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Impacts of AR in Learning Tribal Bodo Language

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Abstract: The objective of this study is to determine the effect of augmented reality compared to traditional approaches for language learning in primary education. We reported BodoAR, a marker-based AR application suitable for teaching the Bodo language, a tribal language of India in this work. The proposed application was developed using UNITY. To find the efficacy of the proposed BodoAR, five research questions were formed. An empirical study was conducted in five primary schools on two distinct user groups: native and non-native speakers of the Bodo language. All the participants were again randomly divided into two other groups- the experimental and the control group. A mixed-method approach was employed to collect the data, utilizing quantitative and qualitative methodologies. Analysis of empirical data shows native Bodo speakers' learning - in terms of academic achievements was significantly improved using the proposed application. For non-native students, experimental groups performed better than the controlled group. Both the native and non-native experimental groups experienced low anxiety, positive attitudes, and high levels of satisfaction while using the BodoAR application. Additionally, the academic achievements and attitudes of the native students in the experimental group were positively and significantly correlated. In contrast, the achievement of non-native students exhibits a positive and significant relationship with usability. The findings show increased satisfaction and academic performance among students who used the BodoAR application, affirming its effectiveness in enhancing Bodo language learning for primary school children. Thus, AR can be a useful tool for incorporating into children's language learning for children.

Index Terms: Augmented Reality, Human-Computer Interaction, Mobile Learning, Language Learning, Primary Education

1. Introduction

Education is crucial in enabling humans to learn, acquire, and deepen their knowledge to improve them. Similarly, language learning is considered important as it is the essential mode of human communication. Many native languages of small populations are disappearing due to people's disinterest in studying their native tongue and acceptance of other widely spoken languages and cultures [1]. For the survival of such languages, it is essential to teach the next generation.

In consideration of language preservation, we came up with the concept of developing an application for the Bodo ethnic people. Bodo is a member of an indigenous tribe and belongs to the Sino-Tibetan language family. The Bodo language is predominantly spoken in the Bodoland Territorial Region, BTR of Assam, India. A total of 2.2 million speakers of this language has been estimated in the late 20th century [2]. In a diversified country like India [1], more than one thousand five hundred languages exist, where the “Bodo” language is spoken by 0.12% of the whole population. According to the 2010 UNESCO List of Endangered Languages, the Bodo language is categorized as vulnerable [2]. Consequently, there is a necessity to preserve such languages. The majority of Bodo people reside in rural areas and are not well-off economically. Many members of the older generation lacked education or had inadequate education for various reasons. Many Bodo children find it difficult to properly gain knowledge due to the deficiency of motivation, guidance, and direction in the academic realm. This creates an opportunity to contribute the society by assisting them to deepen their understanding in their early education.

Scratching the surface of new emerging technologies for developing applications for Bodo ethnic children, we came across augmented reality (AR). This stands out as the ideal pedagogical approach for immersing students in the field of education. It is a technology that adds computer-generated content to enrich the actual physical world. AR enables users to view the real environment with virtual information superimposed on it. This leads the user to believe that both actual and virtual information coexists in the same space [3]. In 1997, Azuma defined the concept of AR [4]. According to his definition, AR needs the following three requirements –

- must combine the real and virtual worlds
- should be interactive in real-time
- must be registered in three-dimensional (3D)

MAR (Mobile Augmented Reality) provides users with virtual information that is integrated into a real-world setting without restricting the user's location [5]. In recent years, there has been a surge in interest in using Augmented Reality (AR) as an educational technology [6]. Immersive learning using AR has emerged as a trend in current educational technology, significantly transforming the classroom learning experience [3]. The growing demand for experiential and interactive learning, featuring 3D experiences, is driving the advancement of AR-based learning. The AR application can display 3D content in the real environment which may attract children’s attention and prolong their attention span in learning. And as a result, they can learn faster and remember more easily. When compared to traditional methods, the use of AR technology has enhanced student’s academic performance [7, 8]. The phenomenal features of AR can provide students with additional information than the conventional representation by superimposing figures, instructions, video, and audio to aid in understanding and helping them visualize complex subjects in three dimensions [9, 10]. The benefits of augmented reality usage in education include increased attention, motivation, satisfaction, engagement, enjoyment, excitement, collaboration, and enhanced learning [11, 12, 13]. Thus, AR applications can be a powerful educational tool in the future [11]. Experimental investigations have shown that students also have positive attitudes regarding the application of augmented reality [8, 14].

AR has also emerged as a significant educational tool, particularly for language learning [15, 16]. Language education is crucial for the next generation because a language dies every two weeks [4]. Numerous languages are at risk of extinction due to factors such as globalization, colonialism, lack of dedicated preservation efforts, and lack of interest in studying native languages [1]. Thus, teaching languages to the next generation with AR technology can help preserve endangered languages. The use of AR technology in education has demonstrated several positive effects on language learning [17]. Researchers have documented advantages such as increased motivation, satisfaction, attention, engagement, enjoyment, and improved learning achievements [17, 18]. Most AR applications created over the years are for widely spoken languages, with very few for the others. There are AR applications available online for learning the English language [11]. For example, "LearnAR" helps users learn English alphabets and numbers with the application. Additionally, "AR Study Ladder" assists users in learning English words and sentences to enrich their vocabularies. However, there are no applications available online for learning Indian tribal or endangered languages. To the best of our knowledge, no research has been done to date on the use of AR technology in primary schools for teaching any tribal language in India to date. The main objectives of the study are listed as follows –

1. Development of an AR-based application for Bodo Language
2. Explore the impact of AR applications on students’ academic performance in language learning.
3. Usability evaluation of the AR application.
4. Identification of students’ attitudes toward AR applications.

