JOIV : Int. J. Inform. Visualization, 7(3) - September 2023 952-958

INTERNATIONAL JOURNAL ON INFORMATICS VISUALIZATION

journal homepage : www.joiv.org/index.php/joiv

AI Educational Mobile App Using Deep Learning Approach

Haslinah Mohd Nasir [a,*], Noor Mohd Ariff Brahin [a], Farees Ezwan Mohd Sani Ariffin [a], Mohd Syafiq Mispan [a], Nur Haliza Abd Wahab [b]

[a] *Advance Sensors and Embedded Systems (ASECs), Centre for Telecommunication Research & Innovation, Fakulti Teknologi Kejuruteraan Elektrik & Elektronik, Universiti Teknikal Malaysia Melaka, Durian Tunggal, 761000, Melaka, Malaysia*
[b] *School of Computing, Universiti Teknologi Malaysia, 81310 Johor Bahru, Johor, Malaysia*
*Corresponding author: *haslinah@utem.edu.my*

***Abstract*—Moving to Industrial Revolution (IR 4.0), the early education sector is not left behind. More of the teaching method is being digitized into a mobile application to assist and enhance the children's understanding. On the other hand, most of the applications offer passive learning, in which the children complete the activity without interacting with the environment. This study presents an educational mobile application that uses a deep learning approach for interactive learning to enhance English and Arabic vocabulary. Android Studio software and Tensorflow tool were used for this application development. The convolution neural network (CNN) approach was used to classify the item of each category of vocab through image recognition. More than thousands of images each time were pre-trained for image classification. The application will pronounce the requested item. Then, the children will need to move around looking for the item. Once the item's found, the children must capture the image through the camera's phone for image detection. This approach can be integrated with teaching and learning techniques for fun learning through interactive smartphone applications. This study attained high accuracy of more than 90% for image classification. In addition, it helps to attract the children's interest during the teaching using the current technology but with the concept of 'Play' and 'Learn'. In the future, this paper recommended the involvement of IoT platforms to provide widen applications.**

***Keywords*—Active learning; mobile application; CNN; deep learning; interactive education application.**

Manuscript received 29 Sep. 2022; revised 24 Feb. 2023; accepted 27 Mar. 2023. Date of publication 10 Sep. 2023.

I. INTRODUCTION

Vocabulary plays an essential part in learning a new language. It is the basic thing of language courses other than grammar and comprehension. Vocabulary is a well-known component that contributes to early reading performance and deserves scholarly attention [1]. Vocabulary knowledge correlates significantly with writing and speaking performance [2]. It is critical to begin learning vocabulary at a young age. Accordingly, many studies have explored the method of vocabulary learning at an early age. Teacher-child interactions are key to language and literacy learning and development [3], [4]. As science and technology evolved, language learning was also affected. It influenced the progress of technology-based language learning. With technology coming in, using mobile phones is one of the approaches to attract children to learn vocabulary in a new era [5]. The idea was to saddle the affordance of portable advancements that students were familiar with to improve their vocabulary. Using mobile learning may help students apply new vocabulary to real-life contexts [6].

Some of the applications provided synonyms and antonyms. Other mobile apps offered just like a conventional flash card with pictures of the words taught, while the other apps conveyed the definitions and instances for writing [7]. The majority of 84% of teachers, have considered using smartphones an effective tool for teaching vocabulary [8]. Mobile apps can be effective tools for vocabulary learning, and it is easy to download to mobile devices for free or at a low cost. Harger [9] explored the effect of the use of smartphones on vocabulary learning and the perceptions of students and teachers. Based on the study, it was shown that using mobile applications not only improves vocabulary learning but also increases the student's motivation to learn. A mobile app is feasible in helping EFL learners; the feedbacks were positive. The accessibility and flexibility of mobile apps attract students to learn and increase their academic performance [10]–[12].

