Towards Enhancing Children's Science Education using Augmented Reality and Computer Vision

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Abstract— **Today's technological advancements in mobile technologies and the growing number of mobile devices are extremely beneficial in the mobile learning process. This study is a work in progress that discusses the possibilities of integrating Augmented Reality (AR) and computer vision (CV) into science education which uses deep learning to detect animals in real-time and teach children to classify animals, and learn about their habitat, sound, and important facts. In this study, the Design Science Research (DSR) is used which is a pragmatic approach to creating substantial knowledge for problem-solving through the development of artifacts. The mobile application - AnimalCircle - was developed following the DSR method, and initial users' study was conducted to investigate the efficacy of the use of AR and CV in mobile learning on children's science education and if it can enhance children learning experience. Semi-structured interviews were conducted with children studying at primary level class in Kathmandu district of Nepal between the age groups of 6-12. The findings show that children are positive toward usage of AnimalCircle app in their learning process because they find it beneficial and effective in their learning. However, most children also found it difficult and complained of getting confused during their initial usage. Therefore, significant efforts are required to improve the usage of these technologies in the mobile app and to provide a child-friendly learning experience.**

Keywords— Mobile learning, Augmented Reality, Computer Vision, Machine Learning, Design Science Research

I. INTRODUCTION

Various teaching techniques have been put into use in educational institutions to teach students. One of the boons of evolving technology is smartphones and wearables which is employed in mobile learning and enhances the learning environment [1]. As smartphone computing power increases, it enables the mobile device to support cutting-edge technologies like Computer Vision (CV) and Augmented Reality (AR). In this study, a mobile application AnimalCircle app that teaches children about animal facts is developed using technologies AR and CV, and its effects on children's education are examined. AR has the ability to help teachers make lessons more dynamic and interesting for students by making complex ideas and concepts simpler to understand. Researchers are looking into its use in children's education as a result of the rise of smartphones [2], [3]. CV which is a subfield of artificial intelligence has been employed to enhance digital education and motivate learners to study. Researchers have been using different sensors to improve the mobile learning experience and study its effectiveness. There has been research on AR technology which has been used to teach different subjects including English, mathematics, and Science Technology Engineering and Mathematics (STEM), in general [4], [5], which has been found to be effective and increase interaction among learners.

While studying the existing and previous literature, it is found that there is either very little or no literature on the use of combined AR and CV in animal learning, or on its effects. In this study, the integration of AR and CV into education is discussed, which is novel compared to approaches found in previous studies. The study tries to address two research questions (RQ), which are:

RQ1. How can we design and develop an intervention to foster children's learning experience using CV and AR?
RQ2. Is AR combined with CV helpful in improving children's knowledge about basic science and in particular animals?

II. RELATED WORK

This section presents an overview of related studies that demonstrated the design and development of AR and or CV to facilitate STEM education in different contexts. [6] in their study used AR to teach students about complex 3D concepts related to physics. Their results suggest that AR has potential to be effective in teaching such complex subjects. In addition, [7] used marker-based flash card to teach children about animals. In another study, [8] found that using AR models rather than physical models enhanced children's learning. However, according to [8], most of the study and development of AR focuses on its use in higher education.

CV has been used to detect engagement level of students, detect emotions and students' attention level which in turn helps course designers to design study content so that its more engaging [9], [10]. In previous study which focused on detecting object, [11] used RFID for learning process. However, in this current study, animal images were detected using CV technology, which then displayed educational materials for children.

III. RESEARCH METHODOLOGY

The research methodology used in this study is Design Science Research (DSR) methodology. DSR method is considered to be effective problem-solving strategy. There are different stages involved in DSR which includes:

(1) *Explanation of problem*: Finding the practical issue is the first step in the research process. In this study, children find learning to be difficult, uninteresting, and unmotivating, which presents a problem. (2) *Requirements definition*: This step defines requirements needed to create an artifact. By acknowledging the problem, the requirements are set to design and develop AnimalCircle app. (3) *Prototype design*: Based on requirements, an artifact is developed in this step which addresses the research problem. (4) *Demonstration of prototype:* The developed artifact is not tested in real world to verify its usefulness and whether it solves the practical problem identified in first step. (5)

Evaluation: At the stage, the artifact is evaluated based on results and findings. After this stage, researchers will have enough data to iterate back to the design and development phase to increase effectiveness of the artifact.

