

## **XR Digital Classroom: An Innovative and Gamified Tool that Aims to Aid Learning in the New Normal**

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**Abstract:** The classroom learning experience has undergone a tremendous change since the adoption of open and distance learning programs, especially during the current global COVID-19 lockdown that forces schools to shift to online learning. Experiential learning became limited, and it affected laboratory-based subjects. With the help of Extended Reality (XR), namely, virtual, augmented, and digital scenarios can be recreated for students to experience, explore, and learn in a low-risk environment. This paper discusses the XR digital classroom mobile application for Android developed by Stock Knowledge. The XR application aims to simulate digital and virtual scenarios that can aid educators in transforming traditional lectures into immersive and gamified learning/teaching experiences. The XR application provides tailored experiences based on the actual syllabus and course materials created by teachers teaching math and science. The application is used as a tool to enhance the learning experience and classroom interaction. With the gamification feature, the classroom experience became more engaging and allowed the students to be actively involved in classroom activities. This study is based on an experiment involving actual student activities using the XR mobile application. The student's behavior suggests that learning needs to become much more interactive and rewarding compared to traditional methods. Simulation and laboratory experiences are recreated at cheaper costs and lesser risks when using the XR mobile application.

**Keywords:** *Extended Reality (XR), Gamification, EdTech, Virtual Reality (VR), Augmented Reality (AR)*

### **1. Introduction**

A number of students tend to be inattentive and disinterested in traditional classroom lectures and activities, this can result in students not reaching their potential during classroom instruction [1]. Classroom-related boredom is commonly showcased by students and it can greatly affect their learning engagement and achievements [2]. Students are often bored in the classroom for a variety of reasons, such as not being sufficiently challenged or simply not feeling motivated by the topic/ subject matter being discussed [3]. During this pandemic and the age of distance learning, it is harder to

manage the classroom and monitor the activities of the students behind the computer screen compared to a traditional face to face meeting. Some reasons why the students get the feeling of boredom is because they do not feel rewarded or they do not see any incentives. Some reasons may include their lack of connection with peers or their teacher, they might not feel comfortable with the current situation. They might need some encouragement and assurance that they are part of the classroom community [3]. It is also possible that they don't find the topic interesting and would just rather play a video game.

Furthermore, the Philippines scored 353 in mathematics and 357 in science, second lowest to the Dominican Republic, in the PISA 2018 result (Program for International Student Assessment). The PISA 2018 is participated by 600,000 students representing about 32 million 15-year-olds in the schools of the 79 participating countries and economies [17].

The current pandemic situation where schools are forced to close worsen the education delivery. Hence, the researchers attempt to enhance traditional learning and classroom experience with immersion and gamification or adding game mechanics into lectures, activities, and assessments. The goal of gamification is to engage students and give them a new learning experience. In the past years, gamification became popular and is used widely in different fields in order to engage and motivate

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users and surprisingly produces successful outcomes [4][5]. Gamification is related, but not identical, to the concept of *game-based learning*. Where gamification is about the use of game design elements in a non-game context, game-based learning refers to the use of actual games to acquire skills or knowledge. In game-based learning, the skills that are being tested in the game correspond to the learning task, as is for instance the case in a game where students explore and escape a scenario by solving puzzles [5].

Auditory and visual illusions are an essential recipe of the experience to make it immersive and for the user to believe what they are seeing and hearing. The audio and visuals should simulate its real world counterparts. XR will not replace reality, the practitioners and the experience, but will be used as a tool or an accessory to simulate and enhance the experience [8].

With the help of XR, educators can create gamified immersive learning experiences to enhance their lectures and activities. The goal of this paper is to leverage 21st-century technologies such as video games, gamification, and extended reality as a medium and tool that increases student engagement and immersion, and promotes a motivational and fun learning experience. The interactive XR application can enhance students' understanding of the subject matter. Additionally, incorporating gamification and game-based learning can help the students visualize and contextualize instructions, motivate

and engage learners, promotes decision making, and encourages positive learning outcomes. The application is used as an educational tool that can help both educators and students in creating a better digital classroom environment, especially for relatively difficult STEM subjects like Math, Physics, Chemistry, Earth Science, and Biology that most students fear [18].