There are many methods embedded to come up with the interactive application. According to Wu [13], using smartphones for vocabulary learning using JAVA application learning is very effective and significantly improves the student's vocabulary acquisition over time. A-Learn is a mobile app developed using augmented reality (AR) technology for Arabic Learning. It scans the letter cards and shows them in the AR environment. It allows the children to learn letters and vocabulary through AR 3D objects [14]. However, AR technology is quite costly, and the app will need to use a specific card to access the app. In addition, it still struggles with the wide range of applications [15]. Learn With IMAN is a mobile app for vocabulary learning using machine learning. TensorFlow software embeds the Artificial intelligence (AI) capability into the mobile app. The app shows the high accuracy of the machine learning image classification approach with interactive learning provided [16]. Learn2Write is a mobile app implementing AR and Machine Learning techniques. The app has two features where AR-based is used to produce the alphabet on the screen, while machine learning works to detect the alphabet written. However, the appropriate learning environment is important, especially for the AR environment [17].

Machine learning is one of the revolutions in AI technology for mobile app development. There are two main architectures to embed machine learning with mobile apps; server-side and client-side. All the work is done on the server side, which provides information on the analysis and results. In comparison, the client side will have a copy of the trained model on the device to execute the results [18]. Deep learning is an unsupervised machine learning approach where it is trained with an unlabeled dataset and predicts the outcome based on similarities and differences. A few researchers did use deep learning on mobile apps. Their findings urge deep learning optimization to deploy in mobile apps that are needed for model protections and can execute on mobile devices with less computational resources [19]–[21].

Currently, deep learning AI has great substantial commercial value. More mobile apps are developed with the deployment of deep learning not only in education but in other sectors also, such as Cybersecurity, Agricultural, Healthcare, Film Industry etc. Most popular AI-based mobile apps such as Netflix, Twitter, and Snapchat look like magic but embed the AI capability to learn what the user wants [22], [23]. However, available AI-based mobile apps in the current market for children's education are limited. Most educational mobile apps offer passive learning where the children complete the activity conventionally, sitting down and static during the learning. Children rarely communicate with their surroundings because they play coolly with their gadgets. Worst case, this may lead to children's gadget addiction [24].

Thus, this study aims to provide an interactive mobile application focusing on vocabulary enhancement in children's early age. This paper presents the AI concept of using Deep Learning Image Classification to allow the children to move and interact with their surroundings while completing the task. The data was assessed by Convolution Neural Network (CNN) model and will classify the image captured by the mobile app through the camera's phone.

II. Material and Method

A. System Architecture

An educational mobile application called IMAN Vocab App was developed using Android. Android is the most widely used smartphone and tablet operating system (OS). It is a Google-created open-source OS accessible to developers of all stripes and skill levels [25], [26]. The approach used in the image classification module for this App is CNN deep learning, where up to thousands of images of each class are collected for data training, validation, and testing. The IMAN Vocab App aims to help children in their early learning of vocabulary. Fig. 1 shows the flowchart of IMAN Vocab App development.

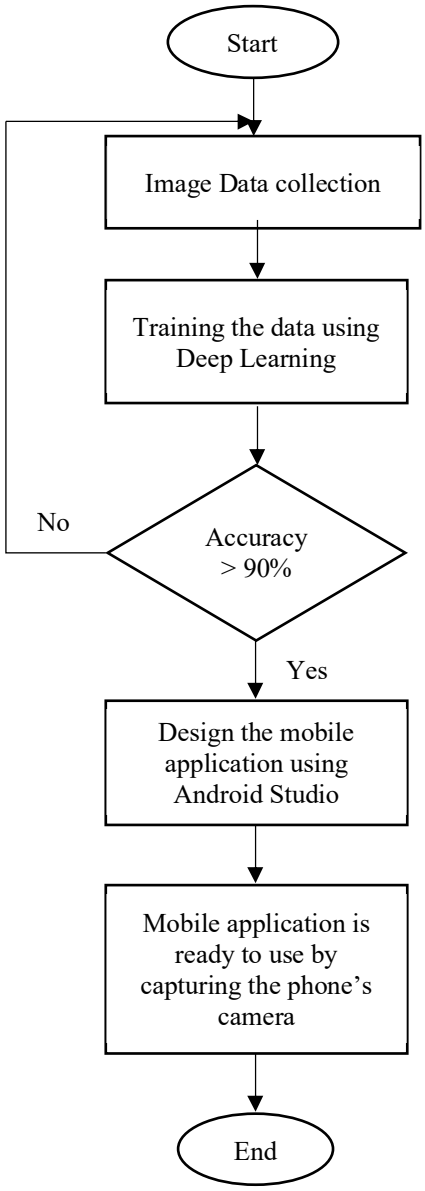


Fig. 1 Project Flowchart

As seen in Fig. 1, the data collection is before being used for data training. The accuracy of validation and training is ensured to exceed 90%, then proceed for application development. The project development consisted of three (3) main stages as follows:

