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AUGMENTED REALITY (AR) AS A TOOL FOR BLENDED LEARNING IN JUNIOR HIGH SCHOOL

UNDERGRADUATE THESIS

B.Sc. Computer Science

Priscilla Acheampong

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UDERGRADUATE THESIS

Undergraduate Thesis submitted to the Department of Computer Science, Ashesi University College in partial fulfilment of the requirements for the award of Bachelor of Science degree in Computer Science.

Priscilla Acheampong

2020

DECLARATION

I hereby declare that this Undergraduate Thesis is the result of my own original work and that no part of it has been presented for another degree in this university or elsewhere.

Candidate's Signature: ………………………………………………………………………………

Candidate's Name: ………………………………………………………………………………

Date: …………………………………………………………………………………………………

I hereby declare that preparation and presentation of this Undergraduate Thesis were supervised in accordance with the guidelines on supervision of thesis laid down by Ashesi University.

Supervisor's Signature:…………………………………………………………………..………

Supervisor's Name:………………………………………………………………………………

Date:..........……………………………………………………………………………………

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Abstract

Junior High School (JHS) student are required to write BECE yearly to transition into Senior High or vocational school. The failure rate of these students has been increasing since 2009 [3]. The educational minister reduced the number of subjects from 11 to 9, added BECE re-sit exams and yet the failure rate keeps rising [5]. According to Ghana´s educational minister, it has been observed that little to no visualization of class content has made learning impractical for these students [4]. Also the theory style of preparing these students for BECE seem to make learning, understanding, and visualization difficult.

This paper aims to provide a solution by introducing Augmented Reality (AR) as a tool to be used in a Blended Learning classroom atmosphere at Junior High School (JHS) level. The Augmented Reality (AR) as a tool is developed using a marker-based AR platform which is preferred to location based AR in this research. Marker-based AR apps scan a marker which may be QR code or a virtual image on a phone screen [25]. Location-based AR apps use GPS to locate places nearby and use that data to satisfy users need [25]. Sherimon et al. describe Blended Learning as a combination of face-to-face or traditional learning with e-learning tools [39]. In terms of Blended Learning, using Junior High School (JHS) in Accra-Ghana as a case study, chosen models are: Inside-Out and Supplementary. Inside-Out Blended Learning Model involves student's lessons starting with a traditional classroom teaching style and ending up with learning outside the classroom [52]. Meanwhile Supplementary Blended Learning Model is where students are given a choice between face-to-face learning for every aspect of a course(s) and an e-learning platform for every aspect of a course(s) [52].

The Augmented Reality (AR) tool developed in this paper is called JunAR. From images to animations and sounds, JunAR visually explain a topic in Social Studies to students. Students´ understanding and visualization are enhanced in JunAR.

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List of Abbreviations

AR – Augmented Reality

BL – Blended Learning

JHSS – Junior High School

SHS – Senior High School

BECE - Basic Education Certificate Examination

GES – Ghana Education Service

MoE – Minister of Education

Chapter 1: Introduction

1.1 Background

Education is one of the major focus of Ghana's current governance as headed by His Excellency John Akuffo Addo [1]. His Excellency's goal is to make education accessible to all Ghanaians. However, accessibility truly happens when those involved meet the pre-requisite, which in this case is passing high school national exams: Basic Education Certificate Examination (BECE) and West African Senior School Certificate Examination (WASSCE). Educational stakeholders in Ghana have been intensely worried about how the failure rate of Junior High School (JHS) students continue to outnumber their pass rates [1]. According to Ghana's Minister of Education (MoE) as of 2017, Dr. Prempeh, aside from the fact that private schools tend to do better in BECE, approximately 30% of BECE candidates in general pass well enough to enter senior high school (SHS) [1]. This percentage is three out of ten of the total number of BECE candidates who register and write the exam, which is very discouraging. Research shows that from 2009 to 2014 in Ghana, the Basic Education Certificate Examination (BECE) results have been declining [2]. This decline is headed in the direction of failure with the failure rate of candidates from urban areas being far better than candidates from rural areas [2]. In an attempt to resolve the failure rate, a sample of second-year JHS students from private and public schools were gathered [3]. These students were tested in Mathematics. The results were measured against the national minimum standards. The comparison showed that private school students results were slightly better than all others. [3].

As BECE results were released each year, students and some educational stakeholders associated students' failure to be partly related to the stress of these students learning eleven subjects yearly [4]. His Excellency took heed, and in agreement with Minister of Education (MoE) and Ghana Education Services (GES), the number of subjects was reduced to eight or nine to help students to focus better during BECE preparation [4]. After 2018 BECE results were officially released, 31,196 failed [5]. His Excellency in an attempt to curb this failure passed a policy that required all JHS to re-admit and re-register these failed students to enable them to re-sit BECE the following year [5]. Efforts put in by government and educational stakeholders over the years with regards to BECE so far, seem not to be paying off.

This paper proposes that Electronic Learning otherwise e-Learning can potentially be a platform that can be used to improve teaching and learning in Junior High Schools as a case study of Ghana. E-Learning, as defined by Peacock, is any learning that uses the internet or intranet [6]. In using e-learning, all educational activities for either an individual or group can be accessed online or offline via a network or standalone [7]. E-learning has several benefits, and few of those benefits include:

Convenience and flexibility to learners [8]: E-learning promotes virtual learning such that learners [8] and teachers do not need to be physically present and contained in a classroom setting. E-learning may or may not be self-paced, depending on the course [8].

Quality education made affordable [8]: Recognized experts have the opportunity of making information available internationally to anyone interested at minimum costs [8]. For instance, people in Africa at the tertiary level can take courses from Harvard via edX without being physically present yet get the benefit of knowledge from that institution.

At the tertiary level in some Ghanaian universities such as Ashesi University and Kwame Nkrumah University of Science and Technology (KNUST), e-learning is not a new concept, and its use is quite common [9]. However, the e-learning concept is not very common at the basic educational level for most Ghanaian schools, whether in rural or urban areas. E-learning systems in terms of development may be traditional or adaptive.

Traditional e-learning systems are for general learners with no consideration for the diversity of learners, their abilities, their knowledge and skills, and the learning context [10]. Meanwhile, adaptive e-learning systems are not generalized for learners. Adaptive e-learning pays attention to different learner characteristics (such as knowledge, affective state, and learning style) and personalizes learning materials [10]. BECE failure rate continues to exceed the pass rate even after subject's reduction because most of the candidates use the "chew and pour" learning style. "Chew and pour," otherwise verbatim learning, is where students learn by memorizing with little to zero understanding and forget all they memorized after an exam [11].

Dutta points out that although user interaction is a vital aspect of e-learning, e-learning users lose interest quite fast [12]. Dutta says intuitive interaction as provided by Augmented Reality (AR) is one way to keep students interest on-going [12]. With intuitive interaction, students can experience education from non-interactive books to highly interactive digital experiences that will keep their senses engaged [12].

1.2 Research Problem

Every year Ghanaian students write Basic Education Certificate Examination (BECE), and students' failure rates either rise or remain constant but barely dropping. Breakdown of the failure rate based on private and public schools shows that students from public schools fail worse [3]. Whether these students are from private or public schools, they go through face to face teaching where their understanding of a topic or subject is solely dependent on the teacher. Most classroom teaching are theory-based and not practical enough for student to vividly visualize their understanding; hence, students resort to "chew and pour" learning style [4]. This paper proposes using Augmented Reality (AR), a form of e-learning, as a tool for Blended Learning (BL) in Junior High Schools (JHS) as a case study of Accra-Ghana to bridge the gap between theory and practice.

1.3 Research Question

In this paper, two questions are explored as below:

- Can Augmented Reality (AR) be integrated into JHS in Accra-Ghana as a tool for Blended Learning?
- Can Augmented Reality (AR) based Blended Learning potentially prepare JHS students to fail BECE less?

1.4 Research Objective

The objective of this research is to explore answers to these questions along the lines of:

i. the feasibility of AR as a tool in JHS for Blended Learning as a case study of Accra-Ghana.

ii. whether the AR approach can potentially replace "chew and pour" learning style being utilized by BECE students.

1.5 Motivation

An observations of Ghana's educational system particularly with regards to BECE is the main influence behind this research. Some Ghanaian junior high students who re-sit BECE end up with more failure not necessarily because of inadequate time to prepare but limited understanding from theory-based teaching [4]. This observation motivated the exploration of how e-learning can be used in teaching high school students practically to aid in visualization and learning of class content.

Chapter 2: Literature Review

2.1 Augmented Reality (AR)

Augmented Reality (AR), as defined by Kiat et al., is a trending technology that bridges the gap between computer world and real-world [23] by allowing its users to view objects in the real world via computer view. AR was first used in 1990 in television and military [24]. Screens, glasses, handheld devices, mobile phones, and head-mounted displays are platforms where AR is being displayed [24]. AR does not create a new virtual environment to replace real-world but overlays virtual animated objects in the form of sound, images, and video in real-world environment [25]. AR apps have been grouped into marker-based apps and location-based apps. Marker-based AR apps scan a marker which may be QR code or a virtual image on a phone screen [25]. Location-based AR apps use GPS to locate places nearby and use that data to satisfy users need [25]. Using AR frameworks, a developer can create an AR app from scratch to suit its specific needs. However, there is limited availability of AR frameworks because AR framework development are expensive [26]. Below is an outline of some AR frameworks [26]:

ARKit 3 – It was first introduction by Apple in 2017 after release of iOS 11 [26]. Current version of ARKit app as at 2019 is ARKit 3 [27]. ARKit 3 creates interactive AR experiences with no prior 3D experience using people occlusion, motion capture, multiple face tracking, collaborative senses, and simultaneous front and back camera. [27].

ARCore – This AR framework has been developed by Google for Android. It enables a phone to sense its environment, understand the world and interact with information using motion tracking, environmental understanding and light estimation [28]. ARCore's limitation is, it only runs on devices with Android 7 and above [28].

