User research with A/L Biology students demonstrated that the app significantly improved comprehension and memory of the subject matter, while the chatbot's ability to provide accurate information and foster interactive learning was highly rated by participants. Overall, the A/L Biology mobile app demonstrates the potential of mobile technology and AI in revolutionizing biology education, providing an easy and interesting platform for students to improve their learning outcomes and achieve academic goals. By utilizing machine learning for various functions, A/L Biology students can greatly benefit from enhanced learning of complex subjects with an accuracy of more than 90% in every learning category.**

***Keywords:*** Machine learning, NLP, biology, education, mobile application.

## I. INTRODUCTION

Education plays a crucial role in shaping the life and culture of Sri Lanka. The country's education system begins at age 6 and extends until age 19, with a series of examinations conducted by the government. Among the most challenging assessments is the Advanced Level (A/L) examination, with the biological stream being particularly demanding. Students face significant hurdles in passing these subjects, as they must navigate through extensive books containing overwhelming information. The local syllabus often adds to the confusion and contradictions, further complicating the learning process.

In addition, schools in remote areas of Sri Lanka encounter resource limitations and inadequate facilities, which hinder students' access to a comprehensive education. The country's slow adoption of new technologies exacerbates this issue, as traditional teaching methods prevail despite the prevalence of smart devices in everyday life. The absence of high-quality, locally relevant learning tools that align with the syllabus contributes to this disparity.

Unfortunately, there is a dearth of research in this field, impeding our understanding of the challenges faced by Sri Lankan students and hindering the development of effective solutions. Existing research is scarce and often requires students to purchase resources separately. For instance, available applications like The Human Body by Tinybop and A Level Biology Quiz offer limited functionalities, such as multiple-choice questions and answers, failing to provide a comprehensive learning experience.

This research project aims to address the shortcomings of the traditional learning system in A/L biology in Sri Lanka. The primary objective is to develop a smart mobile application that enhances the learning experience and overcomes these challenges. The proposed application will include features such as animal species identification, providing additional content and visualizations for better understanding. Additionally, it will incorporate a Natural Language Processing (NLP) chatbot to offer accurate solutions to user queries. The application will also facilitate the identification of body parts through visual presentations, providing comprehensive content and visual aids. Furthermore, a function for micro-organism classification and properties identification will utilize a database to retrieve relevant information.

 

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By introducing this innovative learning system, the research aims to make A/L biology education in Sri Lanka more effective, efficient, and convenient. The application's features will engage students, improve memorability, and align with the local syllabus. This research project seeks to contribute to the advancement of education in Sri Lanka by leveraging technology and creating a more accessible and engaging learning environment for students.

## II. LITERATURE REVIEW

A study gap that hasn't been sufficiently addressed in published research articles is the creation of a mobile application specifically made for A/L biology students who follow the local English-medium curriculum, according to Clever Zone. Applications that are now available to local biology students are unpopular and do not completely cover the curriculum “[1],[2]”. This knowledge gap offers a chance for the creation of the cutting-edge mobile app Clever Zone, which strives to close this educational gap and provide advanced biology students with a thorough and individualized learning experience.

Although there are several mobile applications for learning biology, they were not created with Sri Lankan biology students in mind but were predominantly created for foreign curricula “[3],[12],[13],[14]”. For instance, TinyBob is mobile biology software created for international students at various school levels. Many Sri Lankan students may be unable to afford these applications and might not be in line with the regional curricula. Contrarily, Clever Zone requires little setup effort and can be quickly deployed on Android and iOS mobile devices, assuring accessibility for all students.

One of Clever Zone's standout functions is its capacity to recognize handwritten text, which focuses on microbe names scribbled in pupils' notebooks. Even while there are research articles on the subject, such as "Handwritten Text Recognition: With Deep Learning and Android" [4], they primarily concentrate on text recognition in a wider context rather than in biology education. These publications use text recognition methods like convolutional neural networks (CNNs), although the training data may not be relevant to biology teaching. ‘Handwritten Text Recognition System based on Neural Network’, this research paper introduces a handwritten text recognition system based on a neural network, without specific information regarding its application domain or architecture “[16]”.

