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Augmented Reality as a Visual Aid for Classrooms: Supplemented by a Case Study

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***Abstract*—Traditional educational approaches as we once knew them are fading into history. They are being influenced by technological advancements and becoming more and more digital. Multiple uses for augmented reality in education are possible. It makes it simpler for the pupils to learn, understand, and retain the material. Additionally, AR enhances the fun and engagement of learning itself. A faster and more effective learning process, improved collaboration capabilities, and globally applicable practical learning are just a few of the advantages. Accessible learning resources are available whenever and wherever they are needed, requiring no specific equipment. The project's objective is to develop a computer vision application using the augmented reality concept to provide a 3D visual of the image scanned by the person utilizing the said software.**

***Index Terms*— Augmented reality, computer vision application, 3D visuals, machine learning, advancements in EduTech.**

I. INTRODUCTION

Augmented reality has been used for many different purposes in a wide range of industries over the years. The capacity of augmented reality to combine virtual data with reality is one of its amazing implicit qualities. most cases

In several fields, augmented reality is used as a tool to assist users in carrying out tasks. To help surgeons execute treatments with the least amount of risk and difficulty, it can be utilized as a tool to produce 3D models of the patient's organs or body part.

AR also improves learning's intrinsic appeal and level of engagement. One benefit is that there is no requirement for specific equipment and that there is always access to educational information wherever you are. Practical learning can assist students at any level of education or training, increasing their enthusiasm and involvement as well as their ability to work in a team.

In reality, it is anticipated that the so-called education technology industry will grow at a rate of 17.9% per year, reaching $680.1 billion by 2027. Augmented reality merits this title as a pioneer among the most significant EdTech innovations. There will undoubtedly be new opportunities for businesses and educational institutions, with the value of AR in edtech predicted to reach $5.3 billion by 2023.

Many nations continue to use the time-honoured "chalk and black board" method of teaching, which, while less expensive to begin with, is outdated and ineffective for learning. However, when employed as a teaching tool in schools, augmented reality (AR) speeds up learning due to its distinct position as a combinational or multi-mode audio-visual learning technique. The human brain has the ability to process audio visual information more

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quickly than text-based information. This trait is used by AR in classrooms to speed up learning.
Utilizing computer vision principles like plane identification, motion tracking, and picture recognition, the technology used to create augmented reality completes its functions.
The suggested technology seeks to use augmented reality to produce high-quality 3D video instructions. The 3D models are mapped to fiducial markers (Image Targets) that are tracked by a camera. These 3D models serve as the user's screen-based representation of a certain product or idea. By actively interacting with these 3D models and watching the animations, the user will be able to comprehend the inner workings and specifics of a given product or idea.