Wikitude SDK – It uses Simultaneous Localization and Mapping (SLAM) technology which uses tracking and image recognition [28]. Wikitude SDK is for creating AR apps.

An advantage of Wikitude SDK is it is cross platform. This means it runs on Android, iOS and windows' devices [29]. It has a feature to permit switch to ARCore or ARKit [29]. A limitation to its use is that it costs $2800 per year hence not feasible for use in high school education in Ghana.

ViewAR – It is sub-divided into three: ViewAR App Builder, ViewAR SDK and ViewAR Pro Builder. ViewAR App Builder helps to create an AR app using HTML but requires no programming knowledge [30]. ViewAR SDK create custom functionalities, user flows, UIs, templates and programming knowledge are needed [30]. ViewAR Pro Builder is where AR app is developed by team of experienced AR developers [30]. Technologies being used in making AR include [24]:

- *Simultaneous Localization and Mapping (SLAM)* – In AR, SLAM involves location recognition and location tracking [31].
- *Depth Tracking* – It is a sensor data that calculates the distance to an object [24].

With regards to education, Maijarern et al. used AR in primary school by developing the AR as a media in science for these students with the goal of increasing their interest and understanding in Science [32]. This AR tool works with hardcopy books and cards. In testing the AR, a specific subject in Science for primary school was chosen: Plants life [32]. Vocabulary cards for this topic were created, and behind each card was an image that showed animations related to that vocabulary [32]. The card was made colorful to appear fun and appealing to the primary students. This AR was tested on primary students, and it boosted their understanding of topics in the Science subject. The limitation with this application of AR was that it required constant internet connection which resulted in AR app struggling to capture the vocabulary cards [32]. Integrated science is one of the core subjects in JHS in Ghana hence plays a major role in calculating a student's grade. As such, using AR in JHS to create realistic animations will make content visual in students' minds, and the use of color will keep the primary student clued.

To further encourage students to learn and excel in the Science subject, Rongting et al. developed a Science educational AR app [33]. The application works by scanning images either in a Science book or on a card and viewing contents in three-dimensional form. This AR product was tested on students and their parents, and the test result showed that it was appealing to participants as it developed the interest of students in Science [33]. The adoption of this AR products by parents and children shows that JHS students are likely not to have issues in adopting it. This product seems to support self-learning which will be essential for schools with large class numbers.

Mobile learning as an e-learning platform can be useful for utilizing AR in education. W. Cai and Q. Chen, in their research, explored how mobile learning and AR can be combined to study in universities based on their definition and characteristics [34]. With regard to their definition and features, the combination is possible for improving students' learning. This shows that AR as a tool on mobile devices at JHS level can potentially be useful when student has access to a mobile smart device.

Science as a subject is demanding, and students usually struggle to understand fully. AR has been applied to science by varied researchers, all with the aim to make comprehension of difficult topics easier [35, 36, 37]. Virata and Castro developed an AR app for use in science class, which provided 3D visual versions of simple compounds and their chemical bonding [35]. The feedback issue with this app was, it needed to be a bit more complex and realistic. W. Guo et al. also developed an AR software to meet instructional activities in teaching popular science courses in middle school [36], and like Virata and Castro, the AR tool was best suited for learning abstract science topics. For secondary schools, an AR tool was designed by M. Davidsson et al. to make science education augmented, mobile and cheap [37]. An android AR app was developed by Teichner for K-12 students' curriculum with the objective of increasing students' interest and participation in the class [38]. However, this android AR app failed to use cloud storage, making the app larger to install. The absence of cloud storage can possibly discourage JHS students who probably want to reserve their mobile device's memory for other uses. These reveal that AR has been truly applied to science at a varied level in education showing that its application to JHS Science will be a smooth one.

2.2 E-learning Systems in Education

E-learning as a learning tool is a common trend in many higher institutions [13]. Most public higher institutions have large student numbers in their classrooms with many students unmotivated to learn especially as the opportunity to hide in the crowd during lectures is easy to do [14]. These lecturers in an attempt to get these students involved, organize tests; but the large student number in these classrooms make it a struggle to use the output in any meaningful way. Koike et al. built two (2) experimental e-learning systems that were tested to investigate whether students can be motivated to be academically focused [14]. One of their systems is an automatic marking system that will mark the tests given to students [14]. The limitation of the automatic marking system is that it fails to use the outcome of marking as a guide to recommend instructional materials to individual students. In relation to Koike et al.'s paper, large class size in public higher institutions in Ghana where meeting students academic needs is a struggle, the use of this auto-marking system that fails to give academic recommendations is not feasible [14].

In the area of education, many e-learning systems are being practically used. However, students' use of these e-learning systems has been on the low [15]. Matsuo et al. initially created a Web-based distance learning system that increases students' learning efficiency by recommending instructional materials specific to individual students [15]. Their initial system seems to be an upgrade to the one Koike et al. developed. But Matsuo et al. decided to improve students' interest in using the e-learning system even better [15] by upgrading their previous system with addition of new functionalities [15]. The results of their research showed that their upgraded web-based distance learning system further improved students' interest in using the e-learning system which led to an improvement in the students' learning efficiency. Though the added features of Matsuo et al.'s e-learning system could potentially stimulate high school students' interest in using the e-learning system effectively, its simulation is text-based and not animated [15], which can be quite boring for high school students, so it might not be used for extended period.

E.3 **Adoption**

E-learning, as a learning tool in JHS schools in Ghana, will potentially be faced with certain challenges. One such challenge is a limited budget and knowledge of how to use the tool [16]. Tucker et al. suggest tackling this in two ways: First suggestion was teacher should adopt use of presentation slides and quiz students on learning objectives for ever topic in a course/subject as Tucker et al. discussed that it will cut down e-learning costs. [16]. Last suggestion was students being placed at the center of e-learning mode so that students get used to the e-learning atmosphere with time as time passes, the students [16]. In high schools in Ghana, the use of tools like PowerPoint slide for a presentation is not feasible as some of the schools have access to limited number of projectors and computers.

Another challenge is how usability of an e-learning system in terms of interface and available functions. Ardito et al. discussed that identifying features that make an e-learning system usable for target users is key [17]. They proposed the e-learning system should be interactive, allow feedback, motivate, have goals and avoid any nuisance during streaming [17]. For high school students, learning via an e-learning system is likely to be efficient if any form of distraction including ads is eliminated.

E-learning so far works really well in higher education. An e-learning adoption can be possible in high schools if the system is designed with high school students in mind as it will influence choice of objects and colors used in interface and content design. With regard to cost, Danesh's paper shows that teenagers prefer e-learning more because it is cheaper than traditional learning [18]. For instance, studying a Harvard course on edX is cheaper as compared to paying tuition to attend Harvard. Parents of high school students are likely to embrace e-learning because it is cheaper compared to cost of hiring an extra class teacher.

In 2019, *Magic Leap One* was recorded on technology market as an AR app that can be utilized in education. *Magic Leap One* is a lightweight, wearable device that combines virtual reality (VR) and AR [19]. It has 3 parts: a body-worn computer, a controller and goggles [19]. Users of *Magic Leap one* interacts with device using voice, gesture, and head/eye tracking [19]. However, its price range is $1,500 to $2,500 which seems quite expensive [19]. Due to its pricing, most high schools in Ghana will not be able to afford it in quantities that will encourage a one to one use by students and students comfortable.

Currently in the business world, AR has been implemented on smartphones for use in areas like shopping [20]. In education, AR apps are usually designed to run on smartphone because 80% of young people have been recorded to use smartphones [21]. Digital reports about Ghana released in 2018 showed that sixty-eight percent (68%) of the world population are mobile phone users. Ghana recorded sixty-seven percent (67%) of its population as mobile phone users [22]. This Digital report showed that smartphone is a common device in Ghana and the world Ghanaians, hence AR apps running on smartphone should potentially not be a problem. Some AR apps require internet access. The 2018 digital report showed 53% of the worlds population are internet users and 35% of Ghanaians are internet users [22]. The report revealed 32% of Ghana's population in 2018 are active users [22]. The report further recorded that 75% of Ghana's 2018 population use mobile phones in accessing the internet [22].

These statistics indicate that adoption of AR as a tool in blended learning should not be a struggle in terms of access to internet and mobile devices.

2.4 Blended Learning

Sherimon et al. describe Blended Learning as a combination of face-to-face or traditional learning with e-learning tools such as Virtual Reality (VR), Augmented reality (AR), and online learning, just to mention a few [39]. Blended Learning is currently being applied at varied levels of education: primary level, tertiary, and school of languages [40].

At an elementary school level, Blended Learning was introduced by Chen et al. in combination with Augmented Reality (AR) [41]. Cheb et al. focused on Science subject and chose the topic “leaves”. In teaching the topic “leaves”, teachers conducted face-to-face teaching followed by students exploring “leaves” on campus via their AR mobile device [41]. Students explored these “leaves” by pointing their device’s camera towards the leaf and viewed augmented details about the leaf on their device [41]. In the end, students understood more about “leaves” saving the elementary teachers from long verbal explanation per usual.

In medical education, Noll et al. introduced AR and Blended Learning as a Mobile AR Blended Learning Environment (mARble) in dermatology class. mARble during testing worked like what Chen et al. described except an extra feature. This extra feature in mARble is, it has a paper-based marker with a unique pattern [42], which must be placed on a specific part of the human body, then information about that part is viewed in the mobile device [42]. The only limitation in mARble is it runs on only IOS devices. Results of testing mARble showed that it was successful in helping dermatology students learn.

The Blended Learning approach introduced technology as part of teaching and learning. Meanwhile, typically, classrooms are designed to facilitate mainly traditional learning. Some schools try to design their classrooms to suit the operation of different forms of learning but usually fail at it. Sarmento et al., to solve this, researched by interacting with students to identify their needs with regards to a classroom using a Blended Learning approach [43]. Based on Sarmento et al. interaction with students, they developed guidelines for a Blended Learning classroom. The research designed a finalized prototype simulation on a desktop practically for evaluation, which proved that the nature of a classroom surely affects the effectiveness of Blended Learning.