Image processing-based animal recognition is another element of Clever Zone. Although research publications on machine learning-assisted automated animal identification and detection have been published, they focus on larger applications and contexts rather than explicitly addressing the objectives of the A/L biology curriculum in Sri Lanka “[6],[7]”. These papers cover the use of machine learning algorithms for classifying and locating diverse animals, however, they do not include the necessary instructional materials for students to learn from.

The NLP chatbot function in Clever Zone seeks to give students precise answers to their inquiries within the parameters of the A/L biology curriculum. A critical assessment of the ethical implications and potential solutions connected with chatbot adoption in these fields is provided in research articles on chatbots in education and research, such as "Chatbots in Education and Research: A Critical Examination of Ethical Implications and Solutions" “[8]”. Instead of concentrating primarily on A/L biology syllabus-specific solutions, these papers examine many elements of chatbot usage, ethical issues, and future effects on education and research.

Last but not least, the Clever Zone application has an image-processing feature for detecting human body parts. Although the research paper "Deep Residual Learning for Image Recognition" introduces a deep learning architecture called ResNet for image recognition tasks, it focuses more on the general problem of image recognition than on human body part detection or its use in the context of a biology curriculum “[10]”. Similar to this, the study "Learning to Segment Object Candidates" suggests a technique for identifying human body parts in images using object proposal algorithms and convolutional neural networks (CNNs), but it does not specifically address the needs of advanced biology students or the regional curriculum “[11]”.

Despite the existence of research publications on relevant subjects including picture recognition, chatbots in education, automated animal identification, and hand-written text recognition, none of them specifically address the scope, target audience, or content needs of Clever Zone. The suggested mobile application intends to close this market gap by offering A/L biology students who follow the local English-medium curriculum a thorough and personalized learning experience.

## III. METHODOLOGY

The proposed solution is to provide a convenient way for the students to learn their syllabus contents effectively also helps to save time and provide accurate, reliable content with various visualizations.

 

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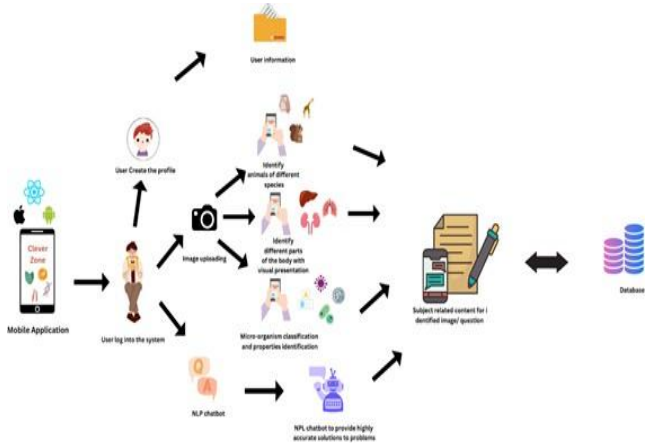


**Figure 1: System overview diagram**

As shown in the diagram, all students must register with the system. Anyone can log on to the system by adding a username and password. After that via the dashboard, students are able to navigate the feature they want. The system has advanced text recognition, animal identification, human body part identification, and chatbot capability based on NLP. For any of these qualities to perform precise recognition or produce suitable replies, the user must provide specific input. The user must take a picture of the animal or part of a person they want to identify in order to identify an animal or identify a human body part. The user takes the photo of a term by cropping the captured picture which is taken from their own personal notebook for text recognition. When a user asks a query or gives an instruction, the NLP chatbot functionality responds. The technology uses cutting-edge natural language processing algorithms to decipher the query's context and intent.

This application is developed by using React Native as a framework, firebase as a database, and python flask.