II. Literature Survey

One of the main difficulties is the usage of AR in education. To create collaborative sessions, augmented reality offers features like photo identification, plane detection, movement tracking, and more. For application of AR in mobile devices, mapping, simultaneous localization, and concurrent odometry have all been shown to be evergreen algorithms. In the realm of education and throughout the learning process, AR is widely used.
[1] is focused and carried out, and that too specifically among neurotypical youth or children without any developmental or learning disorders. High potential for special needs education that can be utilized to help people with disabilities get beyond obstacles.
[2] illustrates how although augmented reality was not initially intended for educational uses, its applications in this area are becoming more and more relevant. AR offers a hybrid learning environment that uses digital technology to enhance reality. Through AR, students can not only have a deeper comprehension but also become more familiar with their future works.
[3] Stakeholders showed a lot of interest in and support for the AR-based artistic challenges and events that were established. The comments and performances of the kids together shown that AR might be a fun and appealing teaching tool in ECE.
[4] research claimed that AR reduces cognitive load, others claimed that it caused cognitive overload. It is still unclear whether there is a usability problem and what causes it—inadequate technology experience, poor interface design, technical issues, or the teacher's lack of technology competence.
[5] is about 42 students (split equally) who were enrolled in the public educational system during the academic year 2015–2016 took part in the study. There were disparities in the experimental group's favour between the control and experimental team’s levels of comfort and ease of use of the English alphabet course that were statistically significant.
[6] can transform reading an old folktale from a traditional book into a new enjoyable, interactive, and engaging learning experience, showed thorough beta testing on the prototype. The AR Playbook Series is being pushed farther along in the development process as a result of the observational study's favourable outcome.
[7] explained that tactile interactions with physical objects lead to more natural learning processes than digital or computer input devices like keyboards and mice, potentially resulting in the reinforcement of memory through motor actions.
[8] data suggests that professors and teachers who heavily rely on the lecture-practice method of instruction are uneasy giving up control of the learning process to their pupils. Some of these instructors guided their pupils through assignments step-by-step, which lessened the activities' cognitive value.
[9] introduces the HoloLens-equipped "flexiSee" glasses, which use colour correction and highlighted green edges to represent real-life situations and settings. It allows for customization and flexibility in the setup of the augmentation filters and input modalities.
‘Children aged between two and six were drawn to the application but were overwhelmed with the application at hand and lacked the motor abilities to interact with the program, while the children aged seven and eight were able to understand the situation and behave appropriately. These kids were able to utilize inductive reasoning to locate the virtual butterflies in the three-dimensional environment around them because they were at the concrete operational stage.[10]
[11] demonstrates how support from well-known videogame engines such as Vuforia and Unity, together with assistance from Google's AR Core, is assisting developers in improving apps for augmented reality. Numerous thousands or maybe millions of students could use this execution for free due to its degree and capacity. It is possible to continue the research so that it is fully included in middle school lesson plans.
The paper [12] highlights the use of two technological trends in Malaysian special education: cloud computing and augmented reality. It is understood that augmented reality has a substantial impact on learning. The

synergistic potential of cloud computing to deliver augmented reality (AR) enhanced education to Malaysian special needs kids is highlighted in this research.

[13] contends that the widespread use of augmented reality (AR) on mobile devices, such as smartphones and tablets, has grown as a result of the increasing popularity of mobile devices worldwide. In order to illustrate the educational potentials of mobile augmented reality, this paper analyses a number of academic publications.

III. SYSTEM DESIGN AND ARCHITECTURE

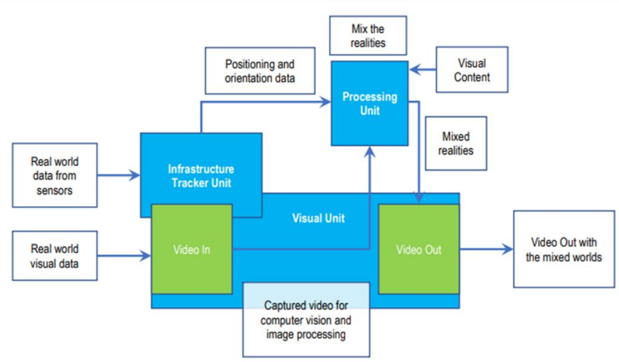


Fig 1: Flow Chart to demonstrate dataflow in an AR system

- Image classification can classify an image when it is seen. In more detail, it can accurately infer the class to which a particular image belongs. For example, a social network company would want to use it to swiftly identify and categorize user-shared inappropriate photos.
- Picture classification is a technique that object detection can use to distinguish and count the presence of a particular class of image in an image or video. Examples include finding equipment that needs maintenance or spotting problems on an assembly line.
- An object is tracked or followed after being discovered. This procedure can be carried out in two different ways: using real-time video streams, or alternatively, using a sequence of sequentially captured photos. For instance, in order to avoid collisions and adhere to traffic laws, autonomous vehicles must track moving objects like pedestrians, other vehicles, and road infrastructure in addition to classifying and identifying them.
- Computer Vision is used by content-based image denotation systems to explore, search, and gather images from enormous data repositories rather than concentrating on the metadata tags that are associated with the photographs. Instead of manually categorizing photos, material can be automatically annotated. Digital Asset Management Systems can leverage these tasks to increase the accuracy of search and retrieval.
- ‘Concurrent Odometry and Mapping’, an application feature, uses ARCore with SLAM (Simultaneous Localization and Mapping) in order to locate your phone in relation to its surroundings as it moves through them. These two, each with unique features, are combined using Unity so they may work together with the native Android platform.