2.4.1 Blended Learning Models

Seven blended learning models exist namely: station rotation, lab rotation, individual rotation, flipped classroom, flex, a la carte and enriched virtual model [44].

Station Rotation Model: In this model, students are section into groups with at least one group operating e-learning each [45]. This model is suitable for schools where students have limited access to a computer. The grouping may be permanent if it's based on learning styles of students such that those who learn better practically are grouped to use e-learning [45]. Where the grouping is flexible, changes may be made daily, but grouping is still on students' need basis [45].

Lab Rotation Model: This model is the same as station rotation except that the e-learning group use the computer lab as their classroom [45]. Like station rotation, this model works well where students have limited access to a computer. Teacher gives a traditional lecture, then student group with better understanding will move to the computer lab for the e-learning session [45].

Individual Rotation Model: In this model, students in a classroom rotate individually between stations. These students are not required to visit every station because each student's schedule is personalized with activities determined by the teacher [46]. Although this model promotes students working at their own pace, it demands total change to teaching role, facilities, and delivery of instruction [47].

Flipped Classroom: In this model, student learn via online at home, then in a face to face class [43]. Every instruction from the teacher is made available on their online portal. Projects and Assignments are done in class with teacher guidance and help struggling student to get needed help. However, this requires each student to have access to good internet [48].

Flex Model: Learning in this model is self-directed via online. Students schedule are fluid and is per the students' need [44]. The teacher's presence is flexible as it is based on whether the student need it or not [49]. This model best supports adaptive e-learning [50].

A la Carte Model: In this model, students take extra courses online with an online tutor while simultaneously taking a face-to-face course [44]. This model is suitable for schools where certain courses are not available [44]. There are certain schools where due to limited resources such as classrooms, teachers or books, courses like French cannot be offered. Hence through the a la carte model, student can still learn French via the use of online tutors.

Enriched Virtual Model: In place of a full-time school, this model offers students an opportunity to finalize a huge chunk of their schoolwork online outside their physical school [44]. Although, these students are required to engage in face-to-face learning with their teacher, daily attendance is not compulsory [44].

There are three additional blended learning models namely: Inside-Out, Outside-In and Supplemental [53].

Inside-Out Model: In this model, lessons for students begin in a traditional classroom and end up outside the classroom [51]. Teachers conduct face-to-face teaching to deliver course content. After that, student on their own and outside the class atmosphere use online or e-learning platform to gain more knowledge.

Outside-In Model: In this model, lessons for course(s) begin online or on an e-learning platform outside classroom setting and ends up in a traditional classroom setting [51]. In traditional classroom, teachers give feedback and students collaborate.

Supplemental Model: This model gives students the choice between face-to-face learning for every aspect of a course and e-learning platform for every aspect of a course [51].

2.5 Requirement Analysis

Knowledge from previous sections in this chapter will be used to outline requirement for AR as a tool. The AR as a tool for this research will be called as ***JunAR***.

2.5.1 Functional Requirements

- JunAR will be designed to focus on one subject in Junior High School.
- JunAR should be marker-based.
- JunAR should provide animated content.
- JunAR should be cloud-based.
- JunAR should be interactive.
- JunAR should be able to run on mobile and desktop.
- Specific Blended Learning model should be chosen.

2.5.2 Non-functional Requirements

- JunAR is not personalized for users.
- JunAR requires a sign-in.
- JunAR should be able to handle multiple users at a time without fail.

Chapter 3: Methodology

3.1 Research Approach

The research topic for this paper has two parts: Augmented Reality (AR) and Blended Learning. Blended Learning concerns incorporating an e-learning system/platform such that student gets additional insight on class topics practically or realistically. The e-learning system considered in this paper is Augmented Reality (AR).

3.1.1 Blended Learning Approach

In the prior chapter of this paper, ten (10) models used to implement blended learning were outlined. Each model was based on resources a school and /or its students have available. In this paper, two models will be considered: Inside-Out and Supplementary Model. Inside-Out Blended Learning Model involves student's lessons starting with a traditional classroom teaching style and ending up with learning outside the classroom [52]. Meanwhile Supplementary Blended Learning Model is where students are given a choice between face-to-face learning for every aspect of a course(s) or an e-learning platform for every aspect of a course [52].

In most Junior High School (JHS) in Ghana, a teacher offers face to face teaching in class, which involves him/her instructing students, guiding them in projects, and giving them assignments. Therefore, the Inside-Out Blended Learning Model would be suitable because it is not far-fetched from the normal system known to JHS students and teachers in Ghana. In using the Supplementary Blended Learning Model, more focus will be on how well it works for the JHS students. The purpose is to find out two things: First, find out the options JHS student will take if given a choice between using JunAR solely and face-to-face learning solely. Secondly, finding out whether BECE results would yield more passes if JHS students used solely AR as an e-learning tool to prepare for their exams.

3.1.2 Augmented Reality (AR) Approach

Augmented Reality (AR) in this paper is an e-learning tool. For this research, JunAR is neither coded from scratch or built using an open-source software. Instead, JunAR is built using an already existing marker-based AR software called Metaverse [52].

Metaverse is best suited for creating JunAR because it is free, user-friendly and does not require users to have any prior programming language skills [52]. In using Metaverse for JunAR, all AR contents built are called **AR experiences**. The AR experiences may be an animation, image or video depending on the medium chosen to explain class content to the students. The creator of the AR experience for this project will be the researchers who will be playing the role of a teacher during testing of JunAR.

In building JunAR, free software was settled on because the user is given the freedom to run, copy, and distribute the software [56]. One user is the creator of the AR experiences in JunAR. To use open source software, the user will need to have some knowledge of programming to collaborate on AR software development [56]. For instance, an AR Software Development Kit (SDK) like Wikitude though free to download, the user is required to have some know-how of programming languages [53]. However, the focus of this project is not to improve AR software for JHS in Ghana by developing one but to use existing software to test its feasibility.

3.2 Design and Implementation

3.2.1 JunAR Design

JunAR, as an AR tool for Blended Learning in this study, has met the requirements outlined for this project (refer to chapter 2). Metaverse is a free software that has two subsections, as shown in Fig 3.2.1a. One sub-section is Metaverse Studio (shown in Fig 3.2.1b), which is a cloud web-based platform [54] for creators of the AR experience and it is where QR code is generated. The other sub-section is Metaverse app (shown in Fig 3.2.1c), which is an android and /or iOS app that is strictly for scanning the AR code and viewing the AR experience in

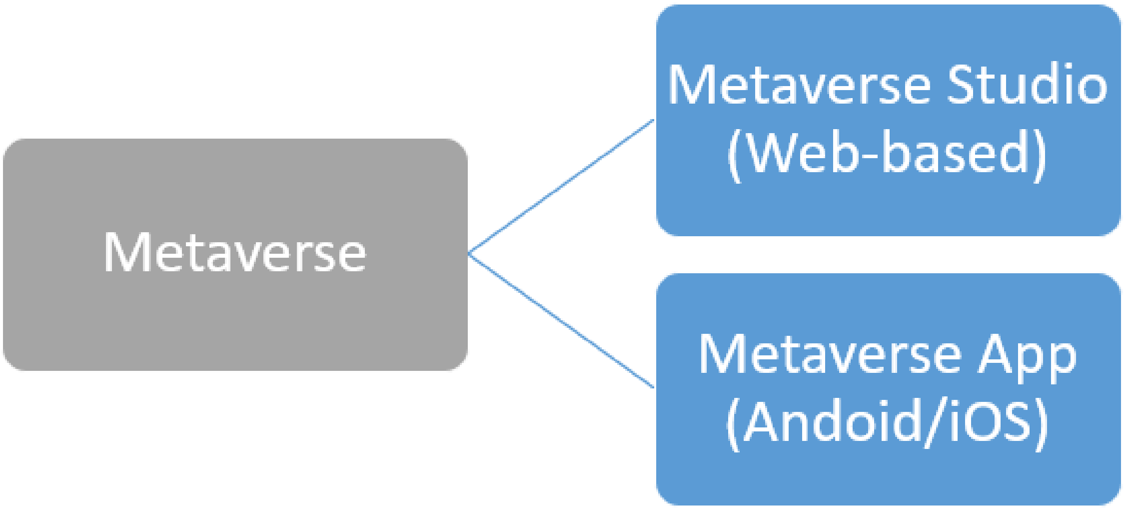

Fig 3.2.1a: Subsections in Metaverse

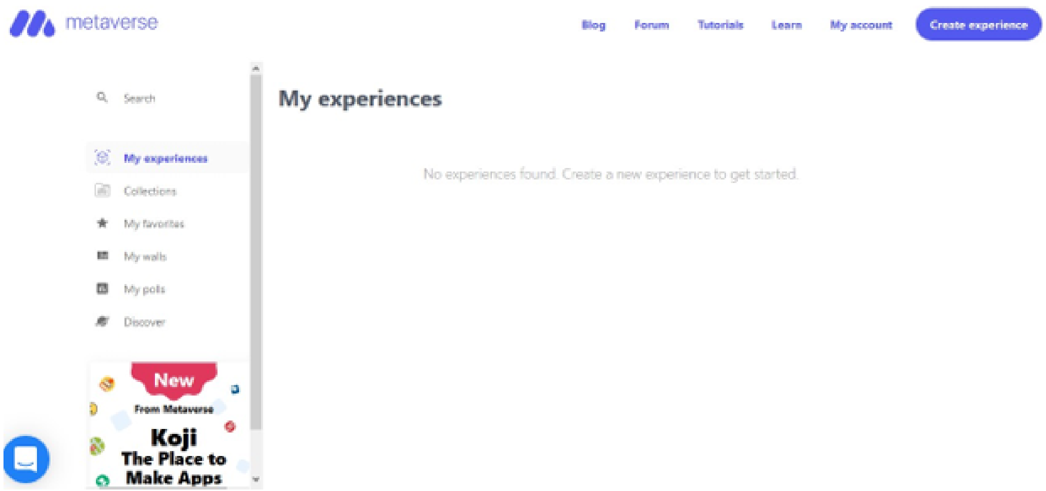

Fig 3.2.1b: Metaverse Studio

the app [54]. For this paper, the researcher will use the Metaverse Studio while the JHS students use the Metaverse app.