In this work, a mobile-based AR application for Bodo language’s alphabet and number system learning - BodoAR was developed. There is a lack of prior research on the use of AR applications for Bodo language learning purposes in primary school settings. The study of the BodoAR application is important because it was the first to be developed for learning the Bodo language using mobile devices. This application features vowels and consonant letters, each paired

[1] https://www.education.gov.in/sites/upload_files/mhrd/files/upload_document/languagebr.pdf
[2] https://en.wikipedia.org/wiki/List_of_endangered_languages_in_India
[3] https://flearningstudio.com/latest-educational-technology-trends/
[4] https://www.nationalgeographic.com/culture/article/saving-dying-disappearing-languages-wikitongues-culture

with a word and a 3D representation. Additionally, the app showcases numbers one through ten with word and 3D representations. It has a simple user interface and features 3D models and sound to create an immersive and interactive learning environment for primary children. The sound was recorded by native Bodo speakers to help both native and non-native speakers learn precise pronunciation. The app also includes quiz options for users to track their learning progress. Upon completion of the quiz, users receive scores and feedback, including expressions such as good, perfect, excellent, and similar expressions aiming to motivate them for further study.

We used empirical data for our analysis of research questions, demonstrating academic learning through AR applications compared to traditional techniques. Furthermore, no previous studies have considered both native and non-native respondents in their examination of language learning through AR applications. In this study, we assessed the effectiveness and usability of our proposed application considering two distinct user groups: very young native speakers (under the age of 7) and young non-native speakers (ages 7-12). By selecting two user groups, we sought to test the effectiveness of the AR application for language learning, independent of the users' language proficiency. We also included two different age groups in the study to identify any age-related usability issues. A total of eighty primary school students took part in the study, which were randomly divided into two groups: the experimental group and the control group. The experimental group used the AR application for studying, while the control group used traditional textbooks. The results of our study show that the AR application had a significant positive impact on the learning of the Bodo language for native speakers compared to traditional learning methods. While there was no statistically significant difference for non-native students, those who used the AR application generally performed better. Both the native and non-native experimental groups expressed positive attitudes toward the AR application, reporting satisfaction and reduced anxiety when using it. However, the findings revealed that older participants in the experimental group were more comfortable and satisfied with the usability of the AR application compared to younger participants.

We also found a significant positive correlation between the attitudes of native students in the experimental group and their academic achievement. The attitudes and academic achievements of non-native students did not show a significant correlation; however, achievement is strongly and positively correlated with usability (SUS). The research findings indicated that AR-based learning improved students' learning performance in comparison to traditional learning methods. Additionally, the study revealed that AR can enhance children's learning by creating an immersive learning environment, facilitating interaction, and reducing anxiety. This makes it an ideal tool for children learning a language and can contribute to the preservation of that language.

2. Related Work

In this section, we reported scholarly works emphasize teaching in English and other native languages.

2.1 Applications Developed for English Language Learning.

Lee et al. (2019) [19] developed an AR mobile application for teaching English vocabulary interactively and attractively using a mobile device. Redondo et al. (2020) [15] created an AR application to teach children English as a Foreign Language. They observed students who utilized AR applications outperformed others in motivation, learning, and socio-affective relationships. 'AR PhonoBlocks' was developed by Fan and Antle, 2020 [20] to assist English language study. Their findings imply children could utilize it without any prior digital experience.

2.2 Applications Developed for Native Language Learning.

Researchers also analyze AR applications for learning native Bengali languages. Motahar et al. (2018) [21] developed an AR application called 'Bornomala AR' for learning the Bengali alphabet. They observed learning improvement among children and parents' preference for independent learning. In 2019, Abrar et al., [22] developed two marker-based MAR applications: 'AR Zoo' and 'Bangla AR Book'. It was observed AR technology can improve children's learning performance and engagement.

For Quechua language preservation, an AR application - 'the smart Mobile-D methodology' was developed [16]. It was noted that using an AR application can significantly increase the understanding, motivation, satisfaction, and performance of children. An AR application for teaching the Quechua language to preschoolers was also developed by Zapata-Paulini et al. (2019) [1].

Many augmented reality applications are intended for language acquisition in different native languages - Tamil [7], Malay [23], Persian [24], French [25], Arabic [26], and Chinese [27] were also reported over the years. Numerous AR applications have been created so far for teaching languages. Many of them have been developed in the English language [19, 15, 20, 28] or other widely spoken native languages - Bengali and Chinese language [21, 22, 27, 29, 30]. Such widely spoken languages have less chance of endangerment. However, due to the merging of cultures and migration, many mother-tongue languages face a threat of extinction over time [16]. It is indeed crucial to preserve native or tribal languages that are spoken by lesser populations as they are in great danger of disappearing. In India, there are twenty-three official languages including English. Additionally, numerous other native or tribal languages also enrich the culture of this country. The AR applications developed in India are intended to teach students the English language [27, 31, 32] or other academic concepts like mathematics [33, 34, 35], chemistry [36], anatomy [37, 38] and engineering concepts [39, 40, 41, 42]. Even though India is home to a large number of languages, very few augmented reality applications have been developed to help people learn their native languages. Examples of a few native languages where AR applications are used include Marathi [43], Tamil [7], and Telegu [44]. To the best of our knowledge, AR applications for tribal languages of India have not been developed to date. Therefore, preserving such languages will be a great challenge for the research community.

In this work, we tried to address this challenge for the Bodo language, a tribal language, which is primarily spoken in the North-Eastern regions of India. To the best of our knowledge, this is the first instance in which a marker-based AR application has been used for educating the Bodo language. We also explored the usability testing of this application. In the following, we presented our proposed application development methodology.

3. Application Design

The Analysis - Design - Development - Implementation - Evaluation (ADDIE) model [45] was employed as an instructional design in this study. This model consists of five phases: analysis, design, development, implementation, and evaluation as shown in Fig.1. The ADDIE model proved to be an ideal framework for directing the development and evaluation of the BodoAR application.