- Stage 1: Application development
- Stage 2: Project Refinement
- Stage 3: Project Testing

B. Stage 1: Application Development

Fig. 2 shows the block diagram of the IMAN Vocab App development process using the image classification module. The IMAN Vocab App was developed with an Image Classification model using CNN deep learning approach for vocabulary enhancement. The CNN approach has been widely used in image processing. It is adept at handling image classification and recognition issues and has significantly increased the accuracy of many machine-learning tasks. It has developed into a powerful, prevalent deep-learning model [27]. Image classification is a process of predicting what an image represents. With enough training data, which consists of up to thousands of images for each class, a CNN Image Classification model can learn to recognize any images if they belong to any classes it has been trained in. Fig. 2 presents the sample of collected data of images.

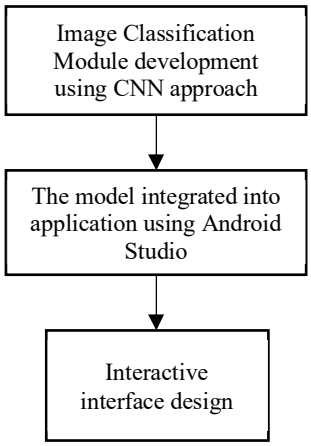


Fig. 2 Mobile application process development

The collected data (see Fig. 3) was divided into training and validation data at 80:20. The training and validation accuracy output was recorded. The graph is shown to make sure that the data is not overfitting.

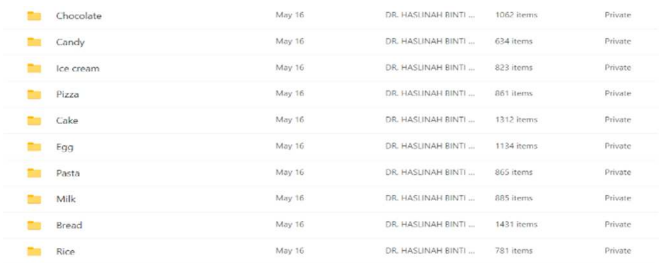


Fig. 3 Sample of data collection

The completed pre-trained model was integrated with the application to enable the AI ability of the IMAN Vocab App to recognize all the items specified. The application is preloaded with TensorFlow object detection API, which uses a single shot detector (SSD) with MobileNet pre-trained model that is trained on Microsoft Common Object in Context (COCO) dataset. The captured image will be compared with the preloaded dataset with the highest score to predict the output result. The Android Studio software will customize the application interface in the Android platform. All the vocabulary listed in IMAN Vocab Apps follows the kindergarten syllabus. Each month, different themes will be used in kindergarten, and the children will be introduced to different vocabulary according to the theme. This application can be used in kindergarten or at home for children's revision to enhance their vocabulary using current technology on what they have learned.

As shown in Table I, IMAN Vocab App is divided into three (3) main interfaces.

TABLE I
IMAN VOCAB APP INTERFACE

Interface	Description
	Login Authentication: The user will need to login to start the application
	Main Interface: The menu of item's category will be displayed. The content of each category is based on the kindergarten syllabus
	Learning Interface: The user are given time to pronounce the vocab in bi-language (English & Arabic) before starts to find the item requested

C. Stage 2: Project Refinement

Three (3) major refining processes have been done. It involved accuracy application refining, content refining, and graphics refining. The teacher's feedback is taken into consideration for better improvement.

1) Application refining: All the data were re-trained using a high GPU Desktop PC to increase the accuracy of the application refining. The data is added more into data collection to ensure enough for data training. The accuracy of each category ensures more than 90% of training and validation accuracy before proceeding to the next stage.