Fig 3.2.1c: Metaverse App (Android)

In using Metaverse Studio for JunAR, students can create an AR experience on their own as a way of visualizing any subject content during their studies [54]. This will be useful for students who might want to brainstorm any subjects visually on their own.

3.2.2 JunAR Implementation

In implementing JunAR, the technology used was Metaverse. Metaverse is a free software built using React and Node.js. Metaverse app is built using android and iOS. It allows users to create an account so their AR experiences can be stored in the cloud under their account. Metaverse as a maker based AR has a QR code feature which is scanned using the Metaverse app.

To visualize the design of AR in JunAR, Client-server architecture and Use-Case Diagrams are used. The client-server architecture was chosen for this study because the use of JunAR requires two resources namely: the internet and a computer (which may be a laptop or mobile device).The internet hosts Metaverse for the user to access, delivers AR tools over the internet and manages QR Code generation for AR experiences over the internet [57]. In client-server architecture for JunAR Fig 3.2.2, there are two main users: the researcher, who acts as the teacher, and the student. Although JunAR is hosted over the internet, the interface used by the Researcher and student is the Metaverse Studio and Metaverse App respectfully [58].

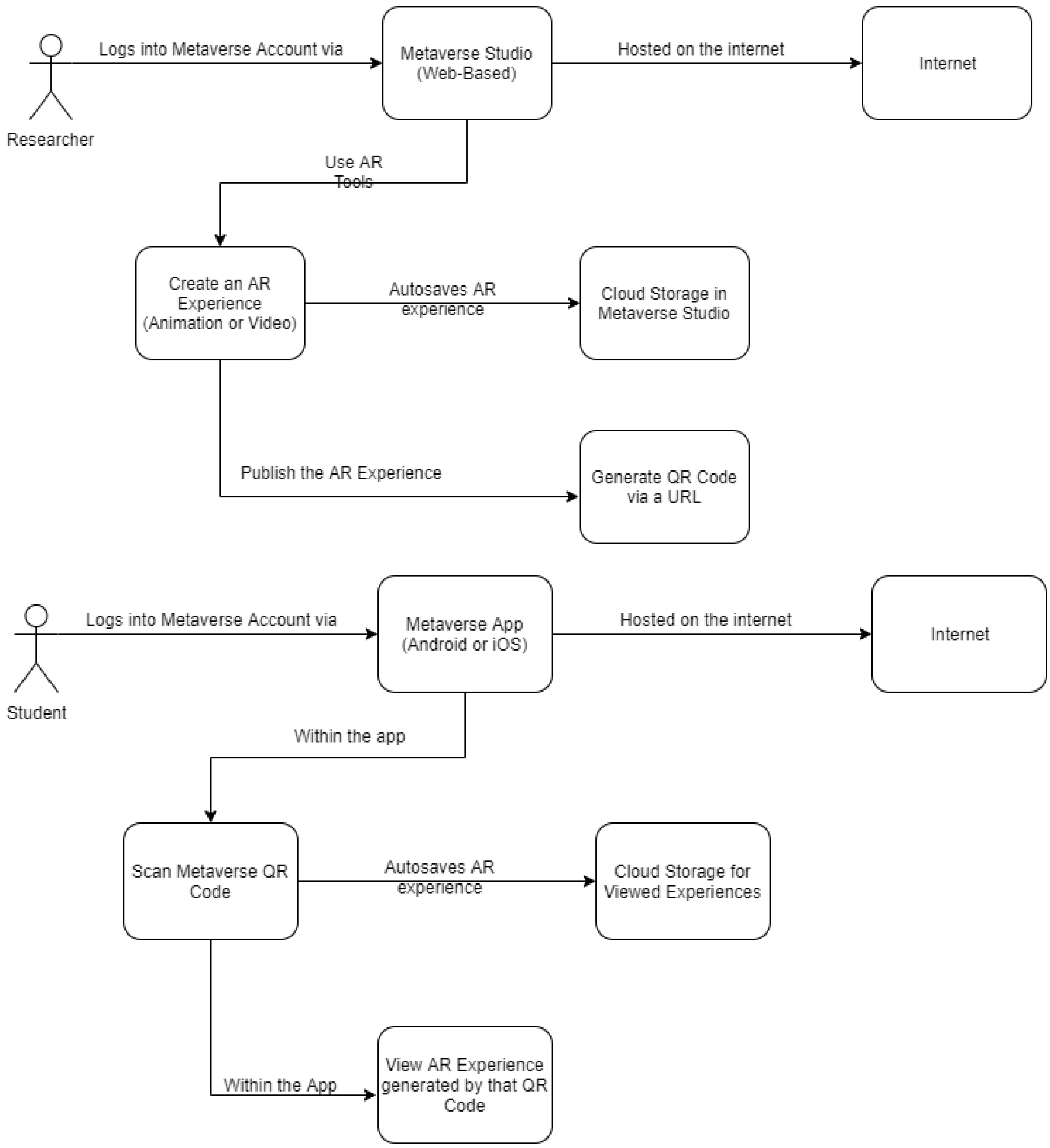

Fig 3.2.2: JunAR Client Architecture

Client-server architecture is useful because student interaction with JunAR is strictly over the internet. Use-Case is suitable for this study because it captures the requirements of JunAR as outlined in the prior chapter [59]. Use case diagram gives a clear picture of what JunAR is supposed to do with regards to how either the Researcher or Student interacts with it [55]. For instance, the Use Case Diagram as in Fig 3.2.3 shows that the student uses the Metaverse app to scan the QR Code generated by the Researcher.

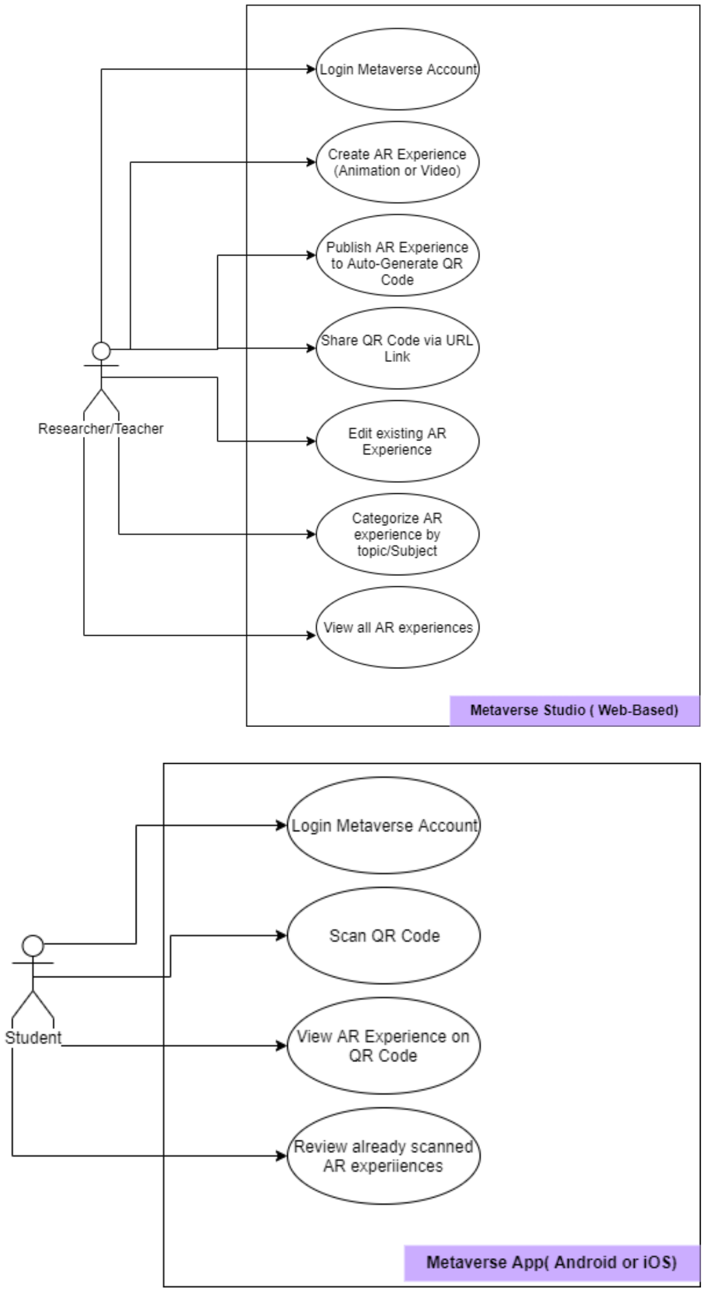

Fig. 3.2.3: JunAR Use Case Diagram

Also, a functional requirement was that JunAR should have cloud storage and AR experiences published are stored in the cloud. Below is a tabular description of JunAR Use Case Diagram:

JunAR Use Case Description	
Actors	Researcher, Student
Description	The researcher uses a laptop/tablet to log into Metaverse account, creates an AR experience, publishes the experiences which generates a QR Code. The student opens the Metaverse app on their mobile device, logs into the app, scans the QR code from the Metaverse app, and is instantly redirected to the AR experience whether a video animation. Student views the experience. The experience is automatically saved to the cloud under their account name hence in future no need to scan QR code.
Comments	Researchers and Students need to be connected to the internet to use Metaverse for JunAR successfully.

3.3 Proof of Concept

The selected subject for this study is Social Studies, as stated under the functional requirement in the prior chapter. The Social Studies textbook to be used is “Social Studies In Scope for JHS 1-3” as shown in Figure D below [60]. This textbook was chosen because its content strictly follows the Ghana Education Service (GES) Syllabus [60].

