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'AReal-Vocab': An Augmented Reality English Vocabulary Mobile Application to Cater to Mild Autism Children in Response towards Sustainable Education for Children with Disabilities

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Abstract: The American Psychiatric Association defines autism spectrum disorder as a neurological illness, in which children with the disorder have trouble communicating socially or have a set of behaviours that are recurrent or restricted. Autism learners are mostly visual method learners who learn best through pictures and visuals. Most learners with autism struggle to learn new terminology due to their cognitive difficulties, and with the advent of the Fourth Industrial Revolution, technology is no longer a foreign concept in the educational sphere. The usage of augmented reality technology has proven to be beneficial in offering more relevant learning sessions for autism learners. As a result, underpinned by the learning theories of behaviourism, constructivism, connectives and cognitivism, altogether with the theory of mind and Frame model, an augmented reality smartphone application, called 'AReal-Vocab', was created to assist children with mild autism in acquiring English vocabulary. The design and development research approach was employed in this study, in which later, the developed mobile augmented reality application was then tested on six mildly autistic youngsters to see how well the designed and developed augmented reality mobile application aided them in acquiring the English language. The AReal-Vocab mobile application, which was planned and built, has had an impact on the English-vocabulary learning of children with moderate autism, according to the findings. Not only has AReal-Vocab helped mildly autistic children learn English vocabulary in a more engaging and meaningful way, sparking their interest in the language learning process, but it also serves as a platform for instilling leisure learning at home, as well as stimulating pronunciation skills and language articulation. The findings of this study are expected to benefit all parties involved, particularly children with autism, autism educators, and parents of children with autism.

Keywords: autism education; augmented reality; ESL learning; mobile application; vocabulary learning

Citation: Hashim, H.U.; Yunus, M.M.; Norman, H. 'AReal-Vocab': An Augmented Reality English Vocabulary Mobile Application to Cater to Mild Autism Children in Response towards Sustainable Education for Children with Disabilities. *Sustainability* **2022**, *14*, 4831. https://doi.org/10.3390/su14084831

Academic Editors: Luis Ortiz Jiménez and José Juan Carrión Martinez

Received: 10 March 2022
Accepted: 12 April 2022
Published: 18 April 2022

1. Introduction

Autism spectrum disorder (ASD) causes a child to have chronic difficulty with social communication and interactions in a variety of settings, as well as to exhibit confined, repetitive patterns of behaviour, interests, and hobbies [1,2]. There are mild and severe symptoms, with the latter requiring more assistance in daily activities [3]. There is a pressing need for learning to be inclusive for all children, particularly those with autism spectrum disorders (ASD), as we work toward UNESCO's sustainable development objectives (number four of which emphasises inclusion in education through excellent education) [4]. Under the Education Act of 1996, students with learning disabilities, such as sight, hearing and speech, Down Syndrome, moderate autism, Attention Deficit Hyperactivity Disorder (ADHD), slight mental disorder retardation, and dyslexia, are designated as special education students. According to [5], the inclusion of children with disabilities has been increasing

internationally since the proclamation of "Education for All" in Jomtien, Thailand, in 1990, and a conference on Special Needs Education in Salamanca, Spain.

According to government sources, the National Autism Society of Malaysia (NASOM) [6] and many other private non-profit organisations in Malaysia, provide a spectrum of help, care, support, and education for autistic children. Fourteen Early Intervention Programs work with younger children to help them transition to regular schooling, while three Vocational Programs teach them basic life skills, including baking, food preparation, laundry, housekeeping, sewing, handcrafts, data entry, and card design [6]. It is intended that people with autism spectrum disorders might learn and live a useful, productive, and fulfilling life. A typical training and intervention strategy is the behavioural method [7]. Autism Awareness Campaigns are held on a regular basis to raise public awareness about the condition [8].

Children with autism, despite their obstacles, have the right to be included in all aspects of their lives, including learning English. English has become a worldwide language, as a result of technological developments and the world of the Fourth Industrial Revolution [9,10], and inclusive education will help children with autism survive in the future [11,12]. Learning a language is a process, and learning vocabulary is the first step. According to [13,14], word knowledge, or vocabulary, is the foundation for most elements of language and achievement. Vocabulary development is a crucial element of language learning, according to Paradis, Rusk, Duncan, and [15]. Several researchers have looked into the possibilities and devised strategies to assist autistic children with their language skills, according to the literature. Take, for example, the use of technology as an assistive device for autistic children. Each autistic youngster is self-contained. Autism affects children all around the world, and their problems and struggles are similar [16,17]. Each autistic child has his or her own learning style and preferences, which can be both advantageous and problematic for them as students. Learning a language, on the other hand, is a difficult task for autistic youngsters [18,19].