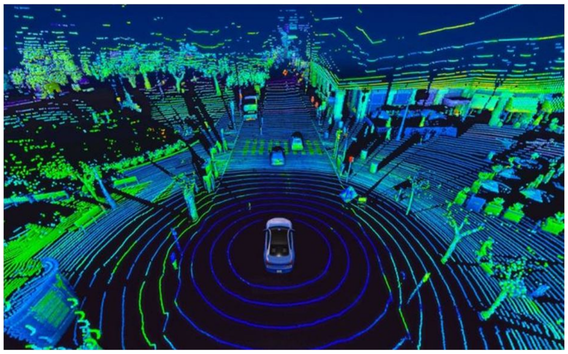


Fig. 2: SLAM used to provide 360° view

The Modules of AR Based Teaching Application

The specifics of the application design and architecture (AR):

1. Decide on workflow
2. Analyze and establish different modules
3. research on the subject and develop rough 2-D implementations for the same
4. Use tools in Unity to develop the models
5. Use URP as a rendering pipeline

Steps in creating UNITY project:

1. Creating UI canvas and panels Singleton class script
2. UI_Controller script
3. Creating Interaction Controller mode
4. Interaction modes behaviour
5. Startup_Mode script
6. Scan_Mode script
7. Main_Mode script
8. Non_AR_Mode script.
9. Testing it out using Unity onboarding UX assets

System code for final product:

1. Utilize existing activity templates to create the structure for an Android application.
2. Connect the appropriate Unity-developed augmented reality model to the application module that is sorted by Subject and Learning Level/Complexity.
3. For more effective mass deployment, test the software's functionality with various environments, host operating systems, storage capacities, processing power, and camera quality.

Working of the application

- The pertinent course modules must be selected in advance, and the subjects the students must learn must be thoroughly surveyed.
- When the survey is finished, the models must be created into 3D graphics in a 3D modelling tool, in this case blender.
- These models must then be rendered into Unity's built-in 3D rendering engine, which supports a number of video games, using a render pipeline.

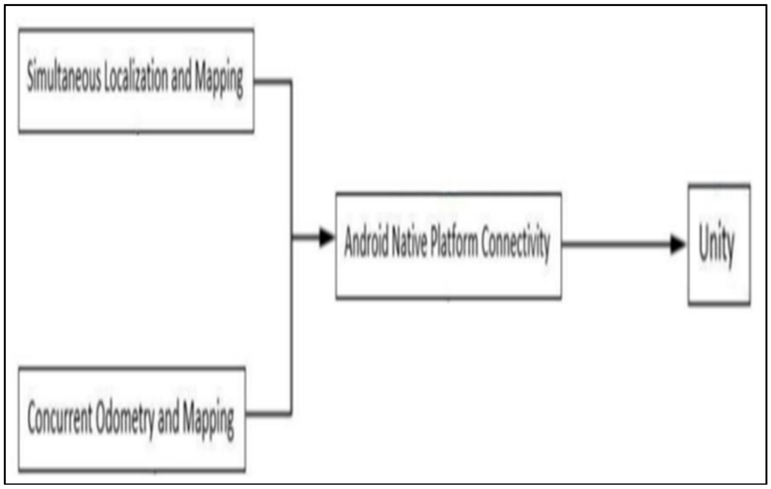


Fig. 3: Unity and Android

- These models may be properly imported into the game engine called Unity and then called into scenes as objects, where the user can describe and change their behaviour as needed.
- These scenes are blended and connected to one another using in-app navigation buttons to produce a fully interactive app.
- The permissions and requirements for Android are specified, the software is signed, and it is exported to an Android device.