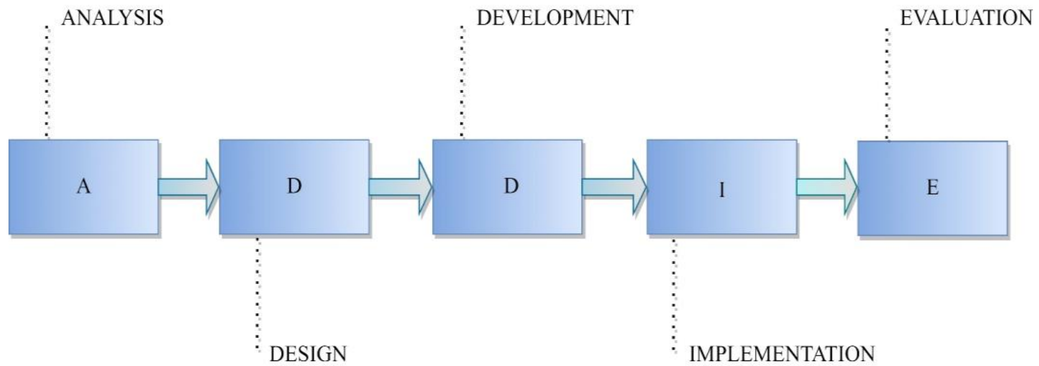

Fig. 1. The ADDIE Model

3.1 Application Overview

BodoAR is a marker-based MAR application that is developed to teach children about Bodo alphabets (eleven vowels and forty consonants) and numbers (1 - 10). Each letter, whether a vowel or a consonant, has a word and sound associated with it. Additionally, 3D models corresponding to each word will be visible. Similarly, everything was adhered to the numbers as well. Audios were recorded by a native Bodo speaker for precise pronunciation. A quiz mode is also added to assist users' progress and proficiency in learning. Fig. 2 depicts the flow of the BodoAR application.

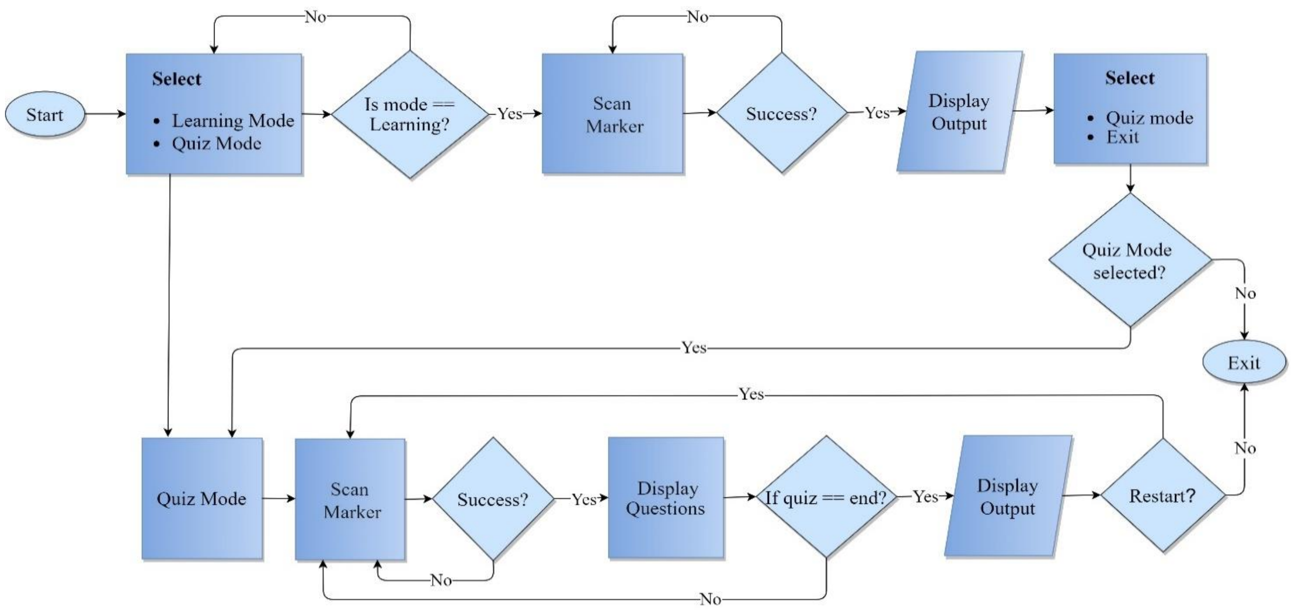

Fig. 2. Flow chart of BodoAR applications

The UI (User Interface) was made simple and child-friendly. The main menu of the start-up screen is shown in Fig. 3a. By clicking the Learn button, the user can go to the Selection Menu page (Fig. 3b). This page has the Options button to download the target image, adjust the volume, and view additional features. The Info button displays the application's information, and the Exit button helps in closing the application, respectively. Fig. 3b depicts the selection menu of the BodoAR application. A scroll bar facility in the selection menu was added for navigation. we divided the BodoAR application into two modes: (i) Learning Mode and (ii) Quiz Mode.

(i) Learning Mode:

Users can choose between vowels, consonants, and number options in this mode. Once, the subject selects the vowels option, a camera will appear on the screen to scan the image target. Once the camera is pointed at the image target, a 3D model of the first vowel with a word associated with it will be displayed. Users can also choose the sound option to listen to the provided precise pronunciation of alphabets and words in real-time. The next button on the screen will lead to the next following vowel. After completing the vowels, an option for the vowel quiz will appear on the screen. A user can choose to take the quiz test, clicking the Back option will return the user to the selection menu, where they can choose other learning options. The application will close when the Exit button is clicked. The functionality of the BodoAR application is shown in Fig. 4. Fig. 4a displays a vowel letter and a word, with the word's 3D model visible on top. Similarly, 4b represents a consonant and 4c stands for a number.

(ii) Quiz mode:

There were quizzes for vowels, consonants, and numbers sections. Each quiz had five sets of questions in which five 3D models were shown randomly, and users were asked to select the correct words from two multiple-choice options. Based on the results of the selected option, users were given feedback as correct or wrong. For each correct answer, one mark is awarded, and on completion of one round, feedback according to the result score is rewarded. Based on the scores, the following feedback is provided: (i) score = 0 - 2 as Try Again, (ii) score = 3 - 4 as Good, and (iii) score = 5 as perfect. In Fig. 5, the resulting menu includes scores, and feedback was shown.