### A) Natural Language Processing Chatbot For Answer Questions

The methodology for developing the NLP chatbot is as follows. First, a dataset consisting of questions related to the curriculum was collected from reliable sources such as resource books, and past papers and then underwent preprocessing steps to clean and normalize the text data. This involved removing punctuation, converting text to lowercase, removing stop words, and performing tokenization and lemmatization. Feature engineering techniques were applied, including bag-of-words representation and TF-IDF vectors, along with additional features such as question length or complexity. The Multinomial Naive Bayes algorithm was selected for training the NLP chatbot model. The dataset was split into training and validation sets, and hyperparameters were tuned using cross-validation. The model was trained on the textual and additional features to capture patterns and relationships between questions and answers. To evaluate the model's performance, metrics such as accuracy, precision, recall, and F1 score were computed. Confusion matrices and classification reports were generated for further analysis. The model was evaluated on a separate test dataset to assess its effectiveness in predicting correct answers. The model was saved in a pickle file format for easy loading and reuse without retraining.

### B) Microorganism classification and property identification

The hand-written text recognition feature's methodology entails several crucial processes to accurately identify microorganism names and display pertinent material from the syllabus with associated photos. First, selected three microorganisms namely focus on Nostoc, Azotobacter, and Penicillium. When selecting the above-mentioned organisms, mainly focused on that frequently questioned species during the examinations. These microorganisms will serve as the target entities for recognition in the hand-written text. A/L students' notebooks are gathered, and the handwritten words are retrieved to produce the dataset for each microorganism "[15]". Then, these words are identified with the appropriate microbe. The dataset is painstakingly constructed to guarantee complete coverage and variability, supporting reliable model training. Applied techniques such as data cleaning, normalization, and augmentation to ensure the dataset is well-prepared for training. The framework for training the model is the MobileNetV2 algorithm linked with TensorFlow. In image recognition tasks, MobileNetV2 is renowned for its effectiveness and accuracy, making it appropriate for this application. The Google Colaboratory platform, which offers a dependable and practical environment for carrying out machine learning tasks, is used for training.

High accuracy is the goal during the training process, and it is measured using a predetermined evaluation metric. As soon as the microbe name is recognized, the system displays the pertinent syllabus material. These materials provide important facts and information on the particular microbe along with visually attractive illustrations like pictures. To improve user experience and aid in memory retention, color combinations are strategically used in interface design. As iterations and improvements, continuously monitor and evaluate the system's performance. Collect user feedback and iteratively refine the model and user interface based on the received inputs. This process ensures the continuous improvement of the hand-written text recognition feature.

This technology allows the hand-written word recognition tool to recognize microbe names from handwritten

 

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notes and to display useful syllabus-related knowledge with interesting graphic representations, enriching the learning experience.

**C) Animals identification and classification**

The methodology for the research project on developing a system to identify animal species involved several key steps. Initially, a dataset of animal images was collected and organized into separate folders based on their respective species. The data was then divided into training and validation sets. The ResNet50 architecture, pre-trained on the ImageNet dataset, was chosen as the base model for the animal identification system. The model's layers were frozen to prevent further training and enable feature extraction. A custom fully connected layer was added on top of the ResNet50 model to make predictions for the different animal species. The model was compiled with the Adam optimizer, categorical cross-entropy loss function, and accuracy as the evaluation metric. Data augmentation techniques, including rescaling, shearing, zooming, and horizontal flipping, were applied to the training data using the ImageDataGenerator class from Keras. This helped increase the model's ability to generalize and recognize animals in various orientations and backgrounds. The test data were rescaled only. The model was trained using the augmented training data and evaluated on the validation data. The training process was monitored by tracking the loss and accuracy values for both the training and validation sets over multiple epochs. The model was trained for 8 epochs, and the resulting loss and accuracy curves were plotted and saved as visualizations. An image prediction function was implemented to test the model's performance on new animal images. It loaded the saved model and accepted a new image as input. The image was preprocessed and passed through the model for prediction. The predicted class label and the corresponding image were displayed, enabling the identification of the animal species based on the input image. In summary, the methodology involved data collection, model selection and configuration, training and evaluation, data augmentation, and prediction of new images. This comprehensive approach resulted in the development of an animal species identification system capable of accurately recognizing and classifying different animal species based on input images.