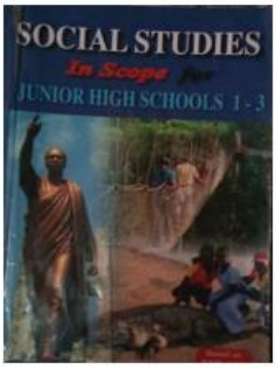

Figure D: Social studies Textbook

3.3.1 Participant

For this study, there are two set of participants. One of these participants is JHS students from a specific school, which is more technologically-inclined will be purposively chosen. The age range of participants is 13 to 14 years. All the student participants will be informed about how the study entails them using Metaverse app as an AR tool in a Blended Learning environment. Student participants are permitted to withdraw from the e-learning section, which uses Metaverse at any moment they feel uncomfortable.

The other participant is the researcher acting as a JHS teacher. The researcher will be in charge of using Metaverse studio to create AR experiences for a specific topic in Social studies and generate a QR code for those experiences. As a JHS teacher, the researcher will introduce both Inside-Out and Supplementary Model. Then the researcher will test out JunAR in the Metaverse app on the JHS students' phones.

3.3.2 Setting and Data Gathering

The school's campus is fully connected to Wi-Fi for use by students and teachers for only academic purposes. In the school, the JHS students have access to an android/iOS tablet or mobile phone. The tablet or mobile phone is a means for the student to access and carry out approved digital class activities such as the Metaverse app. The AR experience in JunAR has texts, clickable buttons, and audio where necessary with regards to a topic in Social Studies. Once QR code for AR experience is generated, it is printed on a sheet of paper and the class size is divided into two: class A and class B.

For supplementary blended learning model, Class A uses the Metaverse App on their tablet or phone to scan the QR codes and learn about culture in Social Studies. Meanwhile class B is given traditional tutorial on the same topic in Social Studies. At the end, both are verbally quizzed to test their understanding. And the responses from class A is compared against that of class B.

For inside-out blended learning model, a different class is chosen. The class time is not divided. In the first half of a class period, the teacher traditionally using theory teach all students in the class culture in social studies. In the last half of the class, students are given smart devices with Metaverse App to scan the QR codes and use the AR experiences to learn the same topic. The students are collectively quizzed at the end of the class. Their responses are recorded.

Chapter 4 - Experiment and Result

This chapter is focused on the procedures used to conduct the experiment. The experiment section has two subsections. One subsection discusses procedures used in creating AR experiences based on a chosen topic in the Social Studies subject. The other subsection discusses how the AR experiences created is used in Blended Learning in a Junior High School (JHS). AR experience is interactive as it utilizes sounds, character mover and user input.

4.1 Experiment

An objective of this research is to investigate the feasibility of AR as a tool. To achieve this objective, Metaverse is employed to create AR experiences.

In the J.H.S 2 section of the Social Studies Textbook, the topic ¨Culture¨ was randomly chosen. Under the topic "Culture", a subsection is titled how Ghanaians express their culture. This subsection introduces language, dressing, food, music and dance, rites of passage, festivals and marriages as ways Ghanaians express their culture. Metaverse Studio is used to create the AR experience for dressing and food as shown in Figure. 4.1.

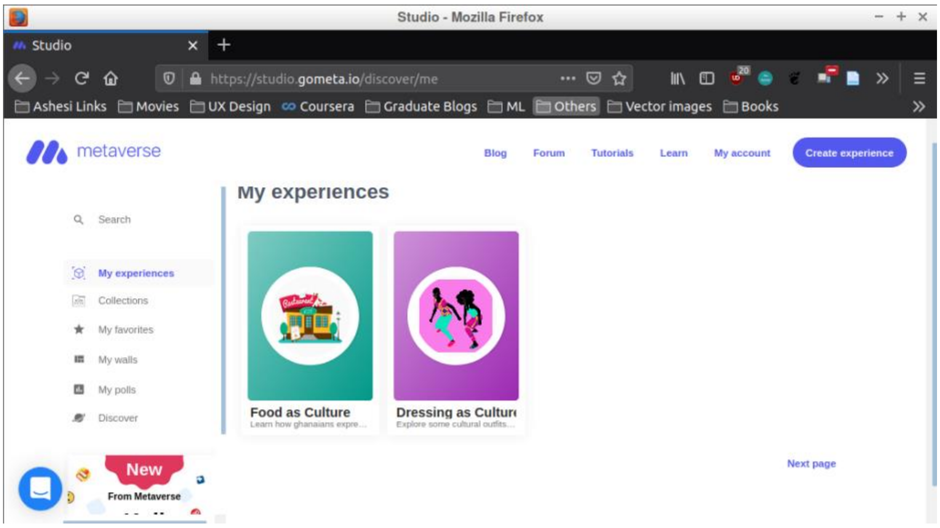

Figure 4.1: the two AR experiences in Metaverse Studio

4.1.1 AR Experiences in Experiment

To create any Augmented Reality experience using Metaverse, scenes and blocks are the basis. Scenes, as shown in Figure 4.2, create the visuals for user interaction. On the other hand, blocks influence the nature of a scene by making the interaction realistic. Scenes in Metaverse use three libraries namely: photos library, sound library and frame library.

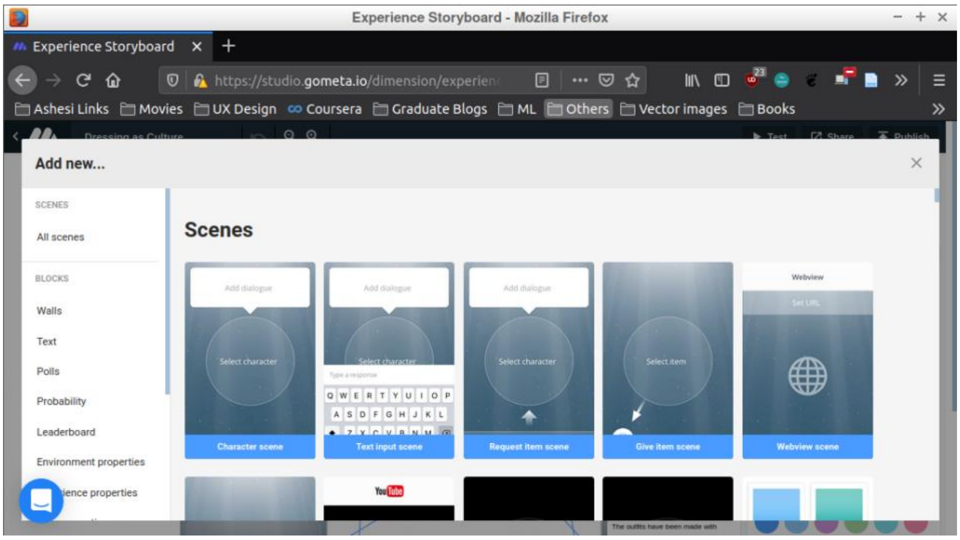

Figure 4.2: Scenes in Metaverse Studio

Metaverse studio has a sound library as shown in Figure 4.3 but an empty frame library. Creators of every experience must create their own sound playlist in the sound library and their desired frames in the frame library.

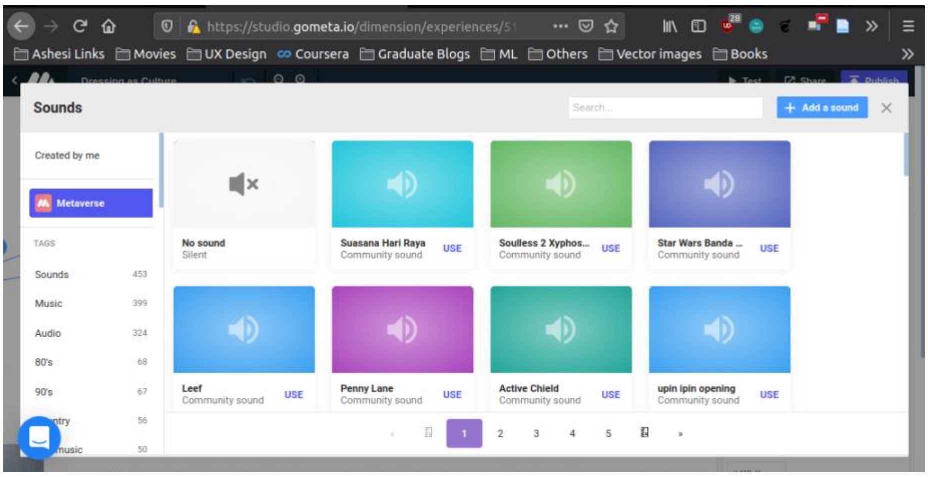

Figure 4.3: Sound library in Metaverse Studio

4.1.1.1 Dressing as a Culture

Dressing as a culture experience is basically a dress up experience for students. Once the QR code is scanned using the Metaverse app, camera filters of traditional Ghanaian clothes allow students to play dress up as a way of experiencing dressing as a Ghanaian culture. Using the camera filter, students can either taker a picture or video of themselves with the outfit fitted to their body.

Fig 4.4: A dress fitted to students body

Here is the procedure taken to create this dress up experience. When this experience is initially created in Metaverse Studio, it is a blank with an edit option to use the Augmented Reality tools available in Metaverse to create the dress up experience as shown in Figure 4.5.