(a) Main Menu (b) Selection Menu

Fig. 3. User Interface of BodoAR

(a) Vowel (b) Consonant (c) Number

Fig. 4. Functions of BodoAR application (Learning Mode)

(a) Question (b) Correct answer (c) Wrong answer (d) Result Menu

Fig. 5. Functions of BodoAR application (Quiz Mode)

4. Experimental Setup

For implementing the BodoAR application, the game development engine called Unity was used. This engine offers a scripting API (Application Programming Interface) in C# (C-sharp). The developed AR application (BodoAR) was designed for the Android operating system. Real-time recognition and tracking of 3D objects and planar images are accomplished by Vuforia. Android Studio helped us as an IDE (Integrated Development Environment) for building applications for Android devices. The 3D models were developed using Blender software. The scripting language used was C# (C-Sharp). Since the BodoAR application is marker-based, we have generated an AR marker and considered it as the only image target for the functioning of the application. GIMP (GNU Image Manipulation Program) was used for editing and creating 2D images.

5. Method

Quantitative research design can quantify users' behavior. Numerical data in the form of figures and numbers are generally analyzed to find correlations, and characteristics and test hypotheses [5]. On the other hand, qualitative research makes use of non-numerical data, such as recording opinion data, and user characteristics. Qualitative research employs a variety of techniques, including interviews, focus groups, surveys, and observation [6]. To assess the effects of BodoAR, we adopted mixed methods (both qualitative and quantitative). For conducting the usability study, we framed five research questions (RQ1-RQ5). Out of them, (RQ1-RQ4) were designed for quantitative analysis, and RQ5 was meant for qualitative analysis.

Using RQ1-RQ5, we performed usability testing in five primary schools located in rural areas of BTR, Assam. India. Participants native and non-native speakers of both these groups were further divided into two separate groups - experimental, and control. Students in the experimental group learned Bodo alphabets and numbers using the BodoAR application, whereas students in the control group used traditional textbook learning.

5.1 Empirical Study

At the beginning, we distributed the pre-survey questionnaire to students, as shown in Table 4. It was a closed-ended question with two answers: yes or no. Following this, the functions of the BodoAR application were demonstrated to both students and teachers. Then the students were randomly divided into two groups: experimental and control groups. The experimental group used the BodoAR application, while the control group used a textbook for learning. Since the non-Bodo medium teachers were unfamiliar with the Bodo alphabet, we had to volunteer to teach throughout the entire session. A few volunteers assisted us in teaching the control group. The study lasted for a week with three sessions, each lasting forty-five minutes, under our supervision. In Fig. 6, we reported a few screenshots during this period. On the last day, students were asked to participate in the quiz.

Fig. 7a depicts the experiment conducted in a Bodo medium school. The left image shows the experimental group and the right image shows the control group. Fig. 7b displays the experiment conducted in a non-Bodo medium school, with the left image representing the experimental group and the right image representing the control group.

[5] https://www.scribbr.com/methodology/qualitative-quantitative-research/
[6] https://www.enago.com/academy/qualitative-vs-quantitative-research/

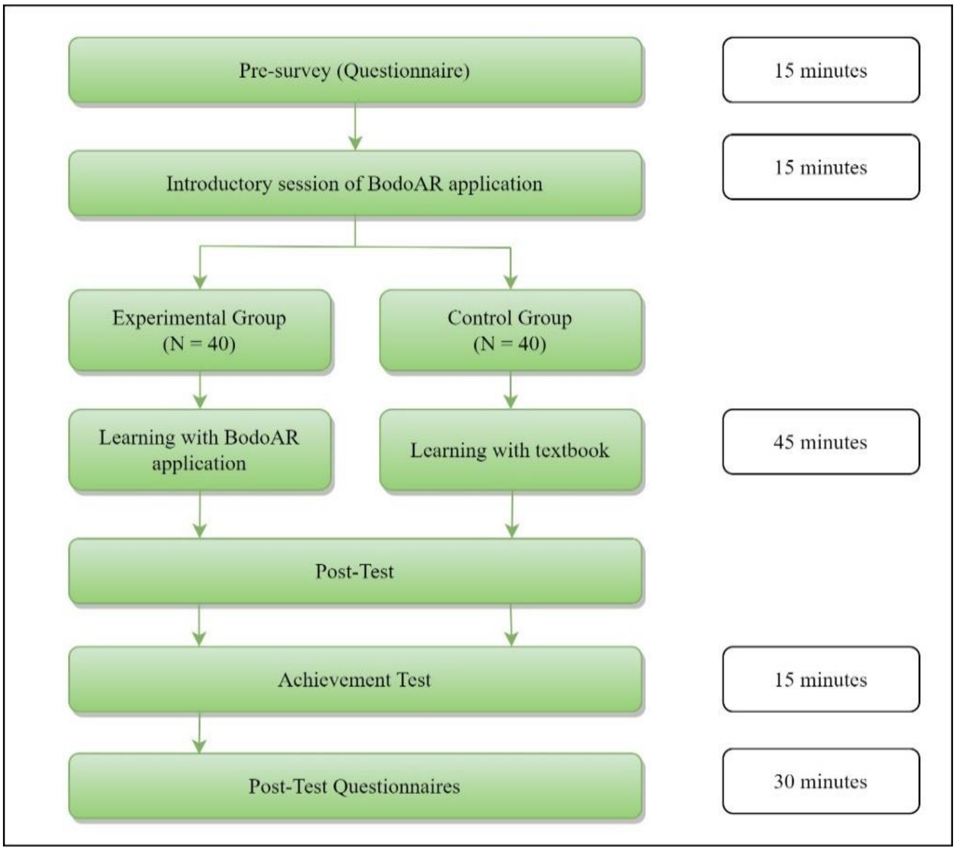

Fig. 6. Flowchart of experimental design

(a) Bodo medium students

(b) Non-Bodo medium Students

Fig. 7. Participants during the experiment

5.2 Participants

In this study, we attempted to gather feedback on our proposed BodoAR application from the primary students as well as their educators.