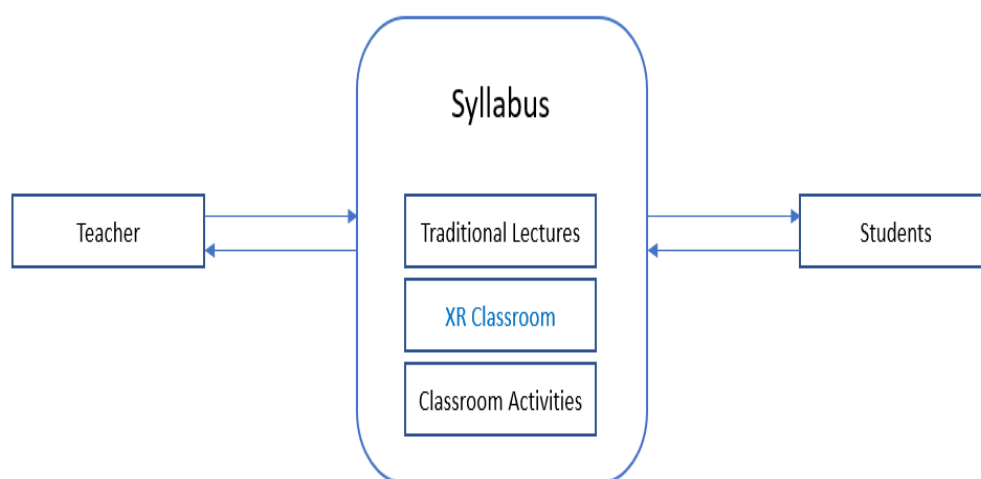
This study was conducted during the COVID-19 lockdown. The Philippines has the longest and strictest lockdown, forcing prolonged school closures that has significantly negatively impacted education access, quality and equity [6]. The pandemic greatly affected the education system, but the researchers thought of this as an opportunity to innovate the current educational system by using XR to simulate different classroom experiences.

## 2. Objective

The research aimed to assist educators in giving an interactive and gamified classroom experience to keep the students engaged and immersed in classroom discussion and activities.

In Figure 1, The XR Classroom is incorporated in the syllabus and is tied up with the traditional lectures and activities. The teacher creates the contents of the syllabus, monitors the student activities, and receives feedback on student learning experience. The students then utilize the application turning their classroom involvement into gamified experiences.

**Fig 1 – The Conceptual Paradigm**



### Research Question(s)

The research aims to answer the following questions:

1. [For teachers] Is there a difference in student engagement before and after incorporating the XR classroom?
2. [For teachers] Is there a significant difference in student performance before and after incorporating the XR classroom?
3. [For students] What are the different student experiences upon using the XR digital classroom (student insights)?

### 3. Methodology

This section discusses the game design, subject content and topics, development process, and deployment of the XR classroom.

#### I. Game Design

The XR Classroom has three (3) different modes: Mode 1, are scenes with interactive lectures and exploration; Mode 2, are scenes with activities and experiments; and Mode 3 are scenes with gamified assessments.

The different modes provide voice over and text instructions about what the user needs to do.

#### Virtual Reality (VR)

There are two (2) ways/ options to view and explore the VR scenes: Head Mounted Display (HMD) using a VR box or a VR Cardboard, this is for mobile phones that supports gyroscope sensors; and Panoramic view, where the users touch and slide the screen to navigate the 360-degree scene.

Interaction in VR supports click (touch) and gaze interactions. The click is used for HMDs with the click mechanism and manual input in the panoramic view, while the gaze is used for HMDs without the click.

Fig 2 – Head Mounted Display



#### Augmented Reality (AR)

AR uses the mobile phone's camera to track and scan images. Each AR content is paired with a visual sheet that

contains the target images for the user to scan. Scanning a target image showcases a 3D model of the topic being discussed. The 3D models are interactive, and the users can rotate, zoom in, and view information.