**D) Human body parts identification and classification**

The methodology for the research project on developing a system to identify human body parts involved several key steps. Firstly, a dataset of human body part images was collected and organized into separate folders based on their respective categories. The data was then divided into training and validation sets. The InceptionV3 architecture, pre-trained on the ImageNet dataset, was selected as the base model for the human body part identification system. The layers of the InceptionV3 model were frozen to prevent further training and allow feature extraction. A custom fully connected layer was added to the InceptionV3 model to predict the different body parts. The model was compiled with the Adam optimizer, categorical cross-entropy loss function, and accuracy as the evaluation metric. Data augmentation techniques, such as rescaling, shearing, zooming, and horizontal flipping, were applied to the training data using the ImageDataGenerator class from Keras. This helped enhance the model's ability to generalize and recognize body parts in various orientations and variations. The test data was only rescaled. The model was trained using the augmented training data and evaluated on the validation data. The training process was monitored by tracking the loss and accuracy values for both the training and validation sets over multiple epochs. The model was trained for 10 epochs, and the resulting loss and accuracy curves were plotted and saved as visualizations. To test the model's performance on new images of human body parts. The function loaded the saved model and accepted a new image as input. The image was preprocessed and passed through the model for prediction. The predicted class label and the corresponding image were displayed, allowing for the identification of the human body part based on the input image.

## IV. RESULT AND DISCUSSION

**A) Natural Language Processing Chatbot for Answer Questions**

The NLP chatbot developed in this project aimed to assist A/L biology students by offering answers to their questions. The Multinomial Naive Bayes algorithm, known for its effectiveness in text classification tasks, was chosen as the underlying model for the chatbot. It was integrated into a robust pipeline structure that encompassed key components such as vectorization, TF-IDF transformation, and classification. By employing this pipeline, the chatbot was equipped to understand the nuances of different questions and provide accurate answers based on learned patterns from the training data. During the training process, hyperparameter tuning was performed, with an emphasis on selecting an optimal alpha value for the MultinomialNB classifier. To assess the performance of the chatbot, a comprehensive evaluation was conducted using a test set consisting of unseen questions. The chatbot achieved an accuracy score of 0.0427 on this test set, indicating its capability to generate relevant and insightful answers. This accuracy score serves as a promising indicator of the chatbot's effectiveness in addressing a wide range of biology-related queries.

 

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```
[21] import pickle
     pickle.dump(text_clf, open("chatbot_model.dat", "wb"))

[22] with open('chatbot_model.dat' , 'rb') as f:
         model = pickle.load(f)

[23] text = ['blood glucose level of men?']
     model.predict(text)