IV. Implementation of AnimalCircle Application

RQ1. How can we design and develop an intervention to foster children's learning experience using CV and AR?

This study attempts to address the first research question by following the software development process and the DSR to design and develop an artifact – AnimalCircle - using the technology AR and CV that helps children to learn about animals. AnimalCircle mobile application was developed as a solution for an identified problem in children education following stages of the DSR presented above.

A. Design and development of AnimalCircle Application

AnimalCircle is an iOS-based mobile application targeted at enhancing children's experience regarding basic facts about animals. A camera view will be displayed through which children can point to the picture of the animal in a book, photo gallery, etc., or can also directly point the camera to the live animal in the surrounding or in a zoo. The app will detect the type of animal using the CV technology in a mobile device and display the relevant information of the detected animal in an AR view. In addition, the children can play the quiz in the app through which children can learn and get more information about the animal. Fig. 1 shows AnimalCircle app showing animal information and quiz section.

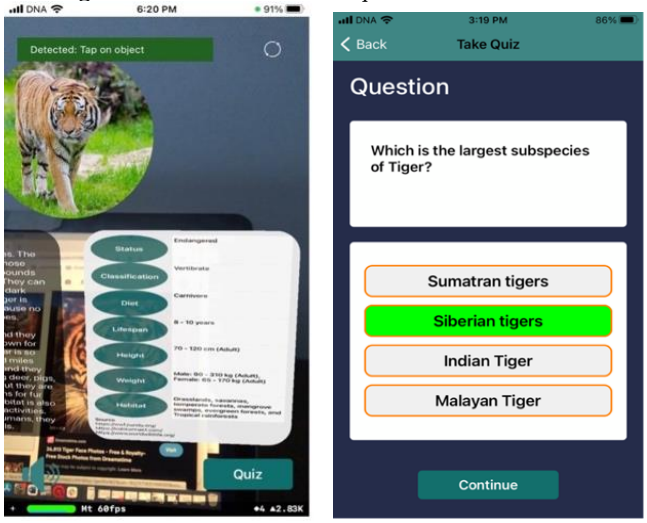

Fig. 1. AnimalCirlce app AR view and quiz

B. Overview of System Architecture

The high-level system architecture diagram of the AnimalCircle application is shown in Fig. 2. The backend cloud platform is comprised of web service. The mobile application acts as a frontend of the software architecture. It is responsible for providing children access to the application functionality of learning about animals. It used technologies including CV and AR to detect and display animal information in AR view. The pre-trained machine learning model resides in the mobile device itself. In addition, the information of the animals is maintained in the SQLite database which resides in the mobile device itself.