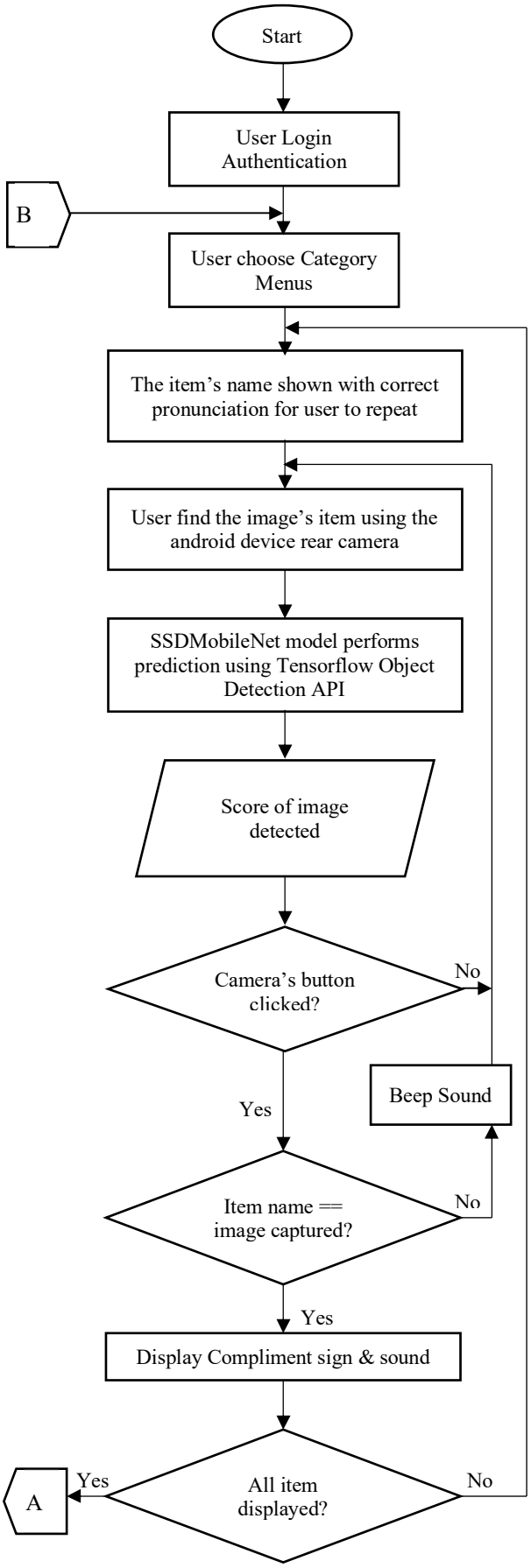
2) Content refining: Based on the teacher's feedback, the feature of the application is added. The time delay for the student to pronounce the item before starting to find the item and dual language is included in the application; English and Arabic.

3) Graphics refining: It is involved the graphic of application where the graphic design is good enough to attract the children's attention. At the same time, the interface is user-friendly and users can easily access the application.

Table II depicts the summary of the changes done during the refinement process. All three processes were completed prior to the project testing.

TABLE IIIII
BEFORE AND AFTER THE REFINEMENT PROCESS

	Before Refinement	**After Refinement**
Application	Pre-trained with fewer images, some categories only 80% accuracy	Pre-trained with more images (~1000 images for each category), all categories achieved more than 90% accuracy
	No pronunciation menu	A pronunciation menu is added to ensure the children's reading capability.
Content for each category	Five items in each category	Ten items in each category
	No guide on how to use	Added 'How to use' page for easy understand
Graphics & Animations		
		



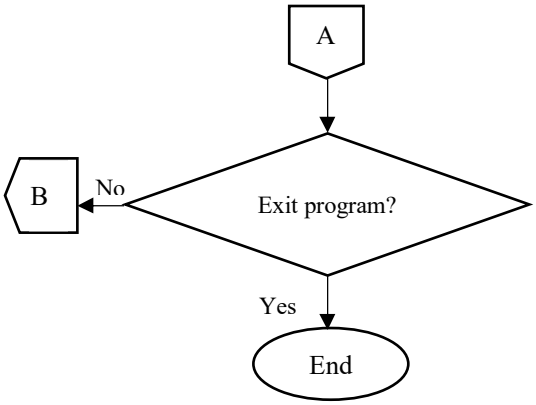


Fig. 4 IMAN Vocab Application Function

D. Stage 3: Project Testing

The testing is conducted in a real environment in kindergarten. The application is implemented in teaching and learning (T&L) where it was integrated with various methods of T&L such as "Hide&Seek", "SayItLoud!", "Play&Stop Song" and many more. The teaching aids, such as The application, were tested twice, before and after the application refinement. The teachers' feedback is gathered to improve the application that suits the kindergarten requirement.