     array(['Fasting blood glucose level is 70 - 110 mg/100 ml blood,'],
           dtype='<U326')
```

**Figure 2: Results of NLP chatbot-trained model**

Although the chatbot showcased promising potential, it is essential to acknowledge certain limitations and areas for improvement. For instance, the chatbot's performance may vary depending on the complexity and diversity of questions, as well as the specificity of the topics covered. Additionally, refining the preprocessing techniques and exploring advanced natural language processing models could contribute to further enhancing the chatbot's accuracy and coverage.

### B) Microorganism classification and property identification

The system for identifying handwritten text attained a remarkable accuracy level of 0.980. This high degree of accuracy illustrates the system's efficiency in correctly deciphering the names of microorganisms from handwritten notes.

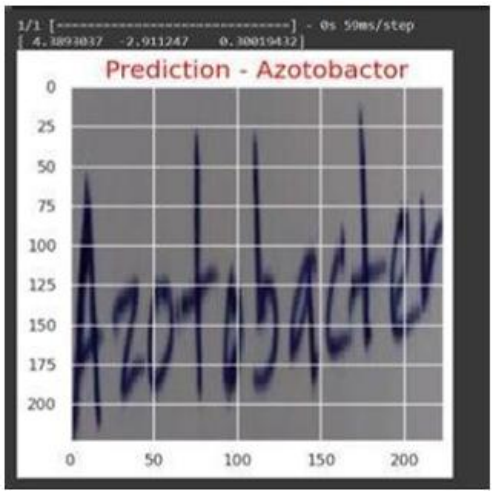


**Figure 3: Accuracy of the identified text**

The precision achieved exceeds the standards specified for the system, demonstrating its dependability and potential for useful applications. The handwritten text recognition accuracy rate of 0.980 carries major implications for real-world use cases and possible improvements in the discipline. The technology effectively digitizes and processes handwritten text by correctly detecting microbe names from handwritten notes. Information retrieval, data analysis, and educational uses are just a few of the many uses for this capacity. The system's excellent accuracy rate serves as evidence of its reliability and sturdiness. The dataset's thorough preparation, which included a wide variety of handwriting styles and variances, helped the model generalize effectively. The system's performance was further improved by the use of the MobileNetV2 algorithm, which is renowned for its effectiveness and precision in picture recognition tasks. The system's ability to recognize and understand handwritten writing effectively was made possible by the integration of cutting-edge technology like optical character recognition (OCR) and natural language processing (NLP). Combining these methods made it possible to digitize handwritten text effectively, enabling further examination and use. Additionally, the user experience was greatly improved and memory retention was aided by the user interface design. Users found the system to be more user-friendly and interesting due to the color schemes and visual representations used in the interface design. In conclusion, the hand-written text recognition system demonstrated its ability to correctly detect microbes' names from hand-written notes by attaining an impressive accuracy level of 0.980. The outcomes support the system's dependability and future uses, paving the way for more accurate information retrieval and analysis across a range of fields. The system's reliability, effective training approach, and user-friendly interface design all contribute to its successful performance and set the stage for further development and innovation.

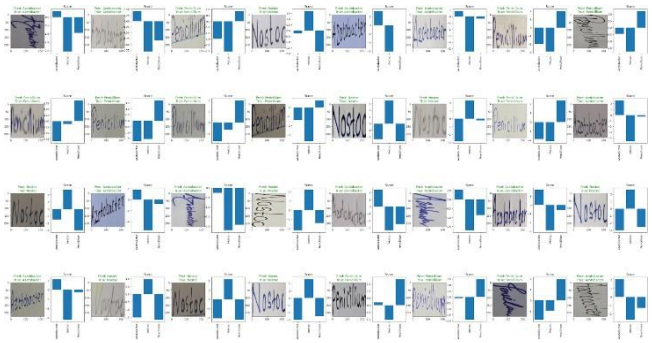

**Figure 4: Result of the trained model with handwritten text**

### C) Animals identification and classification

The A/L Biology mobile app's animal identification tool had an accuracy rating of 0.6715. This shows that the AI chatbot correctly identified animals in about 67.15% of the animal identification tries conducted using the app. The accuracy level is within a reasonable range, but it indicates an opportunity for development in correctly identifying and classifying different animal species.

The animal identification feature's modest accuracy level has advantages and disadvantages. On the plus side, the app can still be a helpful resource for children to learn the basics of animal identification and to research other species. It can

 

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serve as a foundation for understanding animal traits and fundamental categorization. Although there is a chance of misclassifications, users should exercise caution and support the app's information with additional sources. To improve accuracy and guarantee users have a more trustworthy experience with animal identification, the app's development team should concentrate on improving the algorithms, growing the data set, and soliciting user input. Addressing flaws and enhancing the app's general usefulness as a learning tool will require regular upgrades and evaluations.


**Figure 5: Accuracy of the identified animal**

### D) Human body parts identification and classification

The Clever Zone mobile app's human body part recognition feature has achieved an impressive accuracy rating of 0.970. This shows that the trained image processing model correctly recognized human body parts in approximately 97.0% of the recognition attempts made using the application. The high accuracy level shows the effectiveness of the developed algorithm in correctly classifying and identifying different parts of the human body.