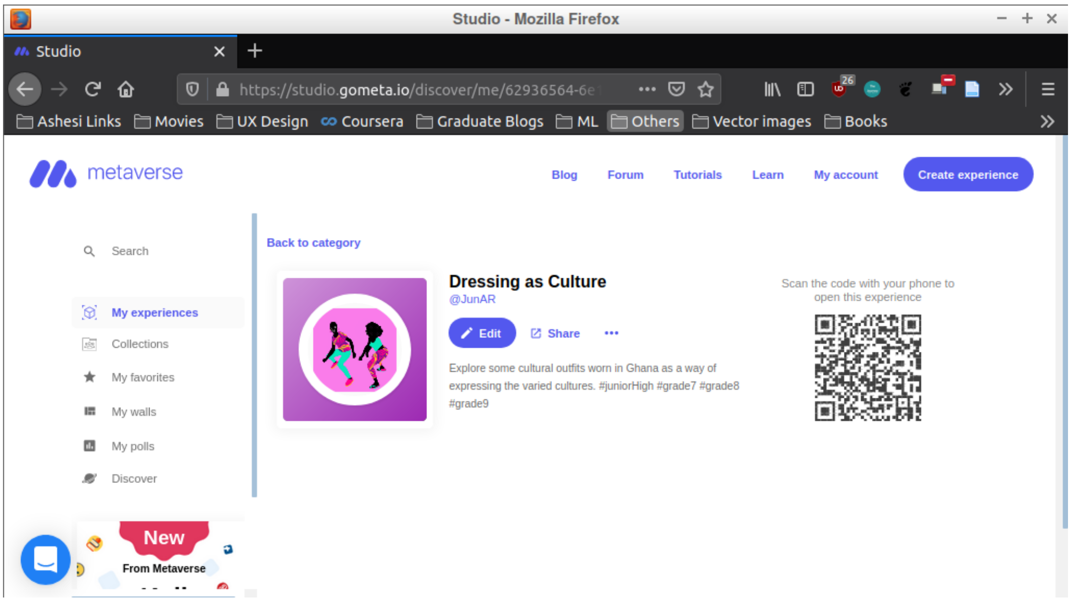

Figure 4.5: Edit Option and QR code in Metaverse Studio for this experience

In editing dressing as a culture experience, character scene wall scene, camera scenes and wall blocks were used. Eighteen scenes were used to create this experience in total with eight as character scene and ten as camera scene.

In creating each character scene, a character is needed and above each character is a text to communicate an information to user and below is a button that connects to the next scene. Every character is an image of the format .jpg, .png, or .gif. Each character overlays the real world via the camera of student's phone or tablet. Finding images and vlipart of Ghanaian traditional clothing in Metaverse photo library was hard. To resolve this, a specific photo library with clipart images of African people dressed traditional was created from google images as shown in Figure 4.6. The introductory scene in this experience uses a Gif image and a Ghanaian dancehall song. This dancehall song was added to the sound library as in Figure 4.7 with the goal to stimulate some form of fun as student play dress up. Figure 4.8 displays snippets of character scenes in Dressing as a culture experience.

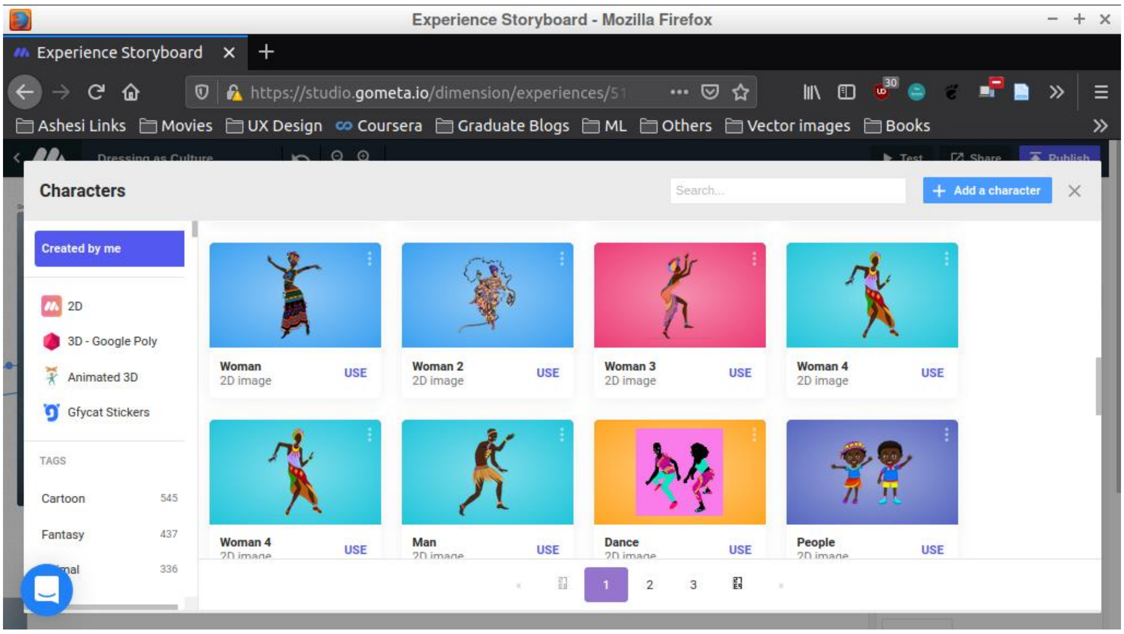

Figure 4.6: Photo library created for this experience

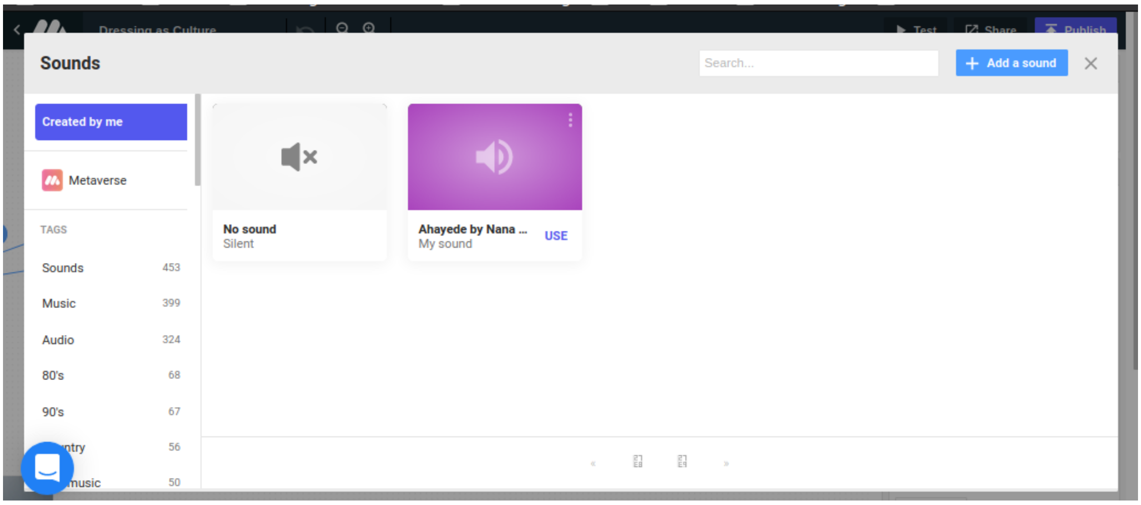

Figure 4.7: Sound library created for this experience.

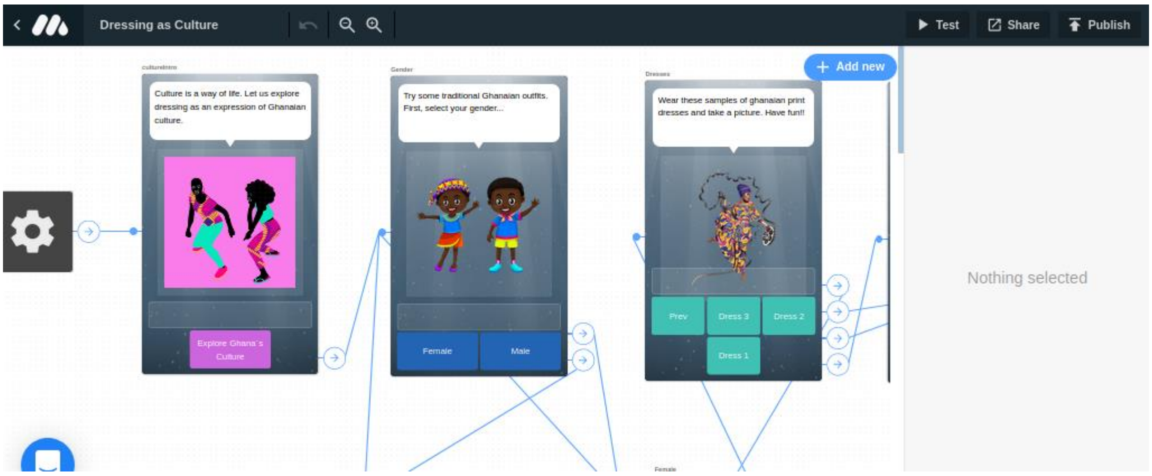

Figure 4.8: Snippets of character scene in dress up experience

For the camera scene, the frame library is used as an overlay. To create each frame, transparent images of traditional Ghanaian clothes uploaded into the photo library, as in Figure 4.9, are used. Snippets of camera scenes created using the frame library is shown in Figure 4.10. When the varying scenes in this experience were successfully created, the experience was published and a QR code was generated as shown in a Figure 4.6.