5.2.1 Students

Consent from the competent authorities was obtained to carry out our usability testing. An initial study shows that native Bodo speakers can use the Bodo language for verbal communication, which is not true for non-native Bodo speakers. Non-native speakers learn the language as older children or adults [7]. After carefully verifying the school curriculum, we observed that the non-native speaker can start learning the Bodo language around the age of eight years. Accordingly, the study considered two user groups: native speakers (ages 4-7) and non-native speakers (ages 8-12). This fulfills our objective of determining the age-related usability study of our application.

Eighty participants (forty students from two Bodo medium schools - native speakers, forty from three non-Bodo medium schools - non-native speakers) were selected, as shown in Table 1.

[7] https://www.tandem.net/blog/native-speakers-for-language-exchange

Table 1. Demographic Details of Participants

Participants	Age	No. Of Students		Total
		Girls	Boys	
Native	4-7 years	19	21	40
Non-Native	8-12 years	21	19	40
Total				80

5.2.2 Teachers

Except for the students, we interviewed (qualitative study) seven teachers (T1-T7) from both mediums to record their opinions about the AR application. The demographic characteristics of the teachers are given in Table 2. All of them were primary-level teachers. We selected primary-level teachers because of their expertise in understanding young children's learning capacities and receptiveness to new learning approaches. They are the best candidates for interviewing about the AR application.

Table 2. Details of teachers participated in our study.

Participants	Gender	Years Of Experience	Age	Subject
T1.	M	>15 years	47	Mathematics
T2.	M	<5 years	30	Social Science
T3.	F	>10 years	41	Bodo
T4.	M	<5 years	29	Science and Mathematics
T5.	F	<5 years	28	English
T6.	M	>20 years	55	Assamese
T7.	F	<5 years	32	Bodo

5.3 Data Collection Tools

The data collection techniques used were achievement tests, questionnaires, interviews, and observations. The achievement test assessed the learning performance of primary students. Students were assessed using a quiz with 15 questions covering vowels, consonants, and numbers. Each correct answer scored one point. There were two types of questionnaires: pre-survey and post-test questionnaires. The post-test questionnaires were only for the students who used AR applications which included the System Usability Scale (SUS), Handheld Augmented Reality Usability Scale (HARUS), and Augmented Reality Applications Attitude Scale (ARAAS).

In this study, we employed two-scale instruments: SUS [46] and HARUS, to evaluate the usability of our BodoAR application. SUS consists of ten items that measure the ease of use of mobile applications using a 5-point Likert scale. HARUS [47] suitable for mobile AR applications consists of sixteen items, eight statements for manipulability that measure the ease of handling the AR application and eight statements for comprehensibility that measure the ease of understanding in a 7-point Likert scale. The ARAAS questionnaire [48] was also used to measure the students' attitudes toward BodoAR. It has 15 items representing three factors: satisfaction (seven positive statements), anxiety (six negative statements), and willingness (two positive statements) in a five-point Likert scale. Additionally, we were looking for a relationship between students' attitudes and their achievement, SUS and HARUS scores. Since the SUS and HARUS scores are all converted into a 100-point scale, we also computed the ARAAS score in a similar method of computing the SUS and HARUS scores to find a correlation in this study. These three post-test questionnaires were converted according to students' preferred languages - Bodo. Since students could not fill out the questionnaire themselves, we along with the teachers assisted them. In addition, an informal interview with the teachers was conducted to identify their views about BodoAR. We asked five questions to each teacher and recorded their response.

The five questionnaires for the teacher interview (QT_1 to QT_5), are displayed in Table 3.

Table 3. Teacher's questionnaires

No.	Questions
QT_1	Have you heard of Augmented Reality?
QT_2	Have you ever used AR technology in the classroom?
QT_3	Can AR technology benefit children's learning?
QT_4	Did the 3D model and sound of the AR application increase children's learning interest and memorization?
QT_5	Is the AR application safe for children?

6. Research Tools

In this study, we were interested in determining whether the usage of our AR application can perform better compared to traditional learning methods. Accordingly, we designed our first research question RQ1 as mentioned below –

RQ1. Does the use of AR application improve the academic achievement performance of the experimental group compared to the control group?

We also intended to assess the usability of the proposed AR application. In addition, we were also determined to evaluate the students' attitudes toward AR applications. Accordingly, we designed the following three research questions - RQ2, RQ3, and RQ4.

RQ2. Does the level of SUS and HARUS scores of students in the experimental group differ when examined in terms of age?

RQ3 Is there a difference in the experimental group's native and non-native students' attitudes toward the AR application?

RQ4. What is the relationship among the experimental group students' achievement, SUS, HARUS, and ARAAS scores?

The fifth research question RQ5, as presented below was considered to explore the views of the teachers towards our developed application.

RQ5. Whether the teachers found BodoAR to have the potential for improving learning?

7. Results

We reported the pre-survey questionnaire and achievement test results in four sections –

1. Findings of the pre-test questionnaire
2. Outcomes of the achievement test
3. Findings of the five research questions.
4. Observation

7.1 Students' Pre-Survey Results

The pre-survey interview of students was conducted using the questions shown in Table 4 for both Native and Non-Native speakers. The result shows that all the eighty students had never used AR(Q1). The majority of them (92.5% for natives, 82.5%) reported (Q2) having smartphones belonging either to their parents or other family members. In Q3, it was observed except for three participants, all others responded that they had previously used smartphones. The majority of the students used mobile phones to watch videos or play games, while others only used them occasionally along with their parents. Among the ten students who did not have smartphones at home, eight of them had used other's borrowed phones, while two students stated they had never used one before. As a result, all of the students who used the BodoAR application were able to navigate on their own with less assistance.