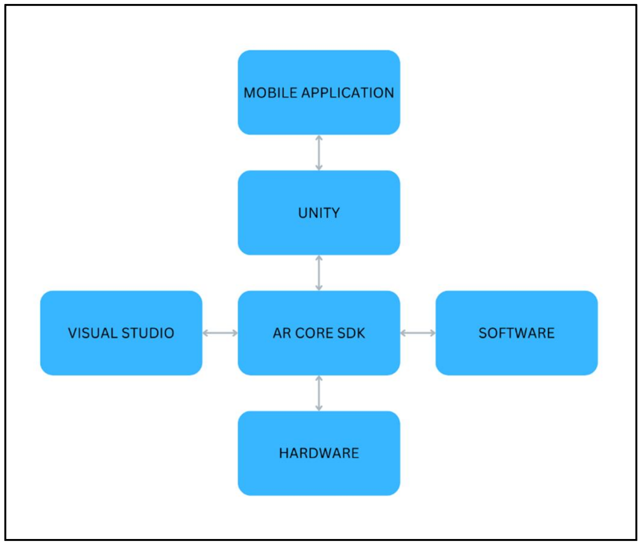


Fig. 3.3: Working of the App

Resulting modules of Application Development

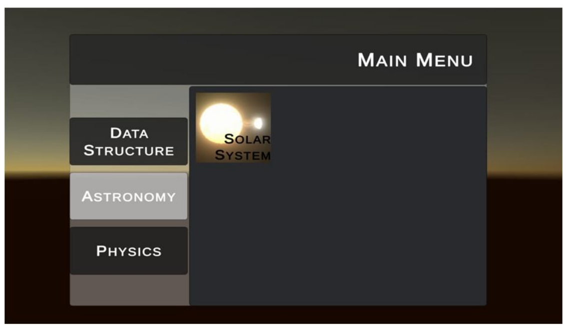


Fig. 4: Main Menu with Astronomy selected

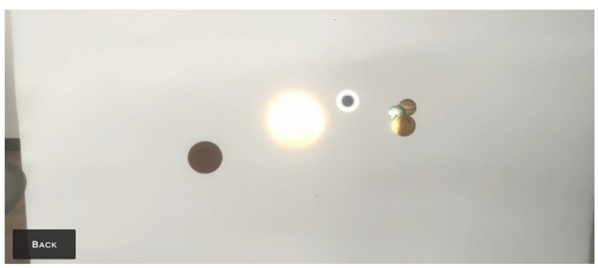


Fig. 4.1: The solar system represented in 3D

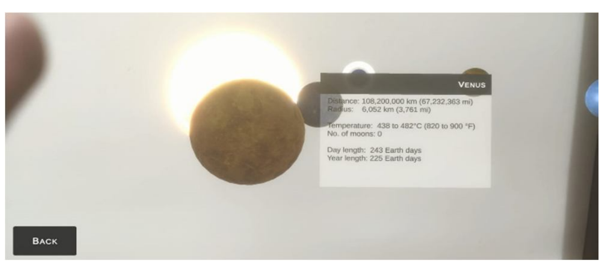


Fig. 4.2: Flashcards with details information on planets

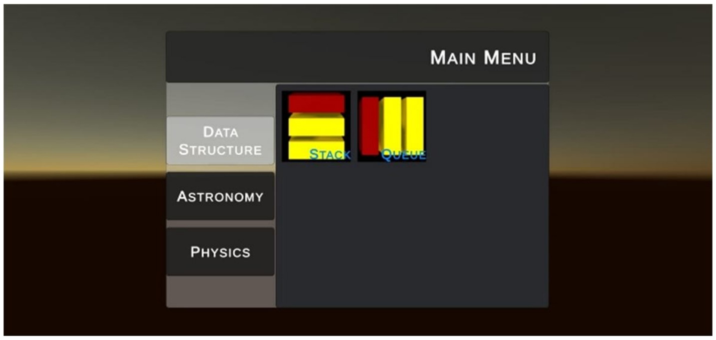


Fig. 5: Menu with Data structures panel selected

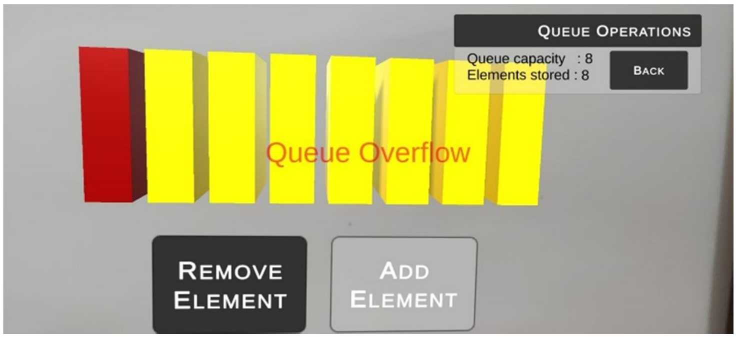


Fig. 5.1 Queue operations

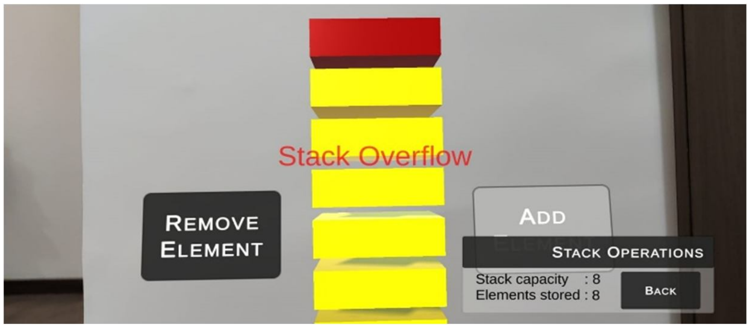


Fig. 5.2 Stack operation

IV. CASE STUDY

A. Setting test parameters

The goal of this Case Study was to compare the efficacy, validity and practicality of a fully functional, semi-realistic rendered AR model to more conventional techniques of importing information, in this case, dense text organized into paragraphs that explained how a Four Stroke Engine Cycle works. The test was administered in a carefully controlled setting under strict supervision, with no access to the internet, additional reading materials, or interactivity amongst the participants.

The preceding query was:

"Are the test results of the AR group and the conventional group statistically different from one another?"

These questions were addressed utilizing two entirely distinct instructional strategies and a focus group that was impartial and evenly distributed.

B. Test Type

A nonparametric test called the Mann-Whitney U test enables two groups, conditions, or treatments to be compared without assuming that the results are regularly distributed.

C. Control group (Traditional) study material

Parts of the Engine:

Piston- In an engine, a piston transfers the expanding forces of gas to the mechanical rotation of the crankshaft through a connecting rod. Crankshaft- A crankshaft is a part that converts the reciprocating motion to rotational motion. Connecting Rod- It transfers motion from a piston to a crankshaft, acting as a lever arm Spark Plug- It is a device that delivers electric current to the combustion chamber, which ignites the air-fuel mixture leading to the abrupt gas expansion.

Four Stroke Engine Cycle

Suction/Intake Stroke- Intake stroke occurs when the air-fuel mixture is introduced to the combustion chamber. In this stroke, the piston moves from TDC (Top Dead Center – the farthest position of the piston to the crankshaft) to BDC (Bottom Dead Center – the nearest position of the piston to the crankshaft.) The movement of the piston towards the BDC creates a low-pressure area in the cylinder.

Compression Stroke-In compression stroke, the trapped air-fuel mixture is compressed inside the cylinder. During the stroke, the piston moves from BDC to TDC, compressing the air-fuel mixture. Compressing the air-fuel mixture allows more energy to be released when the charge is ignited. The charge is the volume of compressed air-fuel mixture trapped inside the combustion chamber ready for ignition..

Power/Combustion Stroke- The power stroke occurs when the compressed air-fuel mixture is ignited with the help of a spark plug. Ignition or Combustion is the rapid, oxidizing chemical reaction in which a fuel chemically combines with oxygen in the atmosphere and releases energy in the form of heat. The hot expanding gases force the piston head away from the cylinder head.

Exhaust Stroke- As the piston reaches BDC during the power stroke, combustion is complete, and the cylinder is filled with exhaust gases. The exhaust valves open during this stroke, and the inertia of the flywheel and other moving parts push the piston back to TDC, forcing the exhaust gases through the open exhaust valve. At the end of the exhaust stroke, the piston is at TDC, and one operating cycle has been completed.