Listening, reading, speaking, and writing are the four basic skills addressed in language studies. It is impossible to master a language without first mastering its vocabulary [20]. The acquisition of vocabulary, particularly in English language learning, is a crucial aspect of the learning process. Beginning in kindergarten and continuing through university education, the language is taught in schools [21]. English language skills, whether for typically functioning or autistic children, can help them succeed in school and in the workplace in the future. However, if they do not understand the vocabulary component of the language, understanding the English language will be impossible [22]. Because of their cognitive impairment, autistic children's communication skills are limited, making it difficult for them to express themselves vocally [23]. They often have communication problems, which is why they use nonverbal communication strategies, such as shouting, sobbing, and throwing tantrums. Autism children find it challenging to learn a new language, particularly English.

The four abilities of hearing, speaking, reading, and writing are examined when learning a language. It is impossible to master them without first developing a strong vocabulary foundation. As previously stated, learning vocabulary is critical to improving English skills. As a result, it has become a crucial component of English instruction. According to [24], several talents and components must be learned when learning a second or foreign language. Without speaking, one of the most important talents and variables in language development is vocabulary. It can be deduced that vocabulary refers to a collection's entire quantity of words and that nothing can be communicated without it. Technological discoveries are pushing the invention of more informatics-based solutions for children with autism, according to [25], and the opportunities afforded by technology today are convenient for children with autism to exploit. The introduction of augmented reality technology in recent years has the potential to have a significant impact on education, providing new approaches for language teaching and learning [26]. ARWAK, an app that stands for Augmented Reality Wordbook, was developed by [27], who discovered

comparable results and believe their app has helped kindergarteners learn a few more words than a regular wordbook. Their research also found that the augmented reality mobile app increased children's involvement and kept them involved in the learning process for extended periods of time. According to [28], augmented reality technology has a lot of potential for children with autism, in terms of therapy, intervention, and education.

Ref. [25] feel that augmented reality technology is not just effective, but also practicable for use in natural settings, compared to earlier technologies. Technology has been making waves in educational settings, especially involving children's education [29]. Ref. [30] mentioned that touchscreen technology, at its best, provides an interactive experience that closely resembles a child's natural constructivist learning. Smart gadgets with associated apps (Apps) can, in theory, provide engaging and effective learning environments in educational settings. Technology is a realistic alternative for children with autism because they can utilise old phones to access augmented reality. A number of prior studies have shown that augmented reality technology can help youngsters with autism. Ref. [31] carried out a systematic review of the impact of augmented reality technology on the social, cognitive, and behavioural domains of children with autism. According to their findings, the majority of data from the literature supports the hypothesis that using augmented reality can deliver meaningful and engaging experiences to children with autism. When the literature on technology-based research for children with autism is examined, it becomes evident that augmented reality technology is one of the most effective technologies for autistic children to use as an assistive tool. Despite the fact that the use and intervention of technology in autistic education has evolved since 2012, researchers may find it more challenging to conduct interventions with special education children.

Scholars and educators have taken a variety of initiatives and innovations to provide learners with additional support resources that may be able to help them with their English language learning [24]. One of the efforts and techniques utilised is the use of technology to assist learners in their English language learning process. Numerous technologies and strategies have been developed to provide technology to ordinary learners, in order to enhance their learning growth, notably in language acquisition [32,33]. The ESL learning process among typical ESL learners, including adults and children, as well as the integration of technology into the English language learning process, have both been studied extensively in the past. In the domain of education, new ideas have been making waves, with new inventions supporting both teachers and students with their teaching and learning processes, including those with special needs [33–35]. However, there has not been much research or focus on autistic learners' ESL learning journeys, let alone the use and integration of augmented reality technologies to help them increase their English vocabulary. As such, in addressing the issue, this study intends to investigate to what extent the designed and developed augmented reality mobile application 'AReal-Vocab' helps to assist mildly autistic children in their English vocabulary learning.

The augmented reality technology used in the development of the 'AReal-Vocab' smartphone application aims to provide a medium for children with moderate autism to enjoy self-paced and independent learning throughout their English vocabulary learning journey. The use of technology and 3D pictures in language learning methods for children with autism has been found to be beneficial. The findings of this study will increase the likelihood that educators and the Ministry of Education will examine the use of technology as a teaching and learning tool for children with autism. The availability of flashcards will assist youngsters with autism in acquiring English vocabulary and grasping the meaning of each word in a more engaging manner. Additionally, a text recognition feature has been added as an advantage feature to make the app more convenient and accessible, even without the usage of flashcards, allowing children to learn English vocabulary in their leisure time, with the help or guidance of their parents. Learners only need to scan the included flash cards to see a visual of the 3D picture feature while using the programme on their or their parents' smartphone. Learners will be able to acquire and study new

English vocabulary in a more interesting way with the help of the mobile augmented reality application.