During the testing, the teacher will help the student recap the vocabulary first, then let the student try to complete the task given through the application independently. This application allows the children to move around, and that makes this application different from other applications.

At the same time, IMAN Vocab App comes with a Flash Card where the children can try them out at home with their parents. The application can be installed in Google Play Store, and the parents may give feedback through the Microsoft Form.

E. Final Project

The final project of the Vocab App was successfully developed, completed, and tested in kindergarten. The Vocab App was finalized and functions as shown in Fig. 4. As can be seen from Fig. 4, The user must log in before entering the applications. The user will then be shown different categories menus to select. After the category is selected, the item will be shown, and the application will allow the user to pronounce the correct pronunciation of each item before looking for it. The user will need to capture the image of the item using the rear camera's phone. Then the CNN will predict once the camera's button is clicked. The compliment sign and sound will pop up for the correct answer, while the beep sound will be triggered for the wrong answer. Then, the next item will be shown until all the items are completed.

III. Results and Discussion

IMAN Vocab App has successfully developed with image classifications model for vocabulary enhancement. IMAN Vocab App allows children to find the item requested by the application. Children will move around and interact with their surrounding to find the item. Once the item is found, the children need to capture the image using the smartphone's camera. The application will recognize the image, and the sound image notification will pop up once the user gets the correct answer. Fig. 5 demonstrates the proof of functionalities for the correct answer of the IMAN Vocab app.

Fig. 5 IMAN Vocab correct answer

In terms of image classification accuracy using deep learning, it achieved more than 90% for all themes of training accuracy. Fig. 6 depicts the training accuracy of 10 different classes of themes.

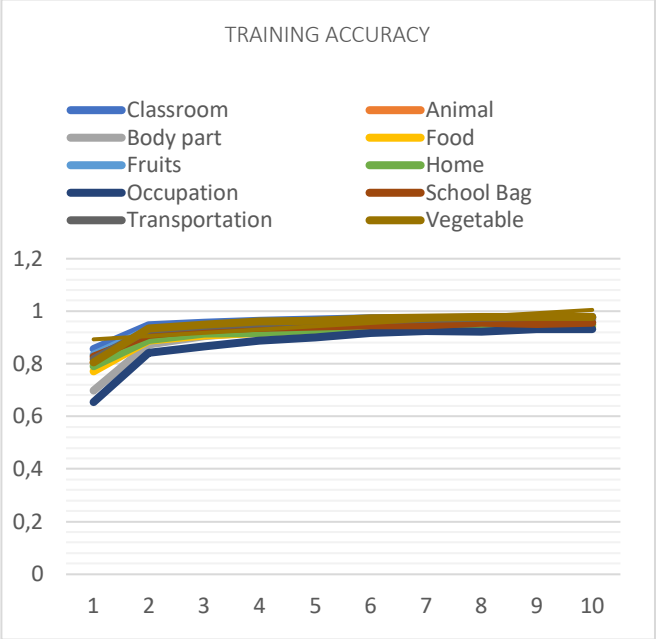


Fig. 6 Training accuracy of IMAN Vocab App

As seen in Fig. 6, all the themes achieved high accuracy in detecting each item for each class. Almost a thousand images for each item have been trained to ensure that the CNN model classification can predict the correct item for each image taken from the camera's phone. CNN model is known to have excellent performance for image classification, where it can directly extract features from the image data without other feature extraction methods [28], [29].

The data collection was pre-trained for the model to predict the image captured by the camera's phone. High accuracy is required to ensure that the classification process is smooth for real implementation. The sample of 1 theme in the IMAN Vocab App for training and validation accuracy is shown in Fig. 7.