Table 4. Result of Bodo students' pre-survey questionnaire

No.	Questions	Native		Non-Native	
		YES	NO	YES	NO
Q_1	Have you heard of Augmented Reality?	0	40	0	40
Q_2	Do you have a smartphone at home?	37	3	33	7
Q_3	Have you used a smartphone earlier?	39	1	38	2

7.2 Result of Academic Achievement Test

To determine whether there is a statistically significant difference in achievement scores between the experimental and control groups. We have declared the null (H0) and alternate hypothesis (H1) as shown in the following:

Null Hypothesis (H0) = There is no significant difference in academic achievement between the experimental and control groups (> 0.05).

Alternate Hypothesis (H1) = There is a significant difference in academic achievement between the experimental and the control groups (< 0.05).

The academic achievement scores of children were calculated using SPSS 26 statistical software. Shapiro-Wilk normality test was applied to the post-test data to check the normality distribution of the data. The findings indicate that the data of native students for both groups were normally distributed (p=.143 for the experimental group and p=.880 for the control group). The test results of non-native students also indicate that the data of both groups were normally distributed (p=.870 for the experimental group and p=.727 for the control group), therefore, we considered using a parametric test. The independent samples T-test method was used for hypothesis testing. The BodoAR prototype was tested on two different groups of users. The first group of users were native Bodo speakers, while the second group was non-native Bodo speakers. As a result, the evaluation of the results will be divided into two parts: (i) Evaluation of Native Bodo speakers and (ii) Evaluation of Non-native Bodo speakers.

(i) Evaluation of Native Bodo speakers:

An independent samples t-test was used to compare the achievement scores of the experimental and control groups of native speakers. The test result is shown in Table 5. We have done a two-tailed test where the total significance value was found to be 0.03. Hence as $p < 0.05$ (as shown in Table 5), there was a significant difference in academic achievement between the experimental group *(M = 10.70, SD = 3.19, n = 20)* and the control group *(M = 8.45, SD = 3.23, n = 20; t (38) = 2.21, p < 0.05).* It can also be reported that BodoAR could significantly increase children's learning performance when compared to traditional methods.

Table 5. Result of Independent Samples Test of Native Bodo Speakers.

	Experimental Group			Control Group			95% Confidence Interval of the Difference		t	df	Sig. (2-tail)
	M	SD	n	M	SD	n	Lower	Upper			
Achievement	10.70	3.19	20	8.45	3.23	20	0.19	4.30	2.21	38	0.03

(ii) Evaluation of Non-native Bodo speakers:

For Non-native Bodo speakers as well, we used the independent samples t-test to compare the achievement scores between the experimental group and the control group. The result is listed in Table 6. This two-tail test found a significant value of 0.69. Here, as $p > 0.05$, we can conclude that there was no significant difference in academic achievement between experimental *(M = 9.80, SD = 2.33, n =20)* and control group *(M = 9.45, SD = 3.17, n = 20; t (38) = 0.39, p > 0.05).* That indicates that both AR and traditional methods can increase children's learning performance.

Table 6. Result of Independent Samples Test of Non-Native Bodo Speaker.

	Experimental Group			Control Group			95% Confidence Interval of the Difference		t	df	Sig. (2- tailed)
	M	SD	n	M	SD	n	Lower	Upper			
Achievement	9.80	2.33	20	9.45	3.17	20	- 1.43	2.13	0.39	38	0.69

7.3 Findings of the Research Question

This section summarizes the results and observations obtained from user evaluation.

RQ1. Does the use of AR application improve the academic achievement performance of the experimental group compared to the control group?

Table 7. Achievement Test of students.

	Group	Native			Non-Native		
		N	M	SD	N	M	SD
Achievement	**Experimental**	20	10.70	3.19	20	9.80	2.33
	Control	20	8.45	3.23	20	9.45	3.17

According to Table 7, the native speakers' students in the experimental group had a higher mean level of achievement score (*M=10.70, SD = 3.19)* compared to the control group *(M=8.45, SD = 3.23).* Similarly, non-native students in the experimental group *(M=9.80, SD=2.33)* also had higher mean levels than the traditional group students *(M=9.45, SD = 3.17).* Therefore, it is evident that AR applications can improve the academic achievement performance of students compared to traditional learning.

RQ2. Does the level of SUS and HARUS scores of students in the experimental group differ when examined in terms of age?

Table 8. Result of SUS and HARUS questionnaire

Participants	N	Age	SUS		HARUS	
			M	SD	M	SD
Native	**20**	**4 - 7 years**	85.75	14.46	89.63	13.51
Non-Native	**20**	**8 - 12 years**	90.62	9.55	94.01	5.42

The findings of the SUS and HARUS questionnaires, as shown in Table 8, indicate that students have high mean scores. When the data from Table 8 are broken down by age, we found that the older non-native students (i.e., 8 to 12 years old) have a higher SUS mean score compared to the younger native students (i.e., 4 to 7 years old) *($M_{non-native}$ =*

90.62, M_{native} = 85.75). Similarly, the mean HARUS score of older non-native students was higher compared to younger native students *($M_{non-native}$ = 94.01, M_{native}= 89.63)*. This data shows that older age students in the experimental group were more comfortable and satisfied with the usability of the AR application.

RQ3. Is there a difference in the experimental group's native and non-native students' attitudes towards the AR application?

Table 9. Descriptive data of students' attitude towards AR application

Participants	N	Age (years)	Satisfaction		Anxiety		Willingness	
			M	SD	M	SD	M	SD
Native	**20**	**4 - 7**	4.51	0.37	1.47	0.49	4.65	0.56
Non-Native	**20**	**8- 12**	4.56	0.41	1.41	0.34	4.72	0.54

The observed mean of attitude subfactors – satisfaction and willingness were high for both groups. It was found that non-native learners had a slightly higher level of satisfaction *($M_{non-native}$ = 4.56, M_{native} = 4.51)* and willingness *($M_{non-native}$ = 4.72, M_{native} = 4.65)* than native learners. Additionally, the average anxiety level of both native and non-native learners was reasonably low. However, Table 9 reveals that non-native learners have lower anxiety than native learners *($M_{non-native}$ = 1.41, M_{native} = 1.47)*. It was noted that the experimental group students were highly satisfied with the Bodo-AR and eager to use it again.