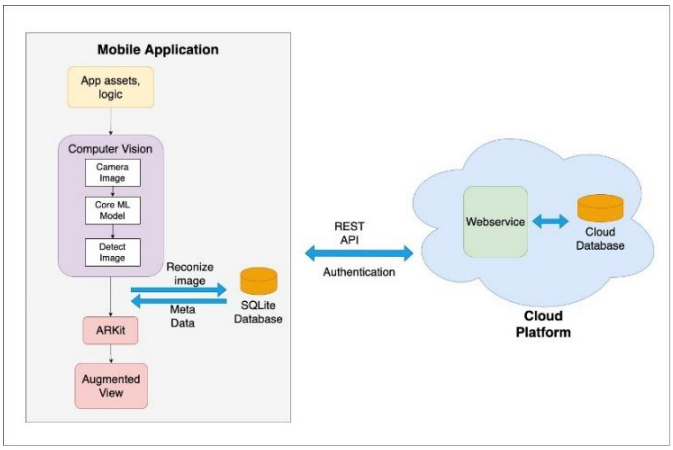

Fig. 2. System Architecture Diagram

C. Users study and context:

The study is conducted in Nepal's capital city's Kathmandu. The goal of the study is to determine whether AnimalCircle mobile app which uses AR and CV technologies is useful and enhance children's knowledge about animals. The research is carried out among children studying at primary level class in Kathmandu district of Nepal. In Nepal, efforts have been made by the government and non-governmental sectors to enhance children's education through the use of cutting-edge technologies. The children between ages 6 to 12 who knows how to read and write were randomly selected. The learning environment was outdoor (informal) and the children can get information about animals by scanning a photo of the animal taken with a mobile device's camera. The interviews conducted were recorded, later transcribed and translated into English for study. The research is qualitative in nature and semi-structured interview was used to conduct interviews among 8 participants. The interview questions are open-ended in nature and allow participants to expand their experiences.

For data analysis, a qualitative approach, thematic coding approach has been used. Thematic coding, according to [12], involves several stages, including 1) becoming familiar with data, 2) generating codes, 3) generating initial themes, 4) reviewing themes, 5) defining and naming themes, and 6) producing the report. The audio recordings of the interview were transcribed and translated data were read numerous times to understand and conduct an appropriate analysis. Then texts were highlighted, and notes were made in the form of code to understand the data. After coding themes were identified which is the foundation of thematic analysis. After carefully identifying and naming the themes, the formal report for the thematic analysis was written. The result is presented to showcase children's experiences as it relate to whether the AnimalCircle app impact their knowledge or otherwise.

V. Results

RQ2. Is AR combined with CV helpful in improving children's knowledge about basic science and in particular animals?

The study result show that the majority of the participants found the AnimalCircle app to be effective and agreed that the technology is useful in creating the best possible learning

environment eliminating the complexity and boredom from the learning process they usually experienced in classroom. They found the AR and CV technologies that were employed in the AnimalCircle app to be fun, interesting, interactive, and provides a novel learning experience motivating them to learn more. A few excerpts of students' read thus "Seeing animal pictures just in front was a really awesome and new experience for me. I liked playing the quiz." [P1]

"The quiz was a lot of fun for me. I like to learn practically also in the classroom and found that this app is quite engaging. So, I liked it." [P4]

"I loved playing quizzes. Also, it was fun to learn about animals using the camera and showing it on the picture of the animal. I haven't used such an app before." [P6]

"The app is very useful, as I could easily learn about animals. The quiz was also informative, I can recognize sounds easily and know general information about animals." [P7]

A few participants also mentioned how engaging learning environment helped them remember the information for a long time and helped them learn effectively overall. Majority of participants in this study found the learning process to be interactive and engaging when the technologies AR and CV are employed in mobile learning. Due to the physical interaction required and the ease and speed with which information about the animal can be obtained, participants felt that this app was easier and quicker to gain information during the learning process. However, some participants complained about the app being tedious to use in the beginning due to lack of clear instructions.

VI. Conclusion

In this study, a mobile application was developed using AR and CV technology. The initial evaluation of the artifact was carried out among 8 children between ages 6-12 studying in primary level school by collecting opinions of children using standard design science research method. Semi-structured interviews which are one of the data gathering techniques in qualitative research were used to gather experiences of children using the AnimalCircle mobile app to learn about animals. Open-ended questions were prepared carefully so that answer to research questions are received. Thematic coding analysis was performed on the transcribed and translated version of the interview data set. According to the study, using technologies like AR and CV in mobile learning can make learning considerably more engaging, interesting, and interactive. Children found the AnimalCircle application enjoyable and easier to learn than the traditional method, and they favor media in the learning app which in turn encourage and motivate them to form a learning habit. They had a positive attitude towards the app and preferred learning through AnimalCircle app over traditional teaching method. However, children also complained about the confusion to use app in the beginning due to lack of proper instructions and proper design. They also preferred not only pictures in the app but also other form of media including videos and animations.

Some limitations were pointed out in this research. The sample size was less due to pandemic. So, in the future, to draw a more reliable conclusion, further research should be done in a classroom with a larger number of students. The artifact can also be developed in multi-platform both iOS and android so that study covers multiplatform. Furthermore, it is important to evaluate how well this technology works in other communities and public schools where technology usage is less and not focus only in urban areas where technology usage is comparatively good.

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