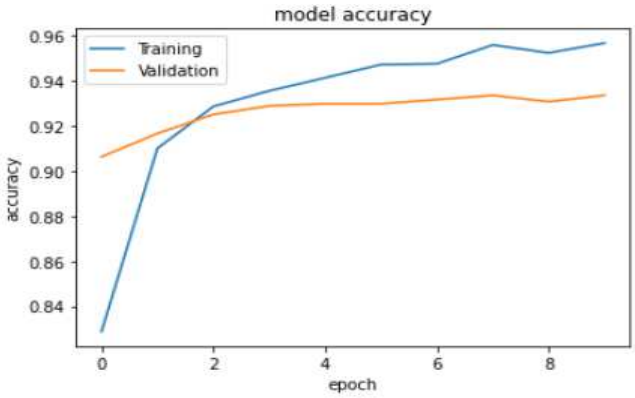


Fig. 7 Model accuracy of training and validation

The analysis showed that the training and validation accuracy increased linearly over time, whereas the validation accuracy achieved more than 90% in the training process. The difference in accuracy between training and validation are closer aligned and not overfitting, which means the model can generalize on a new dataset. Overfitting is one of the issues that may exist and affect the generalizing of the models to fit the data on the training and testing dataset [30].

Fig. 8 depicts the result analysis of testing accuracy for each theme. Referring to the figure, the testing accuracy of dataset testing is quite high, achieving the highest of 96% accuracy. The IMAN Vocab app can detect the item captured through the images of photos, flashcards, real items, or even toys.

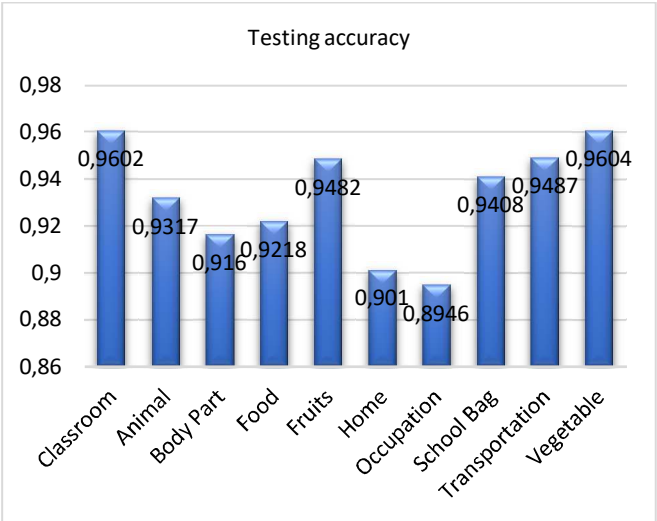


Fig. 8 Testing accuracy of IMAN Vocab App

The testing was conducted in kindergarten with a real classroom implementation of a teaching and learning (T&L)room. This is to prove the functionality of the application with the real implementation. The feedback was gathered, and they found that this IMAN Vocab app is interesting with the use of technology and, at the same time, the interaction between student and teacher is still happening. Fig. 9 demonstrates the conducted testing in kindergarten.

Fig. 9 Application testing in kindergarten

Overall, the project testing is successful. IMAN Vocab app provides the kindergarten with an alternative approach to attract the children's interest in learning. The app allows active learning where the children can still interact with the environment while doing the task. This may help reduce the effect of gadget addiction on children caused by passive application.

In addition, this project's development has contributed to the advantage of kindergarten, parents, and the community in general. It provides an interactive learning platform that integrates current technology and student-teacher interaction. Furthermore, the app's content can be customized for kids' animation production, attracting the children to learn along with their favorite characters.

IV. Conclusion

The project is successfully developed to cater to the needs of children's education through 'play' and 'learn' concepts in the kindergarten called Learn with IMAN Vocab application. The application uses the AI Deep Learning Image Classification model focusing on enhancing vocabulary. The feedback has been gathered to study the effectiveness of IMAN Vocab app implementation in the classroom. Teacher feedback shows that the IMAN Vocab app is suitable and useful in teaching and learning sessions. For Future work, the IoT Platform will be embedded for teachers' monitoring purposes.