Fig 3 – Stock Knowledge Target Image GDrive location



#### Mode 1

Interaction:

- VR
  - Exploration – Look for interactive objects
  - Click/ gaze at interactable objects to show the information and/ or play audio
  - A level will be complete if the user has checked/ viewed all the interactive objects
- AR
  - Scan an image to showcase the topic

- Interact with the 3D object/scene buttons to see information and play audio
- A level will be complete if the user has scanned all the target images

Points and Completion:

- If a level is completed, a pop-up IU telling the user that the level is complete will appear.
- User will gain a badge of the completed level, this will appear in the achievements section of the app
- Records the amount of time the user spent on the module

## Mode 2

Interaction:

- VR
- Exploration – Look for interactive objects
- Click/ gaze to interact and pickup objects
- This mode uses staged experiments, where the developers predefined all the possible outcomes of the experiments.
- Users need to interact with the objects first and view the information of each object.
- If the user has viewed all the interactable object information, start tutorial on the experiment interaction
- AR
- Scan an image to trigger/ start the AR experience
- Interact with the 3D object/ scene buttons to see information and play audio
- Follow the instructions/ guide on how to interact with the scene
- A level will be complete if the user has scanned all the target images

Points and Completion:

- If the user tried all the possible scenarios in the experiment, the level will be completed
- If a level is completed, a pop-up IU telling the user that the level is complete will appear.
- User will gain a badge of the completed level, this will appear in the achievements section of the app
- Records the amount of time the user spent on the interactions
- Records the amount of time the user spent on the experiments

## Mode 3

Mode 3 will be variable, and will depend on the subject/topic requirements. Interaction in mode 3 is similar to both modes 1 and 2.

Points and Completion:

- If the user answered/ solved all the problems and situations, the level will be completed

- If a level is completed, a pop-up IU telling the user that the level is complete will appear.
- User will gain a badge of the completed level, this will appear in the achievements section of the app
- Records the amount of time the user spent on the scenario
- Records the highest score the user achieved

## Experience and Leveling

Users need experience points to level up and unlock advanced modes. Completing modes allows the user to gain experience points.

*Experience points required*

- User starts at Level 1 with Zero experience points
- Users need to accumulate 25 experience points to reach level 2
- The experience points will reset back to zero if the user levels up
- The required experience point is increased by 25 every time the user levels up
- Users need 50 experience points to level up to level 3
- Users need 75 experience points to level up to level 4
- Users need 100 experience points to level up to level 5
- And so on...
- Users will gain a global experience point for the user level.
- Each subject has its own accumulated experience points that the user needs to earn to unlock different modes
- The “per subject” experience points are added to the global experience of the user, but the “per subject” experience points are unique to a subject.
- Eg. User can only unlock a certain mode if he/she has sufficient experience points on that subject
- A certain experience points is required to unlock some of the modes
- Finishing a mode adds to the per subject experience points
- Per subject experience points make up the global experience points

**Fig 4 – SK Game Design Document, Experience Points**

Experience points required		
Mode 1	Mode 2	Mode 3
<ul style="list-style-type: none"> <li>Completing a mode 1 module will have the player earn 5 experience points</li> <li>Completing a module lets the player earn a badge and the badge can be viewed in the app's achievement page</li> </ul>	<ul style="list-style-type: none"> <li>Completing a mode 2 module will have the player earn 10 experience points</li> <li>Completing a mode 2 module will unlock the mode 3 with the related topic</li> <li>Completing a module lets the player earn a badge and the badge can be viewed in the app's achievement page</li> </ul>	<ul style="list-style-type: none"> <li>Completing a mode 3 module will have the player earn at least 20 experience points</li> <li>Additional point will be awarded depending on how well the player performed in the module</li> <li>Player will keep earning point until he reached the maximum points allowed</li> <li>Player will not accumulate the points, but instead will be replaced by the highest score received</li> </ul>