RQ4.What is the relationship among the experimental group students' achievement, SUS, HARUS, and ARAAS scores?

Table 10. Pearson Correlation between achievement, SUS, HARUS, and ARAAS of native speakers.

	Achievement	SUS	HARUS	ARAAS
Achievement	1			
SUS	.526*	1		
HARUS	.262	.842**	1	
ARAAS	.603**	.638**	.631**	1

*(*p<.05 **p<.01)*

To determine the correlation between achievement, SUS, HARUS, and ARAAS scores of the native students who used AR applications, the Pearson Correlation Test was conducted. In Table 10, we reported the observed results. It was found that there is a moderate positive correlation exists between Achievement and SUS *(r=.526, p<.05)*, highly positive and statistically significant *(r=.842, p<.01)* between SUS and HARUS, no significant relationship between Achievement and HARUS *(r=.262, p>0.05)*, moderate positive correlation between ARAAS with *Achievement (r=.603, p<.01), SUS (r=.638, p<.01)*, and HARUS *(r=.631, p<.01)*.

Table 11. Pearson Correlation between achievement, SUS, HARUS, and ARAAS of non-native students.

	Achievement	SUS	HARUS	ARAAS
Achievement	1			
SUS	.508*	1		
HARUS	.351	.663**	1	
ARAAS	.011	.381	.528*	1

*(*p<.05 **p<.01)*

Pearson Correlation test result as shown in Table 11 identified a moderate positive and significant relationship between Achievement and SUS score of non-native speakers *(r=.508, p<.05)*. There is also a significant positive correlation between SUS and HARUS of moderate size *(r=.663, p<.01)*. However, no significant correlation of Achievement was found with HARUS *(r=.351, p>.05)* and ARAAS *(r=.011, p>.05)*. Additionally, no significant relationship between SUS and ARAAS was found *(r=.381, p>0.05)*. A positively moderate significant correlation was determined between ARAAS and HARUS *(r=.528, p<.05)*.

RQ5. Whether the teachers found BodoAR to have the potential for improving learning?

The BodoAR application received positive feedback from the teachers. During the interview, we found that none of the teachers had ever heard of AR technology and were not familiar with it. They also mentioned that they have never used any digital technology like AR technology for teaching in classrooms. After observing the student's enthusiasm for the application and ease of access, teachers agreed that using the AR application in the classroom would be beneficial. They believed that the BodoAR application's 3D models and sounds were the highlights that attracted the students and could improve children's learning interests and memorization. However, one teacher did not consider it safe for young children, since it deals with the use of smartphones. Additionally, he also noted that since children become accustomed to mobile learning through online classes throughout the pandemic, it is impossible to prevent technology from reaching them. Another teacher also thinks that children should not use mobile phones, especially in primary schools. While others believe it to be safe as long as teachers, parents, or other adults are supervising the children.

Further investigations revealed that there is a need for financial aid to adhere to our proposed application in their school. It was also added that the majority of rural primary schools, including their own, could not afford smartphones for the kids. They also mentioned that it would be achievable in government schools and low-budget private schools only if there is an alternate source of funds for procuring mobile devices. However, all the teachers agreed that the BodoAR application will help children's academic development and will be beneficial for primary education.

7.4 Observation

We also tried to conduct a closed-ended interview with students to get their opinions on the BodoAR application. It was observed that children often find it difficult to express their emotions, thoughts, and opinions. Consequently, we favored the observational approach. The observational data will be explained in two sections:

(i) Native speakers (ages 4-7): Based on the children's behavior, it was clear that children liked the application and found it to be highly enjoyable. Students' attention was drawn to the 3D model and sound that are superimposed on the image target. While utilizing the BodoAR app, children were seen smiling and having fun. Two students referred to it as magic, while others attempted to capture the three-dimensional models. Since the experiment of both groups was conducted in the same room, the control group students were exposed to the application, where they were seen diverted from their textbook towards the AR application. While learning using the conventional way, they were observed to be so unmotivated and quite disinterested. We also noticed that children in the control group frequently sought the teacher's help pronouncing the alphabet and numbers. While BodoAR users' kids already have a recorded sound. All they have to do is click the sound option and listen. We also observed that most of the kids could navigate the application with just one instruction demo and use it without any problems. Only a few students asked the instructors for help when they needed to return to the selection menu. They were so enamored with the application that even when the camera occasionally failed to recognize the marker and items were not displayed, they did not give up but instead waited patiently and tried again.

We noticed some usability issues while using the AR application. Young native-speaker children struggled to handle mobile devices for long periods. Holding a bulky phone and navigating for learning was difficult for them, leading to irritation and frequent short breaks. It was also observed one student preferred to learn while her friend held the phone. Additionally, we found that short-height students had difficulty holding the camera steady while scanning the target image, often needing to stand up to get a proper view of the 3D models, which sometimes led to occlusion.

(ii) Non-native speakers (ages 8-12): After the introduction of the BodoAR application, all the students were very happy and eager to learn the Bodo language with the application. On the first day of the class, we could feel their excitement. Children also tried to touch and catch the 3D objects. We observed non-native students were happy. They were tall enough to scan the image target and examine the 3D models without having to stand, and holding the phone was also not an issue. However, three students felt that using BodoAR was time-consuming and preferred to use a regular textbook instead.

8. Discussion

To the best of our knowledge, Bodo-AR is the first application developed in the Bodo language. The objective was to determine how AR technology affected students' learning in comparison to the conventional approach. As required by the BodoAR application's content, this study examined the AR application on very young children. Today's kids are highly habituated to mobile devices and they can use them without any trouble. As a result, evaluations of the BodoAR application's usability were also conducted. The findings suggest that using AR applications can enhance native student’s academic learning.