Acknowledgment

The authors are grateful for the financial support received through Industry Promotion and Development (IPDG) Grant (INDUSTRY(IPDG)/MTSFB/2021/FTKEE/I00055) from Malaysian Technical Standard Forum Berhad (MTSFB). Thanks to Universiti Teknikal Malaysia Melaka (UTeM) for providing a project site to complete this research. Not forgotten to Little Caliph Ayer Keroh Kindergarten for the support to provide site testing for real teaching and learning (T&L) implementation.

References

[1] D. K. Dickinson, T. R. Flushman, and J. B. Freiberg, "Vocabulary, Reading and Classroom Supports for Language BT - Vocabulary Studies in First and Second Language Acquisition: The Interface Between Theory and Application," B. Richards, M. H. Daller, D. D. Malvern, P. Meara, J. Milton, and J. Treffers-Daller, Eds. London: Palgrave Macmillan UK, 2009, pp. 23–38.

[2] M. Kiliç, "Vocabulary knowledge as a predictor of performance in writing and speaking: A case of turkish efl learners," *Pasaa*, vol. 57, no. June, pp. 133–164, 2019.
[3] N. Yang, J. Shi, J. Lu, and Y. Huang, "Language Development in Early Childhood: Quality of Teacher-Child Interaction and Children's Receptive Vocabulary Competency," *Front. Psychol.*, vol. 12, no. July, pp. 1–12, 2021, doi: 10.3389/fpsyg.2021.649680.
[4] A. Langeloo, M. Mascareño Lara, M. I. Deunk, N. F. Klitzing, and J. W. Strijbos, "A Systematic Review of Teacher–Child Interactions With Multilingual Young Children," *Rev. Educ. Res.*, vol. 89, no. 4, pp. 536–568, 2019, doi: 10.3102/0034654319855619.
[5] S. Papadakis and M. Kalogiannakis, "Mobile educational applications for children: what educators and parents need to know," *Int. J. Mob. Learn. Organ.*, vol. 11, no. 3, pp. 256–277, 2017.
[6] Y. Song and Q. Ma, "Affordances of a mobile learner-generated tool for pupils' English as a second language vocabulary learning: An ecological perspective," *Br. J. Educ. Technol.*, vol. 52, no. 2, pp. 858–878, 2020.
[7] M. Makoe and T. Shandu, "Developing a mobile app for learning english vocabulary in an open distance learning context," *Int. Rev. Res. Open Distance Learn.*, vol. 19, no. 4, pp. 208–221, 2018, doi: 10.19173/irrodl.v19i4.3746.
[8] R. A. Sa'di, M. Yaseen, and T. A. Sharadhah, "Smartphones as a Tool for Expediting English Vocabulary Learning: Teachers' Perceptions of Benefits and Drawbacks," *Int. J. Linguist. Lit. Transl.*, vol. 4, no. 4, pp. 123–132, 2021.
[9] L. Harger, "The impact of the use of mobile computing on vocabulary learning in the language classroom," 2020.
[10] K. Demir and E. Akpınar, "The effect of mobile learning applications on students' academic achievement and attitudes toward mobile learning," *Malaysian Online J. Educ. Technol.*, vol. 6, no. 2, pp. 48–59, 2018, doi: 10.17220/mojet.2018.02.004.
[11] X. Ma and B. Yodkamlue, "The effects of using a self-developed mobile app on vocabulary learning and retention among EFL learners," *Pasaa*, vol. 58, no. December, pp. 166–205, 2019.
[12] F. H. Zawaideh, "The Effect of Mobile Learning on the Development of the Students' Learning Behaviors and Performance at Jordanian University," *Int. J. Bus. Manag. Invent. ISSN*, vol. 6, no. 3, pp. 1–07, 2017.
[13] Q. Wu, "Learning ESL Vocabulary with Smartphones," *Procedia - Soc. Behav. Sci.*, vol. 143, pp. 302–307, 2014, doi: 10.1016/j.sbspro.2014.07.409.