**Fig 5- SK Game Design Document, In-Game Points**

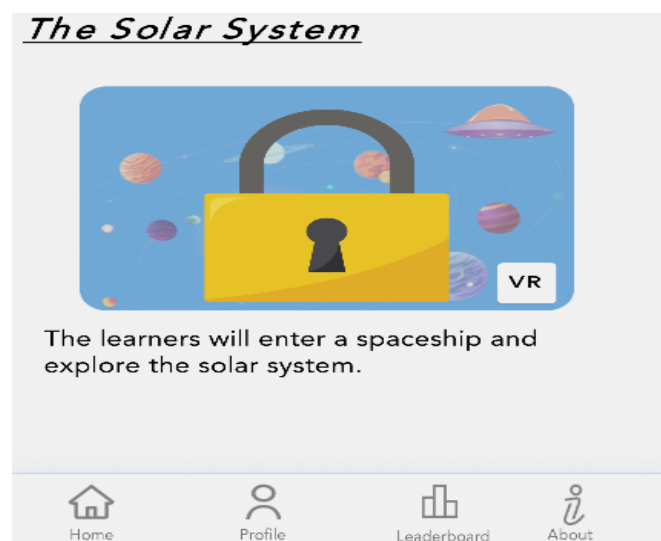
In Game Points		
Mode 1	Mode 2	Mode 3
<ul style="list-style-type: none"> <li>Users will be rewarded with points upon discovering an interactive object.</li> <li>Users will earn 50 points per object interacted.</li> </ul>	<ul style="list-style-type: none"> <li>Users will be rewarded with points upon discovering an interactive item or unlocking a lecture, and triggering a scenario related to the lecture.</li> <li>Users will earn 100 points for discovery and interaction.</li> </ul>	<ul style="list-style-type: none"> <li>Users will be rewarded with points depending on the outcome of the experiment or scenario.</li> <li>The points earned will be variable and will be dependent on the player.</li> <li>Points earned will affect the total(global) experience points earned in this mode.</li> </ul>

Note: Each level/ mode have different total accumulated point. Users need to earn a specific number of points per level to finish it.

**Locked Modes**

- Some “advanced mode” buttons on the menu will not be intractable/ accessible until the player reaches a certain level or accumulates a number of experience points.
- Players need to finish the unlocked levels, and earn experience points in order for him to unlock other modes
- Notification for the player if the player tries to access the mode
  - “Complete the other modes first to unlock this”
  - The mode button will appear faded to depict that it is inaccessible yet.

**Fig 6 – Locked Topics, XR Classroom**

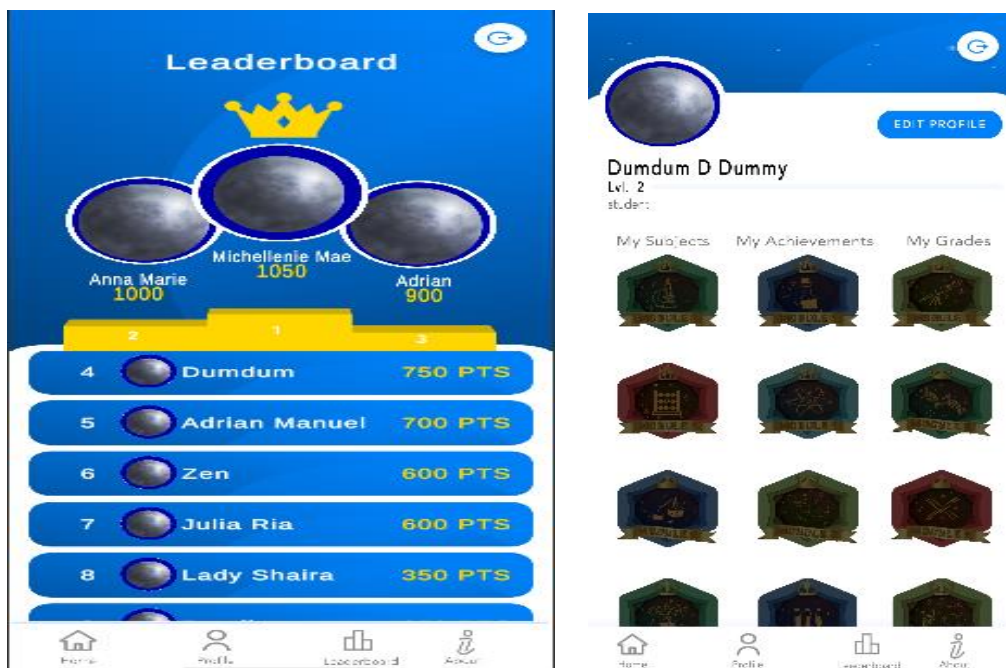


## Achievements

- Users accumulate points for every completed mode. It can be compared to other user's progress in the achievements page.