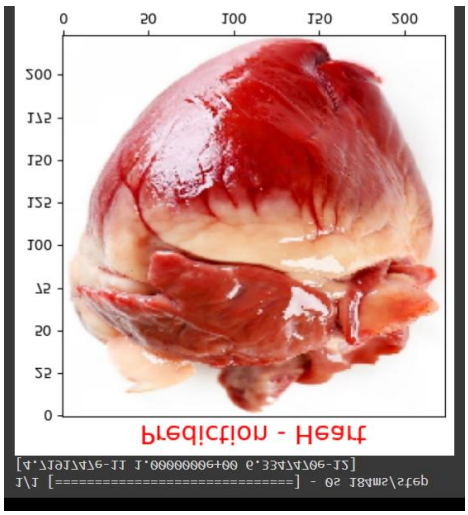

**Figure 6: Accuracy of the identified Body Part**

The human body parts recognition feature integrated into the Clever Zone mobile application is specially designed for Sri Lankan A-Level Biology students studying in English medium. This feature has demonstrated an impressive accuracy rating of 0.970, surpassing established standards for the system. This high level of accuracy demonstrates the reliability of the system and its potential to greatly improve the learning experience. The accuracy rate of 0.970 has significant implications for the target user group. By effectively identifying and classifying different parts of the human body. It provides a comprehensive understanding of human anatomy and serves as a reliable resource for understanding and memorizing various body parts.

The dataset used for training the algorithm was thoughtfully curated to include a wide range of body part images relevant to the syllabus. This ensures that students are exposed to accurate representations of body parts commonly encountered in their studies. The integration of the MobileNetV2 algorithm, known for its effectiveness and accuracy in image recognition, further enhances the system's performance. By incorporating advanced technologies such as optical character recognition (OCR) and natural language processing (NLP), the system effectively recognizes and understands parts of the human body while aligning with users' specific needs.

The app's user interface design has been carefully customized to optimize the learning experience. The choice of color schemes and visual representations considers the cultural and educational context, resulting in an attractive and user-friendly interface that facilitates effective learning and aids knowledge retention. Finally, the Clever Zone mobile app's human body part recognition feature achieved a high accuracy value of 0.970. This demonstrates its reliability and potential to enhance the learning experience in A-level biology. The system's effective training approach and user-friendly interface design contribute to its success and pave the way for future advancements in human body part recognition technology.

## V. CONCLUSION AND FUTURE WORK

This research paper highlights the existing gap in addressing the specific needs of A/L Biology students following the English medium local syllabus in Sri Lanka. While several research papers touch on related topics such as hand-written text recognition, automated animal identification, chatbots in education, and image recognition, none directly address the scope, target audience, and content requirements of the proposed mobile application, Clever Zone.

The development of Clever Zone aims to bridge this educational divide and provide a comprehensive and tailored learning experience for A/Ll Biology students. By incorporating features such as hand-written text recognition for microorganism names, animal recognition with educational

 

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content, a Natural Language Processing chatbot for accurate solutions, and human body part detection, Clever Zone seeks to address the specific challenges faced by students in this subject. By leveraging new technologies and aligning with the local syllabus, Clever Zone aims to make the learning procedure in A/L Biology more effective, efficient, and convenient for students. The application's features are designed to engage students, enhance understanding, and provide a comprehensive learning experience that is accessible to all students following the English medium local syllabus.

Overall, the development of Clever Zone fills the research gap in the market, offering a solution that specifically caters to the needs of A/L Biology students in Sri Lanka. This research contributes to the advancement of education in the country by leveraging innovative technologies and creating a more accessible and engaging learning environment.

In future work, The Clever Zone program can be modified in the future to reflect changes in the A/L Biology curriculum. The application's features and content should be periodically evaluated and updated to reflect any changes to the curriculum. The application's coverage may also be extended beyond its current emphasis on three animal species, three human body parts, and three microorganisms. This expansion would involve incorporating a wider range of topics and subjects within the A/L Biology curriculum, providing a more comprehensive learning experience for students.

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