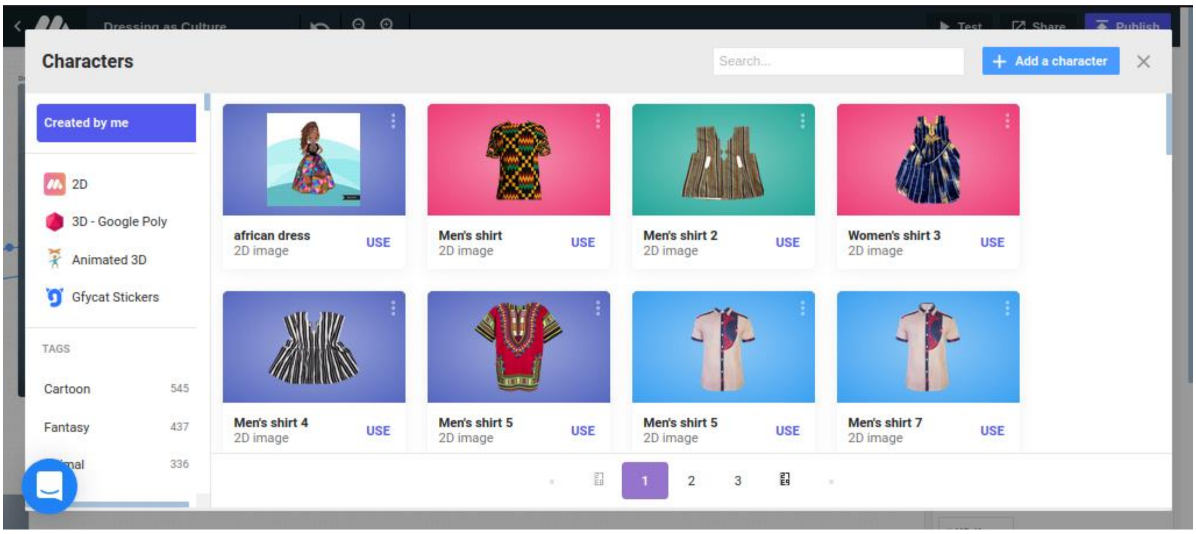

Figure 4.9: Ghanaian traditional outfits photo library in Metaverse Studio

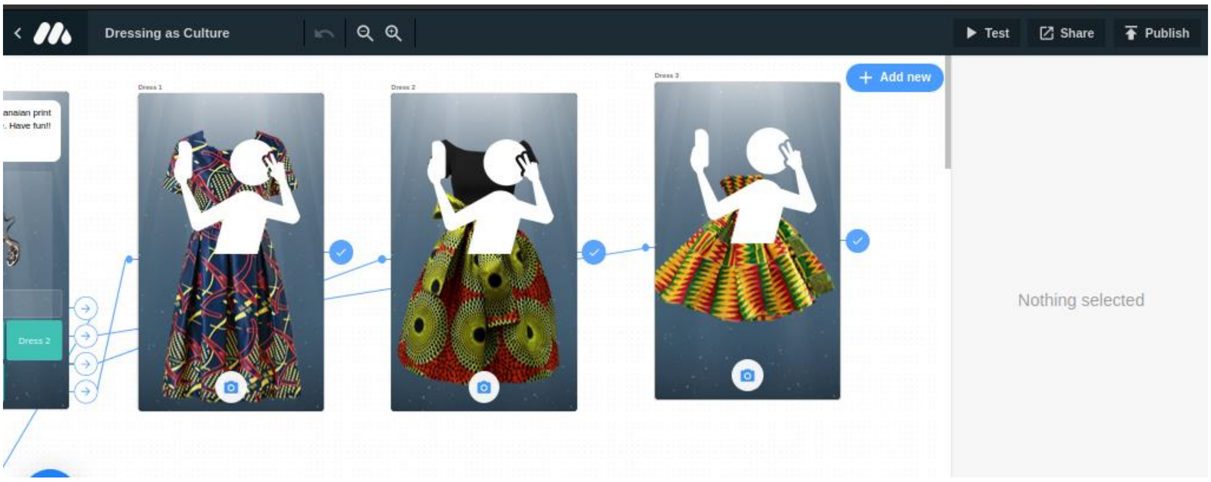

Figure 4.10: Snippets camera scenes in dress up experience

The publishing of this experience implies that anyone with the Metaverse app can view this experience by simply scanning the given QR code or access the QR code via the share link in Figure 4.11.

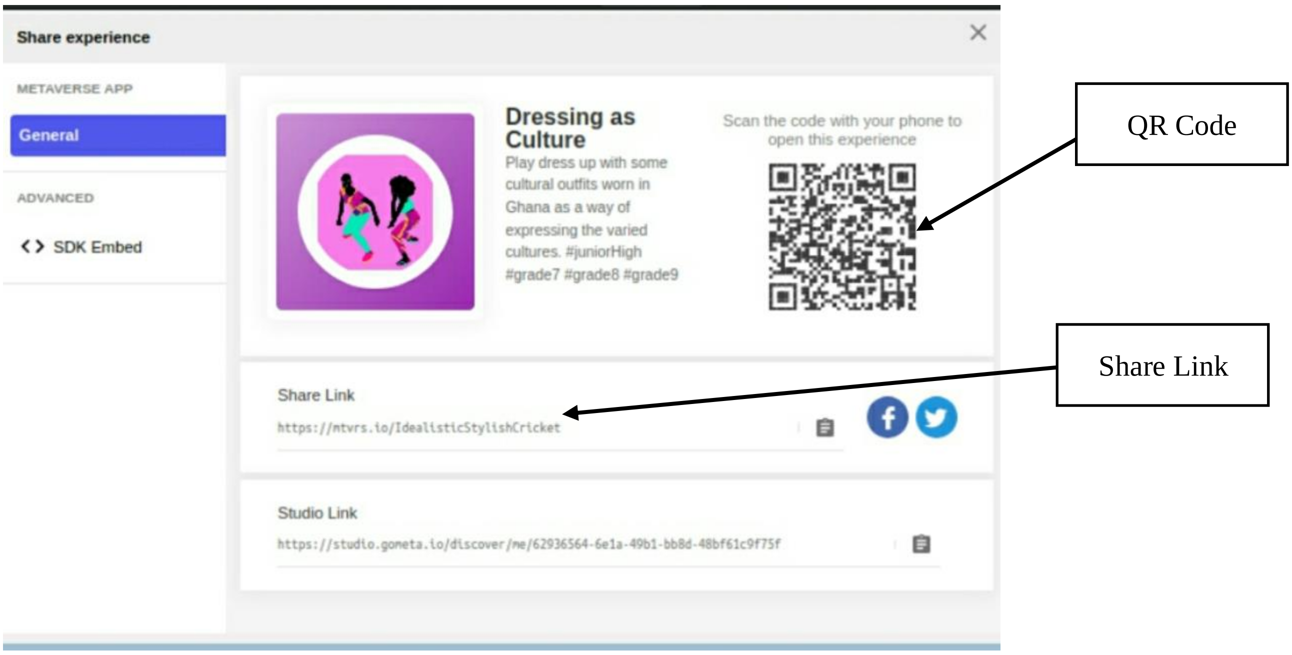

Figure 4.11: Share link for the dress up experience

4.1.1.2 Food as a Culture

Food as a culture experience is a trivia game in Metaverse. The concept is a student starts the experience as a customer in a Ghanaian restaurant called Adiepena restaurant. A waitress in attending to them gives the food menu.

However, the food menu cannot be viewed because it has been hacked and coded. The customer is called upon to crack the code knowing fully well the meals have been categorized into the ten regions. For every code the customer cracks, he/she has access to that menu as shown in Fig 4.12 and Fig 4.13.

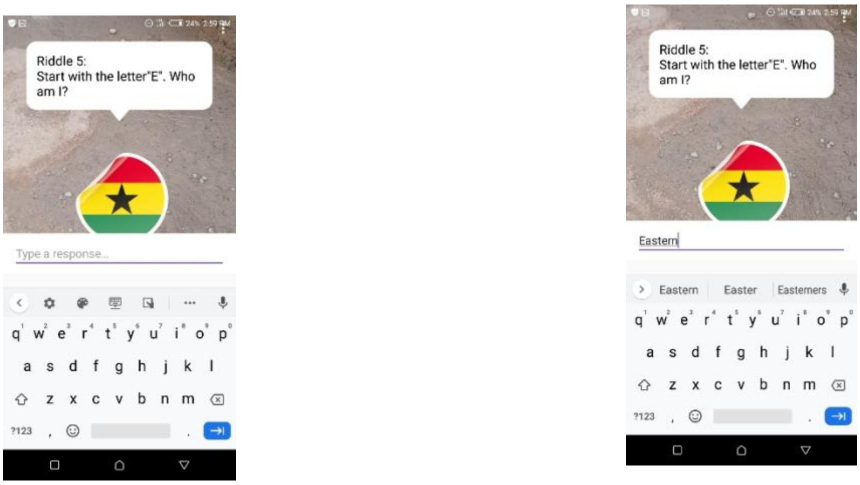

Fig 4.12: Code customer must crack to access menu

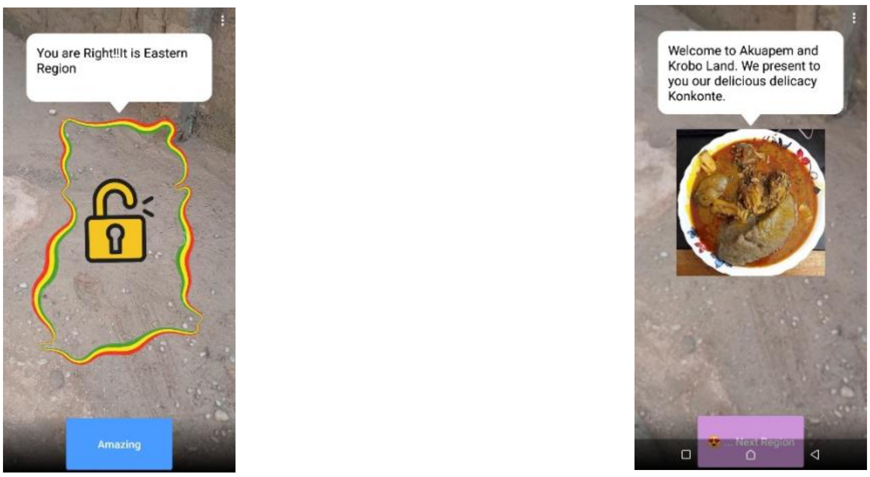

Fig 4.13: Menu related to cracked code in Fig 4.12.

The procedure for creating this experience utilized two scenes and a text block. The two scenes are: character scene and text-input scene. This experience is initially blank when created and the edit option, as shown in Figure 4.13 with red arrow, was used to access the AR tools in Metaverse.