2. Materials and Methods

2.1. Research Design

This study employed a qualitative approach in which field notes and individual interviews were used as the instruments.

2.2. Sample

The sample involved in this study comprised six mildly autistic children and the three parents whom their children involved during the implementation process. Purposive sampling was employed in this study and the purposive sampling criteria are as in Table 1 below.

Table 1. Purposive sampling selection criteria for implementation and evaluation phase.

No.	Selection Criteria
1	Autism children
2	5–12 years old
3	Voluntary

2.3. Instruments and Procedure

Individual interview and field notes observation were employed in this study. The researchers used a double-entry logbook to analyse the data, which allows the observation to be isolated from bias. Aside from that, the researcher recorded portions of the meetings to ensure that the findings were not lost.

Six children with mild autism were observed both as participants and as non-participants by the researchers. Participants' behaviour and reactions throughout the session were observed and documented during the implementation and evaluation phases. Five sessions, each lasting half an hour to forty minutes, were held over the course of five weeks. Each session had a different time slot, however they were all held in the morning. During the 5-week implementation period, the researchers spent around 15–20 h observing the respondents. Table 2 below provides the details of the observation sessions.

Table 2. The observations conducted during the implementation phase.

No.	Date	Time	Observation
1	27 June 2021	10 am–3 pm *	Sessions conducted with the respondents
2	10 July 2021	10 am–3 pm *	Sessions conducted with the respondents
3	28 July 2021	10 am–3 pm *	Sessions conducted with the respondents
4	20 August 2021	10 am–3 pm *	Sessions conducted with the respondents
5	1 September 2021	10 am–3 pm *	Sessions conducted with the respondents

* the time varies for each respondent * the duration for each respondent is 20–30 min per session.

The researchers met with all six respondents for five sessions, with parents conducting the implementation with their children at home during their free time in between. Videos of the child participating in the implementation session with their parents were transmitted to the researchers. The researcher performed a semi-structured interview session with the parents of the mildly autistic children near the end of the five sessions with the children. Three parents of mildly autistic children who were involved in the implementation process agreed to participate in the semi-structured interview. The primary goal of the one-on-one interview was to confirm the data collected from observation.

2.4. Data Analysis

Cohen Kappa value analysis was performed to measure the degree of expert or evaluator agreement on the built topic in order to determine the trustworthiness of qualitative data. Evaluator agreement is critical in determining the high reliability of each unit utilised to characterise a theme. The data were gathered and matched with supporting data collected through document analysis as reinforcement after all interview transcripts were validated by study participants. After that, the data were carefully collated to determine the study's theme. Until the theme findings are obtained, the data-coding process is completed.

The data from the interviews were examined in five stages. The steps were: (i) data transcription, (ii) encoding scheme, (iii) data analysis procedure, (iv) data reduction and (v) data sorting. To guarantee that all of the data were assessed according to the themes and categories developed, the researcher had to revise and analyse the data obtained several times.

3. Results

The demographic background analysis of the six autistic children involved in this research is described in Table 3, below, with the pseudonyms given to each of the respondents.

Table 3. Demographic background of respondents with the pseudonyms given.

Sex	Age	School Background
Boy	12 years old	Special education
Boy	7 years old	Full inclusion
Boy	11 years old	Full inclusion
Boy	6 years old	Special education
Boy	12 years old	Full inclusion
Girl	5 years old	Special education

Children with moderate autism from Presint 14, Putrajaya, Semenyih, Selangor, Bandar Baru Bangi, Selangor, and Seremban, Negeri Sembilan and Malaysia participated in this study during the implementation and evaluation phases. Their ages range from 5 to 12 years old, and all have moderate autism. Mild autism is characterised as youngsters who can respond to instructions but do not have a severe autism diagnosis, according to the study's operational criteria.

3.1. The Feature of the Designed and Developed AReal-Vocab Mobile Application

The application's strengths include being simple for the target demographic and being able to assist children in gaining greater attention in their English vocabulary learning process. The mobile application is also thought to be beneficial in capturing the attention of children with autism throughout their learning process. The created and developed augmented reality mobile application was also thought to be intriguing by one of the responders because of its beautiful and appealing colourful content. The 3D character included in the material has a distinct and lively appearance that can influence the target user to understand the text's meaning, as shown in Figure 1, below.

The flashcards that represent each phrase are another feature of this created and developed augmented reality mobile application, AReal-Vocab. The flashcards were designed with a few different aspects and views in mind. The colour scheme and visuals used to represent the words in the flashcards were chosen to be bright and lively. Furthermore, the researcher opted to include a one-liner of an explanation of the words, as well as their use, on the flashcards.