D. Experimental Group's Study Material

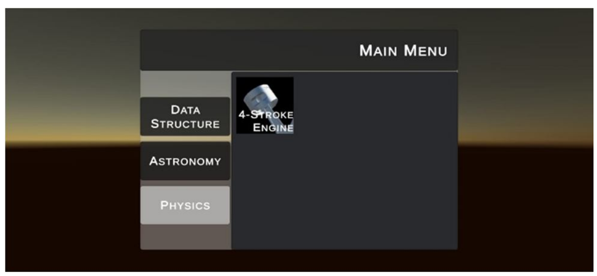
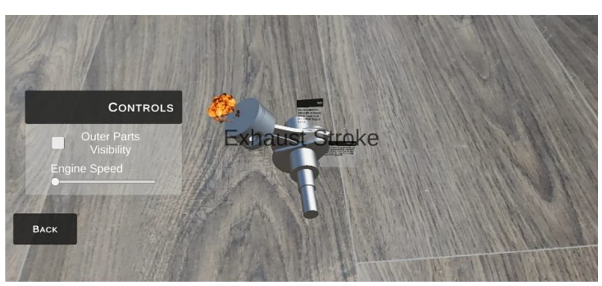


Fig. 6.1: Main Menu with Physics module selected

Fig. 6.2: 4-stroke engine main components



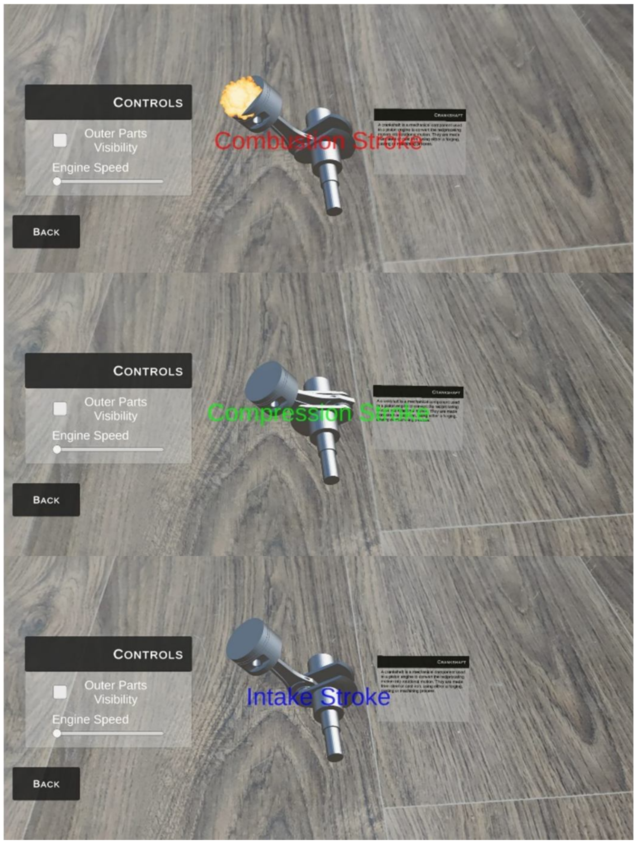


Fig. 6.3: All four strokes shown without engine cover and explained in flashcards, having option to change engine speed, and allowing for in-model zoom interaction

E. Sample Requirements

- Required are two separate, random samples. We divided the 84 individuals in the test group, who were between the age ranges of 18 and 21, into two groups of 42 each using only random allocation. The subjects were first-year engineering students at the same university. They were from various academic streams, had about equal gender distribution, varied socioeconomic backgrounds, and showed academic achievement across the board.
- Since we have made the use of continuous data, it must be possible to discern between nth decimal places' values in theory.
- Interval, ordinal, or ratio scales should be used for measurements. Utilizing ordinal data
- Ties need to be avoided for optimum accuracy, but this exam, like others, contains a mechanism to handle and negate all inter-data ties.

F. Null Hypothesis

According to the null hypothesis, we assume that the medians values of sample 1 and sample 2 are the same.

G. Data Analysis

MCQ-based examinations covering the concepts from the approaches' respective conceptual illustrations were used to evaluate the recordings of the two groups. The pattern and format of the paper were kept secret and it was given (before the learning, observation, and response collection phases). As contrast to an open label study, the grading was carried out by an Associate Professor of Mechanical Engineering (a subject matter expert) who was blinded to the name or group of the students being assessed.