The study found a significant difference in achievement scores between students who used AR applications and those who used traditional books *($p < 0.05$)*. The average achievement scores of the native students in the experimental group *($M = 10.70$)* were higher than those of the control group *($M = 8.45$)*. This suggests that the use of augmented reality positively impacted the learning of native students. This outcome is consistent with previous studies on the effectiveness of AR applications in improving students' learning performance [7, 15, 16, 21]. Based on the findings, it can be concluded that BodoAR applications are beneficial tools for native language learners in primary education. On the other hand, there was no statistically significant difference between AR application and traditional learning for non-native students *($p > 0.05$)*, contrary to previous research [49], where students utilizing AR Speech gained more knowledge than those using the non-AR approach. Nonetheless, those who used the AR application scored higher. The average achievement scores of non-native students in the experimental group *($M = 9.80$)* were higher than those of the control group *($M = 9.45$)*. Therefore, BodoAR applications can be considered helpful learning tools for all students compared to traditional teaching methods. The study's results reflect the effectiveness of AR applications in enhancing the learning process.

The usability problems that arise when children use AR applications were measured using the SUS and HARUS questionnaires, which were based on the age range of the participants. The findings indicated that older students felt more comfortable and satisfied using the augmented reality application. We also measured the attitudes of the students and found that they had positive attitudes, which is consistent with another research [14, 50]. The students expressed satisfaction and willingness to re-use the augmented reality software, similar to the outcomes of the previous studies [14, 50]. Also, they experienced less anxiety when using the application. The attitude of non-native students who were older was discovered to be marginally greater than that of the younger students. The findings suggest that while AR applications can enhance the learning process, however, using and managing an AR learning application may be challenging for young children, potentially affecting their learning outcomes. Therefore, the learner's age should be considered when implementing AR applications in educational settings as it may influence their behavior and understanding.

We also determined the relationship between achievement and other attributes. The attitudes of the native students in the experimental group were found to be positively and significantly correlated with their academic achievement. However, the non-native students' attitudes and academic accomplishments did not significantly correlate; on the other hand, achievement had a strong and positive correlation with SUS. The findings of this study demonstrate that AR applications helped students and had a beneficial impact on them.

Based on our observation, we found that students enjoyed using the AR application. The students in the experimental group were more focused on learning compared to the control group. However, we noticed some usability issues, particularly with younger students between the ages of four and five. They had difficulty holding bulky phones and interacting with the application at the same time. Additionally, they encountered trouble scanning the marker to view and read the alphabet due to their shorter height, which sometimes caused occlusion problems. During our trial, we observed that the AR group's ability to concentrate on listening to the sounds provided by the BodoAR application was slightly hindered by various background noises. To listen, they had to pull the devices close to their ears, which occasionally caused the image target to be lost and led students to confusion. We also observed that students who utilized the AR were quiet and composed, merely repeating the word pronunciation. Therefore, a classroom setup with a slightly quiet environment will be ideal for teaching with AR applications. In addition to this, the use of headphones for children in the experimental group will be beneficial.

This study has contributed to existing research by providing a novel interactive Bodo language learning augmented reality application for use in both academic and non-academic settings. The findings indicates that the utilization of AR application in primary education has positive consequences. Learning a language has been enhanced for both native speakers and non-native speakers by utilizing AR applications. Additionally, the study found that the age group of the students also impacted the ease of use, handling, and understanding of the AR application during learning.

This BodoAR application is not only for academic learning or school students but anybody who wants to read, write, and learn could use it. Aside from students, it can also be a useful tool for teachers, as well as parents. The Bodo youngsters will mainly benefit from it in terms of learning and retention of the alphabet, words, and numbers. In 1975, the Devanagari script was officially adopted for the Bodo language. Since the Devanagari script is commonly used in Hindi (language) and most Indians are familiar with it, the BodoAR application could be useful for a wider audience beyond just Bodo speakers. This application could be used by any user for language learning as well, including both native and non-native speakers of the Bodo language.

Using quiz mode, users can test their progress, which in turn can boost their confidence. Encouraging feedback such as good, perfect, or excellent might motivate them to study more. Based on our observations, AR has the potential to be a useful teaching and language-learning tool. Children often lack the motivation to learn, however, our research indicates that employing AR applications can motivate and help children in learning. In a way, the BodoAR application will keep the language alive of Bodo tribal people, if it reaches out to people and solves the problem of affording smartphones. Along with the aim of language preservation, we also wanted children to learn effectively in their academic pursuits.

9. Limitations

During the implementation of the BodoAR application, we encountered some limitations. One of the main challenges was the lack of smartphones in schools for the experiment. We noticed insufficient resources to purchase devices for future augmented reality implementations in rural schools. Consequently, we had to provide the devices for the students during the experiment. Another hurdle was the limited digital knowledge among some teachers, requiring training to effectively use AR applications in the classroom. Additionally, younger students found it challenging to handle bulky devices, and many struggled to hold large smartphones for extended periods. One potential solution to this issue could be to use mounts to hold mobile devices.

10. Conclusion

In this study, we presented an AR application - “BodoAR” designed to teach Bodo alphabets and numerals to the Bodo tribal people, an ethnic tribe of India. To evaluate the usability of this AR application, an experiment was done on primary students who are native speakers and non-native speakers of the Bodo language. The achievement test and attitude towards the BodoAR application were also examined. The statistical analysis shows a significant improvement in the native Bodo speaker students' learning performance. No significant difference in academic achievement between the experimental and control groups ($p>0.05$) was observed for the non-natives. We also noted no sign of anxiety, and willingness to use Bodo-AR in the future. It was observed that the BodoAR application had a high mean level of SUS and HARUS scores. However, there were variations between native and non-native SUS and HARUS scores. The non-native kids (ages 8–12) experienced fewer usability problems with the AR program than the native students (ages 4-7). We found teachers also agreed on the possible advantages of utilizing the augmented reality software in the classroom. As a result, we may conclude that the BodoAR application can be used as an effective teaching tool, even in rural primary schools. Restrictions such as device unavailability and lack of knowledge regarding technology learning may hamper augmented reality learning. In the future, there might be more AR applications developed for learning other native languages. It will be intriguing to find out if our findings conquer or contradict their findings.

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