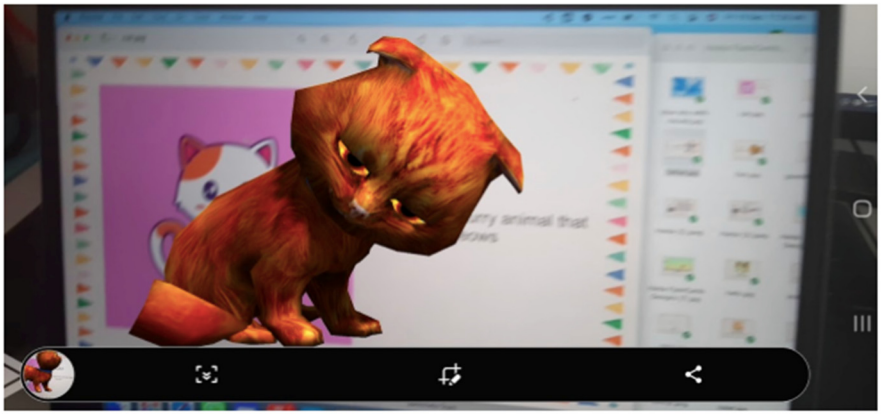

Figure 1. The 3D feature of the designed and developed AReal-Vocab mobile application.

Figure 2, above, depicts a flashcard design sample. The flashcards' design features graphics in bold and appealing colours. The rationale for the bright and appealing visuals is due to the demands of autistic children, who learn best through pictures and appealing imagery. Colourful graphics can assist autism youngsters in focusing on vocabulary learning by capturing their attention and keeping their attention span longer. Furthermore, the flashcards contained more than just words. In addition to the words, the flashcards included a brief description or example of how to utilise the words. The presence of this factor is attributable to the fact that the majority of autistic children lack Theory of Mind.

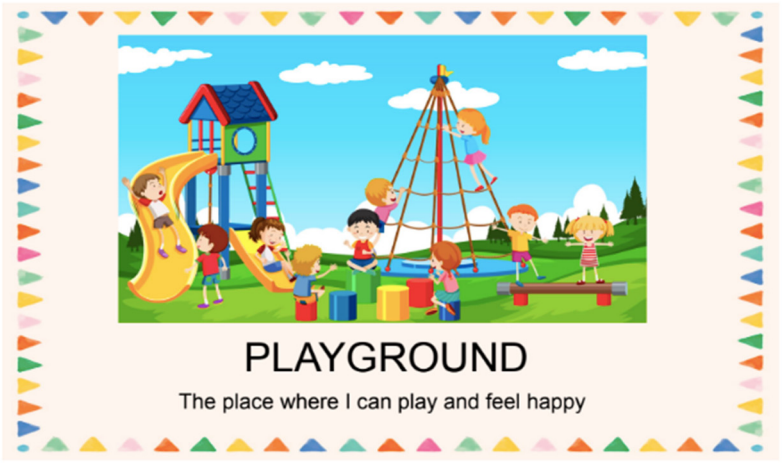

Figure 2. The sample of flashcards.

3.2. Descriptive Findings of the Observation

Each child with moderate autism has various characteristics and symptoms of autism spectrum disorder, but they are all classified as mild autism, since they respond effectively to instructions and may react appropriately.

3.2.1. A. Danial (12 Years Old)

Danial, a 12-year-old child with autism spectrum condition, is a joy to be around. He presently resides in Putrajaya's Presint 14, Malaysia. He attends a special education school because, according to the parents, his diagnosis requires him to be in a special education classroom because he requires more attention, and his motor skills are inadequate. When he was initially introduced to the created and developed mobile application AReal-Vocab during the observation, his reaction was awkward. When he was given the device, he had no idea what to do with it. Seeing his mother's reaction, he asked for aid and was told to attempt to hold the phone tightly. However, due to his limited motor skills, he struggled to grasp the phone and scan the flashcards. He only started to get the hang of it after a few

rounds of practise holding the phone and scanning the flashcards. He occasionally needed assistance holding the phone and scanning the flashcard.

3.2.2. B. Haziq (7 Years Old)

Haziq is a 7-year-old child in Semenyih, Selangor, who attends a full-inclusion school. He had no idea what to do with the mobile application when it was first handed to him. Then, his parents told him to scan the flashcards, and that is when he realised what he had to do. With only one lesson, he was able to utilise the mobile programme independently to scan flashcards and play about with it at his leisure. He was engrossed in the 3D interactive pictures presented in the smartphone application for the entire five sessions.