To process the data points using the Python program for the Mann-Whitney U Test, data points were captured and processed in comma separated and delimited format.

Sample 1 (Control Group):

4,5,3,6,5,2,4,5,4,4,3,5,6,5,1,3,4,7,5,5,3,6,4,5,3,4,5,4,5,8,3,4,2,5,7,5,4,10,4,5,4,3
Sample 2 (Experimental Group):
7,6,8,8,9,7,8,8,7,7,10,7,8,8,9,6,10,9,7,8,6,6,8,7,6,9,9,7,8,7,6,3,8,7,8,5,7,8,6,7,9

S1 Values	S1 Ranks	S2 Values	S2 Ranks
1	1	1	7.5
2	2.5	2.5	30.5
2	2.5	2.5	42.5
3	7.5	7.5	42.5
3	7.5	7.5	42.5
3	7.5	7.5	42.5
3	7.5	7.5	42.5
3	7.5	7.5	42.5
3	7.5	7.5	42.5
3	7.5	7.5	54.5
4	17.5	17.5	54.5
4	17.5	17.5	54.5
4	17.5	17.5	54.5
4	17.5	17.5	54.5
4	17.5	17.5	54.5
4	17.5	17.5	54.5
4	17.5	17.5	54.5
4	17.5	17.5	54.5
4	17.5	17.5	54.5
4	17.5	17.5	54.5
4	17.5	17.5	54.5
4	17.5	17.5	68
5	30.5	30.5	68
5	30.5	30.5	68
5	30.5	30.5	68
5	30.5	30.5	68
5	30.5	30.5	68
5	30.5	30.5	68
5	30.5	30.5	68
5	30.5	30.5	68
5	30.5	30.5	68
5	30.5	30.5	68
5	30.5	30.5	68
5	30.5	30.5	77.5
5	30.5	30.5	77.5
6	42.5	42.5	77.5
6	42.5	42.5	77.5
6	42.5	42.5	77.5
7	54.5	54.5	77.5
7	54.5	54.5	82
8	68	68	82
10	82	82	7.5

The significance level assumed: 0.05
Hypothesis was Two-tailed.

Equation

$$U = NM + \frac{N(N+1)}{2} - \sum_{x_i} Rank(x_i)$$

Result
In general, one can say about the effect strength: Effect Size r less than 0.3 → small effect.
Effect Size r between 0.3 and 0.5 → medium effect. Effect Size r greater than 0.5 → large effect.
In this scenario, upon calculation we get that

Control Group (S1):
Sum of ranks: 1051.5
Mean of ranks: 25.04
Expected sum of ranks: 1764

Expected mean of ranks: 42
U-value: 1573.5
Expected U-value: 861

Experimental Group (S2):
Sum of ranks: 2434.5
Mean of ranks: 59.38
Expected sum of ranks: 1722
Expected mean of ranks: 42
U-value: 148.5
Expected U-value: 861

Sample 1 & 2 Combined
Sum of ranks: 3486
Mean of ranks: 42
Standard Deviation: 109.7907

The value of U is 148.5
The z-score is -6.48507.
The p-value is < .00001.
The result is **significant** at p < .05.

V. CONCLUSIONS

We have found that when AR is used as a visual aid, there is a noticeably higher understanding rate when compared to difficult process-based concepts through the examination of a relevant target group. There are a few applications for augmented reality, but its usage in the field of education is the most compelling. The support offered by well-known video game engines like Vuforia and Unity, along with assistance from Google's AR Core, is assisting developers in improving AR applications. Numerous thousands or maybe millions of students could use this execution for free due to its degree and capacity. The development of modules for higher education institutions can benefit from more study in the disciplines.

It is possible to continue the research so that it is fully included in middle school lesson plans. The program will include a virtual assistant and a number of other interesting features for students that were created using IBM's open-source Watson Software Development Kit. Offering information about the object and performing immediate recognition of photographs now in the camera flow are further potential improvement points, while this feature may also have uses outside the realm of education.

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