- Users gain experience points per subject
- Users can unlock a badge for every mode completed

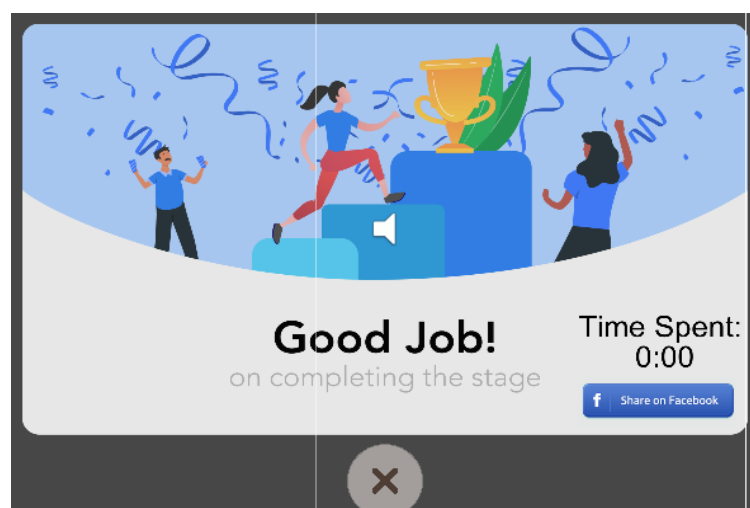
Fig 7 – XR Classroom Leaderboard & Badges



## Sharing to Social Media

- Upon completing a scene, players have the option to share the achievement screen on social media.
- Upon completing, the app will take a screenshot of the end message UI with the total time spent and earned points displayed.

Fig 8 – Sharing on Social Media



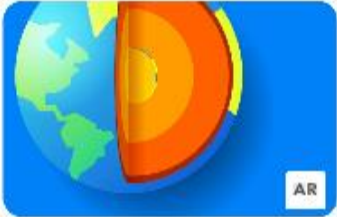
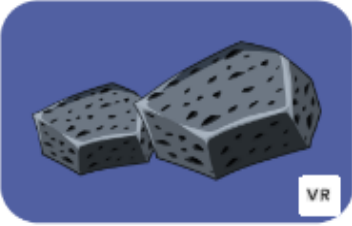
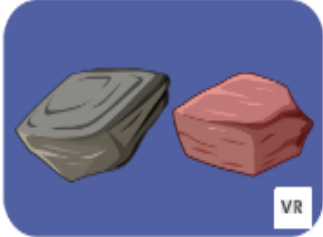

## II. Content and Topics

XR Digital classroom focuses on the general subjects of senior high school students, namely, Math and Science.

The following are the current available topics in the mobile application, version 14-9-4 [15]:



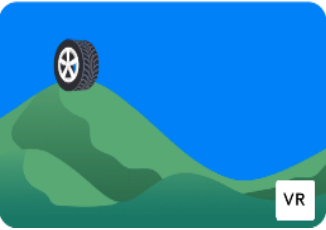



**Table 1 – Mode 1 Topics**




Mode 1		
Topic/ Module	Status	Requirements
Earth Science		
<p><i><u>The Solar System and Earth Structure</u></i></p> 	Unlocked	N/A
<p><i><u>Igneous Rock Examples</u></i></p> 	Unlocked	N/A
<p><i><u>Metamorphic Rocks Examples</u></i></p> 	Unlocked	N/A
<p><i><u>Sedimentary Rocks Examples</u></i></p> 	Unlocked	N/A

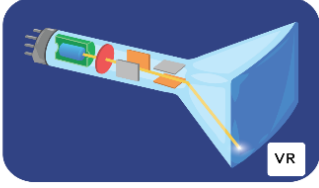




Chemistry		
<p><i>Millikan's Theory</i></p> 	Unlocked	N/A
<p><i>Parts of the microscope</i></p> 	Unlocked	N/A
Biology		
<p><i>Animal Cell</i></p> 	Unlocked	N/A
Physics		
<p><i>Measurements and Conversion</i></p> 	Unlocked	N/A