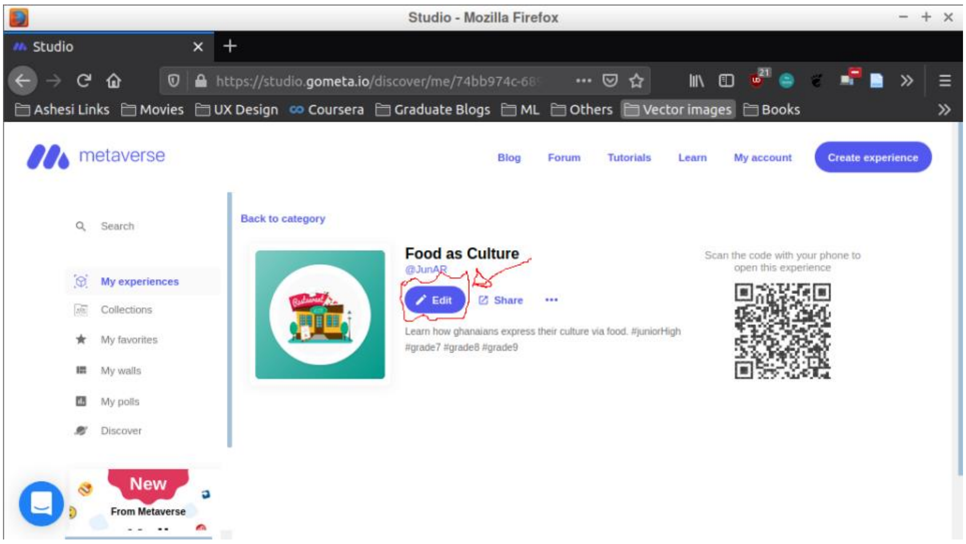

Figure 4.13: Edit option and QR for this experience

Images used in the character scene include restaurant, African waitress, African chef, menu, padlocks, Ghana map and Ghanaian meals. Similar to the dressing as a culture experience, every character scene has three sections: the character, text above the character and button below character. Each character over the real world as it tells a story. A photo library consisting of uploaded clipart images from Google images and food images from Ghanaian food Instagram account. Snippets of some characters scenes in food as a culture experience is shown in Figure 4.14.

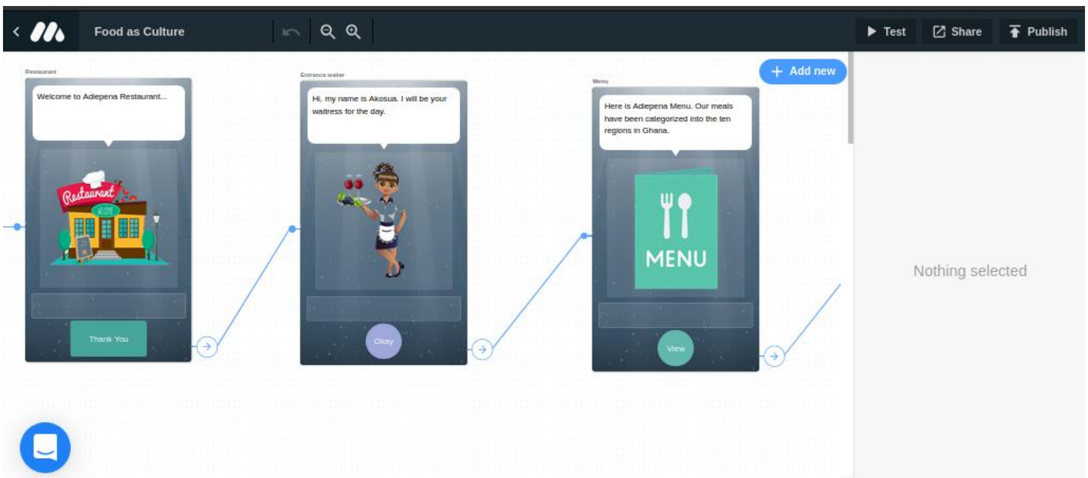

Figure 4.14: Snippets of character scenes in this experience

The text-input library provides an interaction as user inputs answers to every coded question as shown in Figure 4.15. To verify every answer to a coded question, text block. Whenever a user input is wrong, the text block redirects the user to a scene that tells the user he/she is wrong with the option to try again. When the user input is correct, the text block redirects him/her to a character scene with content of that food menu.

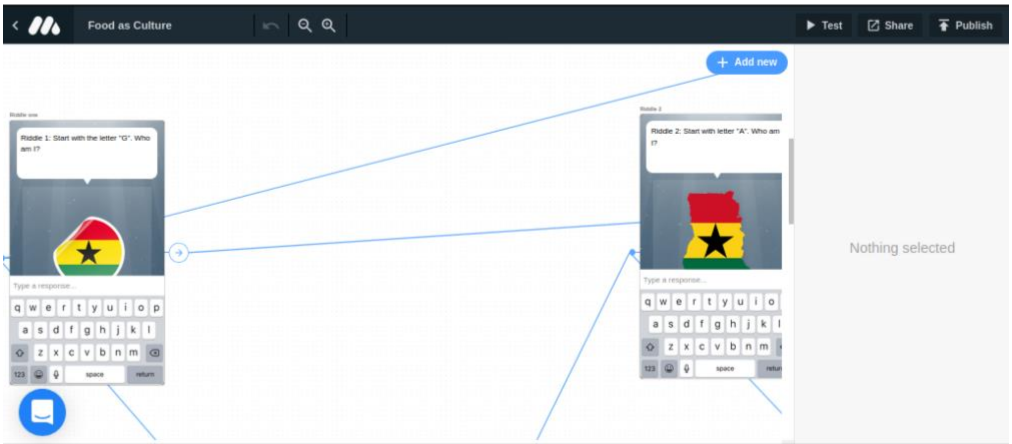

Figure 4.15: Text input scenes used in this experience

This experience has been published on Metaverse and can be accessed by using the Metaverse app to scan its QR code as generated in Figure 4.13. This QR code can also be accessed via the share link in Figure 4.16.

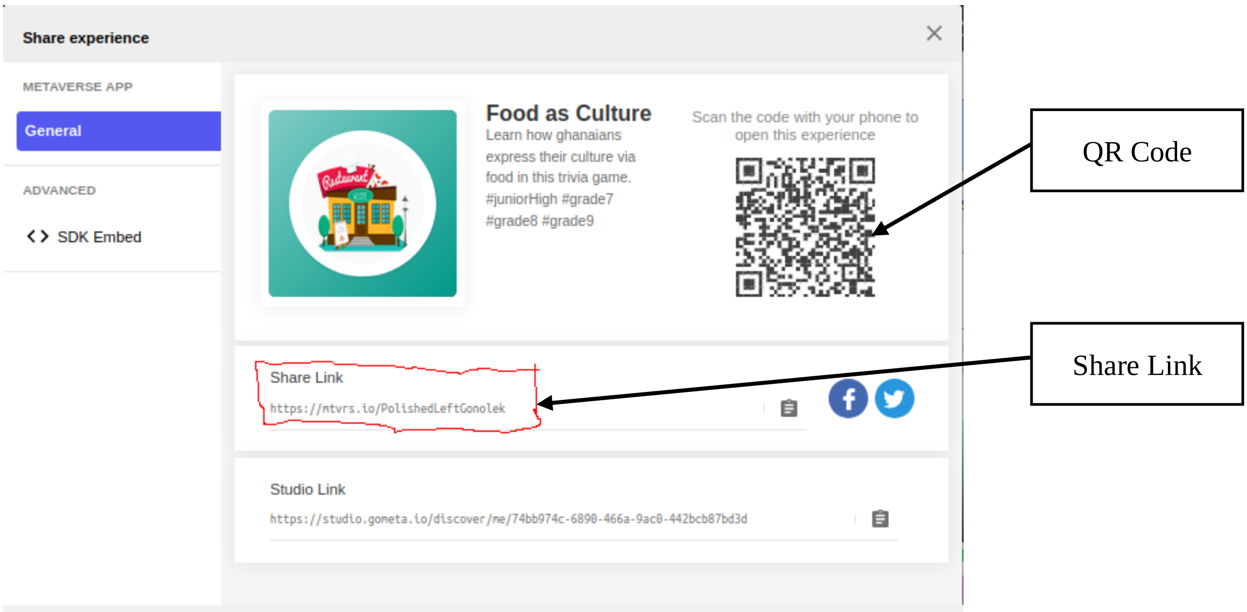

Figure 4.16: Share link for this experience

4.1.2 Blended Learning in Experiment

Another objective of his research is to investigate how AR can be used as a tool in blended learning at JHS After the augmented experience has been created, JunAR can be used as the tool.

Unfortunately, Coronavirus (COVID 19) is an ongoing pandemic in the world at the time of this research [62]. As a result, the classroom aspect of the experiment could not be carried out. Schools in Ghana have been closed and lockdown has kept students indoors as the world resorts to online learning as an alternative [61].

In relation to using AR as a tool, one subject was found to test JunAR on an android device. This subject is female and in JHS 1 as shown in Fig 4.17.

Fig 4.16: Student using the Metaverse app on an Android phone

It took her two hours to use the android Metaverse app. At the end of the test, she reviewed the design of JunAR as good. According to her, the lessons were clearly represented using images, text and sound.

Chapter 5 - Conclusion and Future Work

One major benefit of AR in a Blended Learning environment is students have the opportunity to experience theory based teaching in combination with visual teaching. This research has shown that introducing AR at JHS level is a fun way to motivate students to learn with some level of understanding. Using Accra-Ghana as a case study, with chosen Blended Learning models in this study, introduction of AR at junior high level is feasible. The use of AR usually requires the internet and a smart device. In terms of resources, using Ghana as a case study, statistically as at 2018, thirty-five percent (35%) of Ghanaians use the internet and sixty-seven percent (67%) of Ghanaians use mobile devices. It can be concluded that adoption of AR as a tool is likely not going to be an issue in terms of these resources.

However, based on this research, conclusions can not be made that AR as a tool in a Blended Learning environment is all a student needs to maximize their understanding enough to be better prepared to fail BECE less. It is recommended that further research should be conducted on ways AR combined with other comprehension methods can actually amplify students understanding and potentially better prepare them to fail less in BECE.

A proposal to improve this research is after COVID 19, JunAR should be tested in a JHS classroom specifically with chosen Blended Learning models for this study. More animations should be used to stimulate interaction. Final proposal for improvement is JunAR should be redesigned to operate effectively offline so that in cases of internet connectivity issues, student can still use it.

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