3.2.3. C. Azfiras (11 Years Old)

Azfiras, an 11-year-old child, was diagnosed with a mild form of autism. His main issue is that he has a limited attention span. He has a tendency to become bored with things in a short period of time. He is an excellent English speaker, and English is his first language at home with his parents. He appeared uninterested when first shown the created and developed mobile application, and he questioned the researcher about what he needed to accomplish. The researcher told him to open the mobile app on the phone he had been given and then scan the flashcards. Surprisingly, he was enthralled by the characteristics and 3D visuals in the mobile application when he first scanned the flashcards. He was the only one who said the words in the flashcards out loud while scanning them. The researcher was able to pique his interest in the augmented reality mobile app and keep him interested for an extended period of time.

3.2.4. D. Carl (6 Years Old)

Carl is a six-year-old boy who is still unable to communicate verbally. His mother claims that communicating is her greatest struggle. Other concerns, such as meltdowns and tantrums, arise from a lack of communication and understanding on both ends. His ability to understand what he can and cannot do is, likewise, covered by communication. It was difficult at first, but according to his parents, he has advanced to pointing to tell them what he wants, gesturing and making sounds, and occasionally pulling his parents to the object he desires. He was excited when he first saw the augmented reality mobile application because it allowed him to play around with the phone. He was ecstatic to be able to play with the phone and scan the flashcards, and he was more than willing to do so. Simultaneously, his mother questioned him and modelled the content terms in the flashcards. Following his mother's lead in saying the words, he followed suit.

3.2.5. E. Zul (12 Years Old)

Zul is a 12-year-old boy with communication problems. In a public school in Bandar Baru Bangi, he is enrolled in a full-inclusion classroom programme. His parents claim that he is not a particularly active student in class. His cognitive ability is at an all-time low, and during classroom classes, he has been reported to only be able to copy the questions rather than answer them. He knew what he needed to accomplish when he was given the created and developed augmented reality mobile application AReal-Vocab. However, the researcher noted that while examining the flashcards, he had not said anything. As a result, the researcher attempted to probe him by modelling the words, and he was able to say them.

3.2.6. F. Afiyah (5 Years Old)

Afiyah is a five-year-old girl who has yet to attend pre-school. The parents, on the other hand, discovered that their daughter has a speech impediment. When she was three years old, her parents noticed the symptoms. She was still unable to communicate phrases or complete words at the age of three. She could only utter a single word and has a restricted vocabulary. All she had to do if she wanted something was grasp her parents'

hands and gesture to it. Her parents also mentioned that she has tantrums and cries for no apparent reason. Her parents imagined she threw tantrums because she could not express herself verbally. She was unsure what to do when she first saw the created and developed augmented reality mobile application AReal-Vocab. Only after her parents persuaded her to hold the phone and scan the flashcards did she follow the instructions. She was so pleased when she scanned the flashcards and saw the lovely and colourful visuals that she wanted more.

3.3. To What Extent Does the AReal-Vocab Mobile Application Assist Mildly Autistic Children in Their English Vocabulary Learning Journey?

Observations and semi-individual interviews with six mildly autistic children and three parents whose children were involved in the observations were used to address the research question. The researcher took field notes before, during, and after the observation. After the sessions, an individual interview with the parents of the children who participated in the observations was conducted to gain their perspectives on the usage of the AReal-Vocab mobile application in supporting autistic children with their English vocabulary learning. The autistic children were observed five times (in five sessions) throughout the trial, and their parents were questioned once after all five sessions of implementation were completed. Each implementation session lasted 30–40 min.

The data were categorized into themes on to what extent the designed and developed augmented reality mobile application (AReal-Vocab) assists children with autism. The five themes found were (a) helps to inculcate self-paced learning at home, (b) helps to train in listening and understanding instructions, (c) helps to keep the attention span longer, (d) helps with word pronunciation and enunciation and (e) helps keeping mildly autistic children engaged and interested in learning vocabulary.

3.3.1. A. Helps to Inculcate Self-Paced Learning at Home

There were reactions that led to the creation of this theme based on interviews conducted with parents of autistic children. Parent 1 said that her son behaves differently at school and at home at times.

> *" . . . he is different with me at home, so I try to engage him through play, talking to him or inculcating learning in everyday tasks. I also try to involve him in what I do . . . ".*
>
> (Interview, Parent 1)

Parent 1 is certain that the AReal-Vocab mobile application can assist in instilling self-paced English vocabulary learning in autistic children at home, as she also said that the augmented reality mobile application AReal-Vocab assisted her in keeping her child engaged and interested.

> *" . . . This mobile application can help me with that . . . "*
>
> (Interview, Parent 1)

Furthermore, Parent 2 stated that the use of AReal-Vocab, an augmented reality mobile application, is beneficial when using mobile phones and gadgets as the platform. Parent 2 went on to say that the AReal-Vocab mobile app had successfully captivated her child's attention to learn.