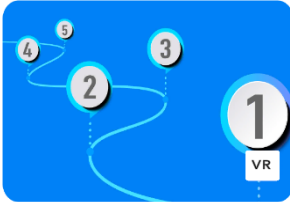


<p><i><u>Energy</u></i></p> 	<p>Unlocked</p>	<p>N/A</p>
<p><i><u>Freebody Diagram</u></i></p> 	<p>Unlocked</p>	<p>N/A</p>
<p><i><u>Forces and Interaction</u></i></p> 	<p>Unlocked</p>	<p>N/A</p>
<p>Mathematics</p>		
<p><i><u>Conic Sections</u></i></p> 	<p>Unlocked</p>	<p>N/A</p>



**Table 2 – Mode 2 Topics**




Mode 2		
Topic/ Module	Status	Requirements
Earth Science		
<p><u><i>Rocks and Minerals identification</i></u></p> 	Locked	<p>5XP point from EarthScience XP</p> <p style="text-align: center;"><b>and</b></p> <p>needs to complete the following Mode 1 topic/modules:</p> <ol style="list-style-type: none"> <li>1. Igneous</li> <li>2. Metamorphic</li> <li>3. Sedimentary</li> </ol>
<p><u><i>The Solar System</i></u></p> 	Locked	<p>5XP point from EarthScience XP</p> <p>This will unlock after completing any earth science mode 1 topic/module</p>
Chemistry		
<p><u><i>ARDart</i></u></p> 	Locked	<p>5XP point from Chemistry XP</p>

<p><i><u>CathodeRayTube</u></i></p> 	<p>Locked</p>	<p>5XP point from Chemistry XP</p>
<p><i><u>Boyle's Law</u></i></p> 	<p>Locked</p>	<p>10XP point from Chemistry XP</p>
<p>Physics</p>		
<p><i><u>Conversion</u></i></p> 	<p>Locked</p>	<p>5XP point from Physics XP</p>
<p><i><u>Impulse and Momentum</u></i></p> 	<p>Locked</p>	<p>10XP point from Physics XP</p>
<p><i><u>Freefall</u></i></p> 	<p>Unlocked</p>	<p>N/A</p>
<p>Mathematics</p>		

<p><u>Conic Sections</u></p> 	Locked	Complete the Mode 1 Conic Sections
<p><u>Arithmetic Series and Sequences</u></p> 	Unlocked	

**Table 3 – Mode 3 Topics**

Mode 3		
Topic/ Module	Status	Requirements
Chemistry		
<p><u>ARSoccer</u></p> 	Locked	10XP point from Chemistry XP
Physics		
<p><u>Energy</u></p> 	Locked	Complete the Energy 1 Module

<p><i>Energy</i></p> 	<p>Locked</p>	<p>Complete the Energy VR Module</p>
<p>Math</p>		
<p><i>Probability</i></p> 	<p>Unlocked</p>	<p>N/A</p>
<p><i>Advanced Probability</i></p> 	<p>Locked</p>	<p>50XP points from Math XP  <b>and</b> Complete the Probability 1 Module</p>

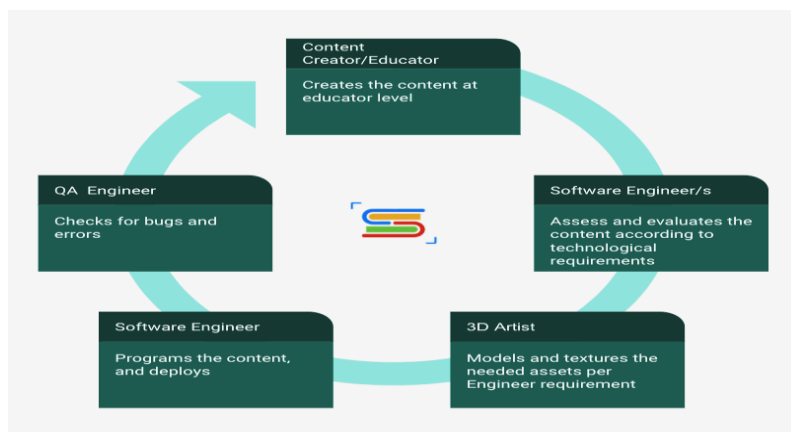
### III. Development Process

The XR Classroom is an open source educational solution that provides Virtual and Augmented reality experiences [11].