[14] D. Al-Thani, A. Othman, and A.-D. Mohannadi, "A Learn App: Mobile augmented reality vocabulary learning application - Supported through Mada Innovation Program," *Nafath*, vol. 6, no. 18, pp. 26–29, 2021.
[15] G. M. Santi, A. Ceruti, A. Liverani, and F. Osti, "Augmented Reality in Industry 4.0 and Future Innovation Programs," *Technologies*, vol. 9, no. 2, p. 33, 2021, doi: 10.3390/technologies9020033.
[16] N. M. A. Brahin, H. M. Nasir, A. Z. Jidin, M. F. Zulkifli, and T. Sutikno, "Development of vocabulary learning application by using machine learning technique," *Bull. Electr. Eng. Informatics*, vol. 9, no. 1, pp. 362–369, 2020, doi: 10.11591/eei.v9i1.1616.
[17] M. N. I. Opu, M. R. Islam, M. A. Kabir, M. S. Hossain, and M. M. Islam, "Learn2Write: Augmented Reality and Machine Learning-Based Mobile App to Learn Writing," *Computers*, vol. 11, no. 1, pp. 1–12, 2022, doi: 10.3390/computers11010004.
[18] V. Ganesan, "Machine Learning in Mobile Applications," *Int. J. Comput. Sci. Mob. Comput.*, vol. 11, no. 2, pp. 110–118, 2022, doi: 10.47760/ijcsmc.2022.v11i02.013.
[19] M. Xu, J. Liu, Y. Liu, F. X. Lin, Y. Liu, and X. Liu, "A first look at deep learning apps on smartphones," in *WWW '19: The World Wide Web Conference*, 2019, pp. 2125–2136.
[20] "Machine Learning What it is and why it matters," *SAS Insights*, 2022. .
[21] Y. Wang *et al.*, "A survey on deploying mobile deep learning applications: A systemic and technical perspective," *Digit. Commun. Networks*, vol. 8, no. 1, pp. 1–17, 2022, doi: 10.1016/j.dcan.2021.06.001.
[22] H. Steck, L. Baltrunas, E. Elahi, D. Liang, Y. Raimond, and J. Basilico, "Deep Learning for Recommender Systems: A Netflix Case Study," *AI Mag.*, vol. 42, no. 3, pp. 7–18, 2021, doi: 10.1609/aimag.v42i3.18140.
[23] R. Bunod, E. Augstburger, E. Brasnu, A. Labbe, and C. Baudouin, "Artificial intelligence and glaucoma: A literature review," *J. Fr. Ophtalmol.*, vol. 45, no. 2, pp. 216–232, 2022, doi: 10.1016/j.jfo.2021.11.002.
[24] V. M. Putri and E. Delfi, "The Impact of Negative Gadgets on Children ' s Language Development during the Covid-19 Pandemic," *Int. J. Emerg. Issues Early Child. Educ.*, vol. 3, no. 1, pp. 1–7, 2021.
[25] H. F. El-Sofany, S. A. El-Seoud, H. M. Alwadani, and A. E. Alwadani, "Development of mobile educational services application to improve educational outcomes using android technology," *Int. J. Interact. Mob. Technol.*, vol. 8, no. 2, pp. 4–9, 2014, doi: 10.3991/ijim.v8i2.3509.
[26] C. J. Ejiyi, J. Deng, T. U. Ejiyi2, A. A. Salako, M. B. Ejiyi, and C. G. Anomihe, "Design and Development of Android Applicationfor Educational Institutes," *J. Phys. Conf. Ser.*, vol. 1769, p. 012066, 2021.
[27] M. Xin and Y. Wang, "Research on image classification model based on deep convolution neural network," *Eurasip J. Image Video Process.*, vol. 2019, no. 1, pp. 1–11, 2019, doi: 10.1186/s13640-019-0417-8.
[28] V. H. Phung and E. J. Rhee, "A High-accuracy model average ensemble of convolutional neural networks for classification of cloud image patches on small datasets," *Appl. Sci.*, vol. 9, no. 21, p. 4500, 2019, doi: 10.3390/app9214500.
[29] A. Patil and M. Rane, "Convolutional Neural Networks: An Overview and Its Applications in Pattern Recognition," *Smart Innov. Syst. Technol.*, vol. 195, pp. 21–30, 2021, doi: 10.1007/978-981-15-7078-0_3.
[30] X. Ying, "An Overview of Overfitting and its Solutions," *J. Phys. Conf. Ser.*, vol. 1168, no. 2, pp. 1–6, 2019, doi: 10.1088/1742-6596/1168/2/022022.