> *"the use of mobile application will capture the children's attention in learning . . . "*
>
> (Interview, Parent 2)

Parent 2 noted that her child is usually fascinated by cell phones and other electronic devices. AReal-Vocab, an augmented data smartphone application, has managed to pique his interest in studying. When he is told to use the AReal-Vocab, he gets quite thrilled because of his interest in mobile phones and electronics. When he is asked to utilise the smartphone application, he becomes more excited and intrigued. One of the reasons for this is that he enjoys the concept of being able to hold the phone in his hands and scan the flashcards that come with the mobile application.

"my child is very familiar with mobile phone, he gets excited whenever it involves phone . . . "

(Interview, Parent 2)

Furthermore, it is clear from the findings that in today's technological world, autistic children are no different than usually developing children, in terms of their familiarity with devices, particularly mobile phones. The findings also showed that using mobile applications combined with augmented reality technology to teach English language to autistic youngsters helped to attract their attention. Parent 3, on the other hand, went on to say that her child is different from him and his teachers at school. He adjusted well in school and was able to recognise when he was required to do his task. He will also pay attention to the job at hand. Parent 3 claims that:

" . . . With his teachers, he has adapted well and understands when he needs to do his work and pay attention to tasks. With me it is very different . . . "

(Interview, Parent 3)

Parent 3 expressed her frustration with her child acting differently at home and at school with his teachers. According to Parent 3, he is constantly demanding attention at home. As a result, Parent 3 stated that she makes every effort to include him in her everyday activities so that he does not feel neglected.

" . . . So, I try to include him in my daily routines. For example, if I am working on my laptop, I put some coloured pencils and paper by me with some paper or colouring books and encourage him to scribble or colour . . . "

(Interview, Parent 3)

Keeping her child occupied, according to Parent 3, can be difficult at times, but she has discovered that the designed and produced augmented reality smartphone application AReal-Vocab can be useful as a tool or medium to keep her child occupied while also learning. At the same time, she can utilise AReal-Vocab to keep him occupied, entertain him, and be a part of it via the mobile application. Not only that, but Parent 3 believes AReal-Vocab is an excellent platform for her child to learn English vocabulary at home while having fun.

"now with this mobile application, in a way I have a medium that can have both me and him involved . . . "

(Interview, Parent 3)

"now he can learn vocabulary at home . . . "

(Interview, Parent 3)

The findings suggest that AReal-Vocab can assist parents in becoming more active in their autistic children's learning at home. With this topic under discussion, Parent 1 agreed, stating that not only is AReal-Vocab useful as a platform for involving both parents and autistic children in their learning process, but that the designed and developed AReal-Vocab is also useful as a platform for assisting parents in their autistic children's school learning process. AReal-Vocab, according to Parent 1, is useful as a follow-up to what the children have learned in school.

"this can be helpful as a 'follow-up' from what the children have learnt at school . . . "

(Interview, Parent 1)

Being able to be part of the autistic children's learning process is helpful, as it can help the parents to inculcate a self-paced learning routine among the autistic children, with the parents as guides. Findings reveal that all three parents of children with moderate autism who participated in the implementation sessions agreed that AReal-Vocab aids in the instillation of self-paced learning at home. Based on the findings, the planned and created augmented reality smartphone application AReal-Vocab can be beneficial in instilling self-paced English vocabulary learning in autistic children at home.

3.3.2. B. Helps to Train in Listening and Understanding Instructions

During the implementation phase observations, one type of behaviour occurred that piqued the researcher's interest. The six mild autistic youngsters all had the same reaction during the first session of implementation: they were unsure of what to do. When Danial was originally handed the mobile programme Areal-Vocab and flashcards, he had no idea what to do with them. He just comprehended what he needed to accomplish after being instructed by his parents. Danial could utilise the AReal-Vocab and scan the flashcards on his own with just one lesson.

When Aafiya, a mildly autistic 6-year-old child, was initially handed the AReal-Vocab and flashcards, she was unsure of what to do. She only handled the phone and scanned the flashcards after being persuaded by her parents. During the implementation session, other ASD youngsters displayed the same pattern of conduct. Seeing the behaviour, the researcher intervened and investigated, with the support of parents, giving the autistic youngsters instructions on what they needed to accomplish. All of the moderately autistic children were able to function independently after only a few drills of instructions and direction, and they were aware of what they needed to do; nevertheless, it took a few instructions for them to understand what they needed to accomplish.