Figure 9 discusses the XR Classroom’s content and software development lifecycle. The contents are created by teachers based on their syllabus and lesson plans. The

contents are then evaluated by the Software Engineers and Game Designers for the technical specifications. The Art Asset team then creates the game objects and visual elements. After the assets are completed, the contents are assembled by the software engineers and deployed to the target platform (build). The QA engineers then check the build for quality assurance. The Content creators then evaluate the build to check if it meets their requirements.

**Fig 9 – Software Development Life Cycle**



#### IV. Deployment

The XR classroom was distributed and tested to partner schools under the Department of Education Manila and Makati Divisions. The VR classroom is also published in the *Google Play Store* [11].

A group of high school students from Manila Science High School and Makati Science High School are deeply involved in the tight feedback loop and several product iterations to meet the students' learning needs during the alpha, closed-beta, and open-beta tests [12, 13, 14]. They

currently use the XR classroom to supplement their learning activities.

In line with the classroom discussion, the teachers from partner schools are incorporating the XR classroom in their lectures as part of the interactive learning process. Students then use the XR Classroom application to review their lectures (Mode 1), experiment (Mode 2), and practice assessments using the gamified quest/mission – systems (Mode 3).

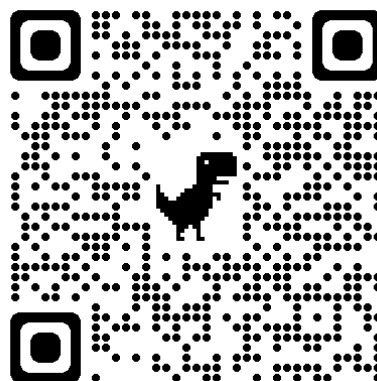
**Fig 10** – VR Box Distribution to Partner Schools



**Fig 11** – Stock Knowledge VR Classroom at Google Play that was first published on August 2, 2021.



**Fig 12** – Complete Stock Knowledge XR Classroom that is composed of VR and AR



#### 4. Results and Discussions

The data gathered through observation are summarized in this section.

*Problem 1: Is there a difference in student engagement before and after incorporating the XR classroom?*

Based on classroom monitoring and observations, students get excited talking about and experiencing VR and AR. “They are learning as if they are playing a game”. After incorporating the XR classroom, student participation increased because most of them wanted to experience XR and play games. XR gave an opportunity to students to experience different digital situations that cannot be achieved in this pandemic. Instead of going out, they experienced virtual and augmented realities that simulates real world experience.

*Problem 2: Is there a significant difference in student performance before and after incorporating the XR classroom?*

According to students, they understand the lectures better and remember the words easier. “It’s like comparing memorizing a song to memorizing a short paragraph, it’s easier to memorize a song because of the tune and melody. Similar to playing games, it’s easier to remember gaming terminologies if you play it all the time”.

Based on a study conducted by the SK team on *Gamified-infused Assisted Instruction Through Extended Reality Mobile App: Impact on Students’ Performance and Attitude Towards Mathematics* [7], it revealed that the increase in the achievement test scores are statistically significant. This implies that meaningful learning occurred when students were taught through the use of Extended Reality Mobile App. In particular, it signifies that students who used Gamified-Infused Assisted Instruction through Extended Reality Mobile App tend to develop their inductive, deductive, and analyzing skills when faced with word problems in Math.

**Table 4** – Difference between pre- and post-test scores of the class based on [7] study results.

Test	t-value	p-value	Decision	Interpretation
Pre-test	-20.791	0.000	Reject H <sub>0</sub>	Significant
Post-test				

*Problem 3: What are the different student experiences upon using the XR digital classroom?*

Extrapolation was used to interpret different student responses. Most of the answers are similar and related to each other.

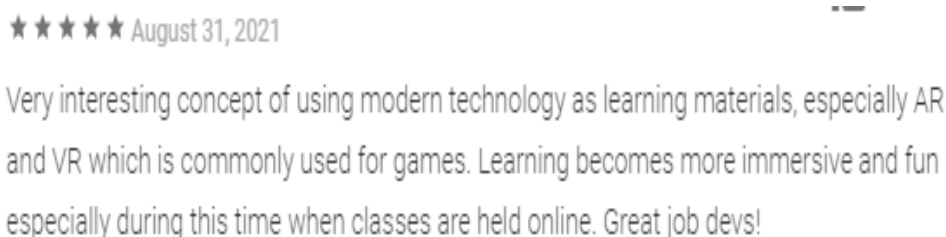
The following questions are asked to learn more about the insights of the students about the XR classroom experience.