3.3.3. C. Helps to Maintain Attention Span Longer

One of the challenges autistic children face with regard to their English vocabulary learning is that they are typically visual strategy learners, meaning they learn best through images and pictures, as evidenced by the data gathered during the observations and focus group discussions in the analysis phase. The AReal-Vocab mobile application is designed and developed using intriguing and appealing visuals as part of the material to grab autistic children's attention and address this difficulty that they confront in their English vocabulary learning journey. Augmented reality technology is also being used to assist autistic children in learning the English language in a more pleasurable way. One of the mildly autistic children, Azfiras, appeared uninterested at first when the mobile application and flashcards were handed to him during the implementation phase observations. However, as soon as he began scanning the flashcards, he became enthralled and captivated by the visuals. After a few minutes, he became completely absorbed in the activity and remained thus for a long time. When he was given the mobile application and scanned the flashcards, Haziq, a mildly autistic child, was immediately fascinated by the engaging and intriguing visuals. The visuals offered as material in the AReal-Vocab mobile application piqued the interest of all six of the moderately autistic children. From this, it can be observed that the AReal-Vocab mobile application was intended and built to assist in keeping moderately autistic children's attention spans longer and concentrated on an activity for a longer amount of time.

Parent 2 noted in one of the interviews that her child got hooked on nursery rhymes on television, which led to him wanting to watch them on his phone.

> *" . . . He used to be extremely hooked to nursery rhymes on the tv, which slowly progressed to watching them on phones"*
>
> (Interview, Parent 2)

She is so concerned about nursery rhymes that she and her husband have decided to restrict her son's access to screens and electronics. However, she believes that this well-designed and created mobile application, which incorporates augmented reality technology, will assist her in resolving her dilemma. Instead of becoming addicted to nursery rhymes and other videos on the Internet, this mobile application can be used to keep her son engaged with electronics for the goal of informal learning under her supervision. She feels that the created and produced mobile application, with its 3D pictures that can catch autistic children's attention, is as entertaining as nursery rhymes available on the Internet. Finally, it can be concluded that the created and produced augmented reality technology can aid in attracting mildly autistic youngsters to learn the English language in a more engaging way.

At the same time, the AReal-Vocab has been shown to help moderately autistic children learn English vocabulary for longer periods of time.

3.3.4. C. Helps with Words Pronunciation and Enunciation

During the individual conversation with the parents, they noted that difficulty with language articulation and pronunciation is one of the characteristics of autism spectrum conditions. One of the parents, Parent 3, stated that seeing her child struggle to pronounce words used to worry her as a mother. However, the mother noticed that her child was progressing over time when he began to use the mobile programme, as she said.

> *" . . . Alhamdulilah now slowly he is willing to read English words. He likes English words more than Malay as he said Malay words are too long to pronounce . . . "*
>
> (Interview, Parent 3)

Probing the moderately autistic children's pronunciation and having them repeat the words could be an effective strategy to encourage them to improve their language articulation. Based on the information gathered during the semi-structured interview, the parents realised that drilling is the greatest strategy for improving their autistic children's verbal articulation.

Findings reveal that all three parents interviewed agreed that the created and developed augmented reality smartphone application AReal-Vocab aids their moderately autistic children's word pronunciation and enunciation. This shows that the constructed and developed augmented reality smartphone application can assist mildly autistic youngsters in improving their pronunciation and willingness to speak up, which indirectly aids language articulation.

3.3.5. D. Helps Keep Them Engaged and Interested in Learning Vocabulary Leisurely

Furthermore, based on the observations made, it is clear that multiple paces are available for each issue in the content of the mobile application. This is normal, since, depending on the autistic children's abilities, each topic was completed at a different rate for each of them. Furthermore, it has been shown that each autistic child has diverse preferences in terms of topics. They get highly enthused about specific topics and scan the flashcards of the same topic again; however, they were not as enthusiastic about other topics and took longer to complete those topics.

One of the observations revealed that the topic of 'Animals' piqued the interest of all six autistic children. Animals that children are familiar with, such as cats and fish, are featured in that particular theme. They are interested in it because the issue is relatable to them, and cats and fish are animals that they see frequently, which excites them. The positive thing about this pattern is that the children occasionally requested their parents for more, and some even asked their parents to repeat the animal photographs for them to scan. This is intriguing to parents because their children, in some cases, were unwilling to speak up or talk at all. However, the planned and developed mobile application prompted their youngster to speak up and beg for more, making them more eager to acquire the English language.

On the subject of mobile phones and gadgets, the observations show that the interactive graphics of the content aid students in their involvement in learning English vocabulary. The prospect of being able to play with mobile phones while scanning flashcards made all of the moderately autistic children joyful and eager.

Carl, a 4-year-old boy with mild autism, was excited at the prospect of being able to handle the phone and play with it during the implementation sessions. Aafiya, a mildly autistic 6-year-old child, on the other hand, became enthralled and craved more the instant she saw the appealing and colourful graphics. She could not wait to scan the other flashcards and look at other words just so she could see the 3D visuals that will pop up when she scans the flashcards. The planned and produced augmented reality smartphone application AReal-Vocab is useful in keeping their moderately autistic children involved

in their English vocabulary acquisition, according to all three parents in the separated individual interviews. All three parents noticed that their mildly autistic children were more involved and eager, and some even requested additional opportunities to use the mobile app, scan the flashcards, and even pronounce the phrases.

Parent 3 mentioned that she can see that the idea of playing around with the mobile phone and scanning the flashcards got her mildly autistic child excited and he was more than happy to do it again.

> *" . . . playing with the phone and scanning the flashcards got him excited and he was more than happy to do it again..."*
>
> (Interview, Parent 3)

> *"the images in the mobile application are as interesting as the nursery rhymes available . . . "*
>
> (Interview, Parent 2)

In contrast to nursery rhymes, Parent 2 realised that the created and developed augmented reality smartphone application AReal-Vocab might be used to teach her child the English language. She stated that the AReal-Vocab mobile application's content images are as attractive as nursery rhymes, and that her child now finds the AReal-Vocab mobile application as captivating. Parent 1 said that the element of augmented reality technology aids her child to pay attention during the sessions. She believes that incorporating augmented reality technology into a smartphone application is a fantastic idea, since it will help to catch the attention of mildly autistic children. As a result, it has been demonstrated that the created and developed augmented reality mobile application AReal-Vocab can assist moderately autistic children in acquiring English vocabulary by keeping them curious and involved.

4. Discussion and Conclusions

According to [18], autistic children have difficulty focusing on objects, especially if the objects are unable to maintain their attention; therefore, an augmented reality or pop-up book can assist them in focusing. According to the findings of this study, the use of augmented reality technology incorporated into a smartphone application was able to pique the interest of children with moderate autism. They were captivated by the appealing 3D visuals that appeared on their devices. Previous research by [27], who developed ARWAK, an app that stands for Augmented Reality Wordbook, found similar results, and they believe their app has helped kindergarteners learn a few more words than a traditional wordbook. Their studies also revealed that the augmented reality mobile application enhanced children's engagement and kept them engaged in the learning process for longer. According to [28], augmented reality technology offers a lot of potential, in terms of therapy, intervention, and education for children with autism.

In their evidence on the potential of augmented reality technology, they compiled three main advantages of augmented reality technology in autism education: AR aids in learning engagement, learning interaction, and the learning process. Furthermore, the findings of this study were confirmed by previous research conducted by [30], in which they showed that the use of mobile applications can benefit children for its feature of interactiveness that can cater to the children's natural constructivist learning. Hence, the planned and produced augmented reality mobile application AReal-Vocab aided in the instillation of customised and autonomous learning, as well as constructivist learning in children with autism. During the summative evaluation, all of the respondents only needed to be instructed once, and they were able to utilise the mobile application independently after that. For autistic youngsters, learning on their phones is intriguing enough, but adding a touch of augmented reality, where the images appear genuine, piques their interest. They are more inclined to participate in the educational process. The findings of many prior studies have validated the use of augmented reality technology in autism education, and they are consistent with the findings of this study.

The findings also revealed that the AReal-Vocab augmented reality mobile application, which was devised and developed by the researchers, was successful in stimulating pronunciation abilities and language articulation at home. The flashcards utilised as information in AReal-Vocab, a planned and developed augmented reality mobile application, helped youngsters with moderate autism practise their pronunciation through modelling. When their parents practised speaking the words, they imitated them. Increased referential vocabulary in ASD children, which means teaching the child what specific words refer to, such as teaching the child that the word car refers to the four-wheeled vehicle that the parents drive to work every morning, has the potential to activate syntactic development, according to [20]. As a result, the individual's understanding of the language's grammatical norms will improve over time.

Author Contributions: Conceptualization, H.U.H., M.M.Y. and H.N.; Formal analysis, H.U.H., M.M.Y. and H.N.; Investigation, H.U.H., M.M.Y. and H.N.; Methodology, H.U.H., M.M.Y. and H.N.; Resources, H.U.H., M.M.Y. and H.N.; Supervision, M.M.Y. and H.N.; Validation, M.M.Y. and H.N.; Visualization, H.U.H., M.M.Y. and H.N.; Writing—original draft, H.U.H., M.M.Y. and H.N.; Writing—review & editing, H.U.H., M.M.Y. and H.N. All authors have read and agreed to the published version of the manuscript.

Funding: This project was supported by Universiti Kebangsaan Malaysia, grant MRUN-RAKAN RU-2019-003/4.

Institutional Review Board Statement: The study was conducted according to the guidelines of the Universiti Kebangsaan Malaysia (UKM) and approved by the Institutional Review Board (or Bioethics Committee) of the Universiti Kebangsaan Malaysia, which is required for the research grant MRUN-RAKAN RU-2019-003/4.

Informed Consent Statement: Informed consent was obtained from all subjects involved in the study.

Data Availability Statement: The data presented in this study is openly available.

Conflicts of Interest: The authors declare no conflict of interest.

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