- What was your experience like when you used the XR app?

- Did it help you understand the topics/ lessons being discussed?
- Did you have fun?
- Would you prefer incorporating the XR classroom as part of your classroom experience?

For questions about experience when using the XR app, students commonly answer that the application is interesting and immersive. Some answers talk about the future and some compare it to animated films.

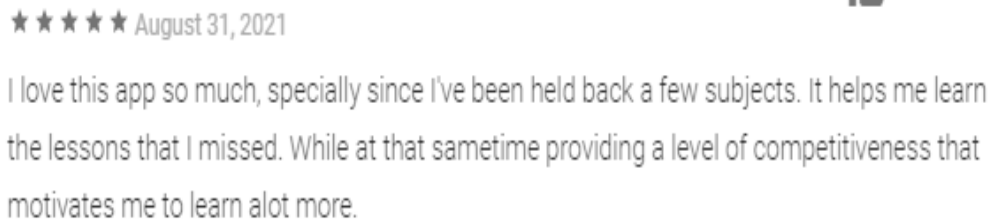
**Fig 12** – Student response





For questions about helping understand the lectures and topics, students commonly answered “Yes, and It’s just like playing a game”.

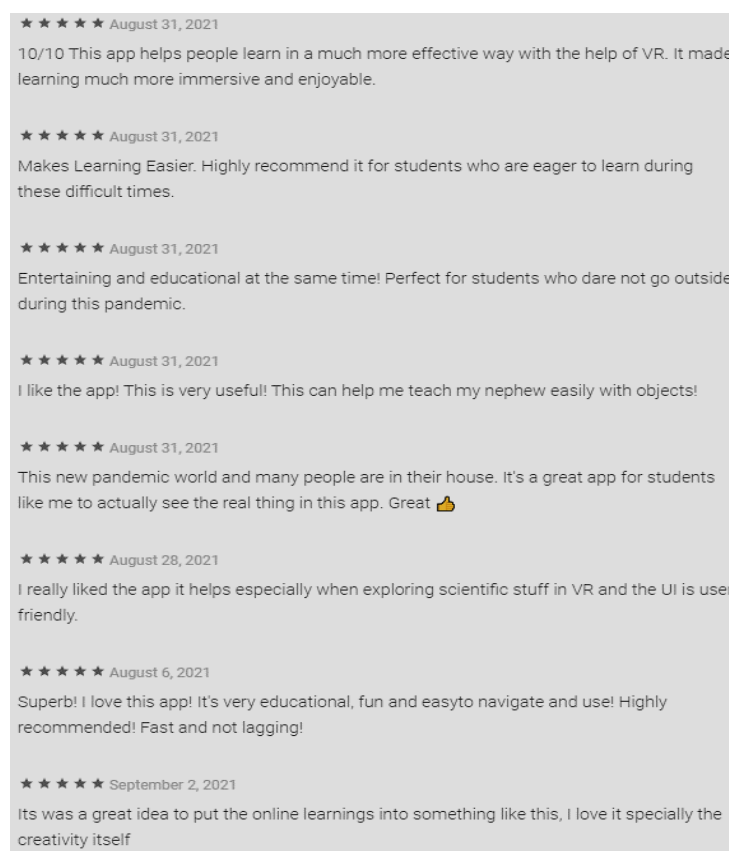
**Fig 13 – Student response**



Based on student comments and reactions, the students did have fun and enjoyed the XR experience.

For the incorporation of the XR classroom, most of the students are willing to use it as part of their learning experience, but some are worried about the required hardware and software.

**Fig 14 – Student Comments and Ratings on Google Play Store, SK first launched version.**



### Challenges

Since the mobile application is initially developed for Android, and the VR features require a smartphone gyroscope, 15.6% of students cannot access the AR and VR contents as seen in Figure 15 below. The Stock Knowledge team added a VR “360” feature to cater students whose smartphones don’t have gyroscopes. (However, for more immersive experiential learning, we strongly suggest using the XR mobile application with the HMD’s mentioned in Figure 2).

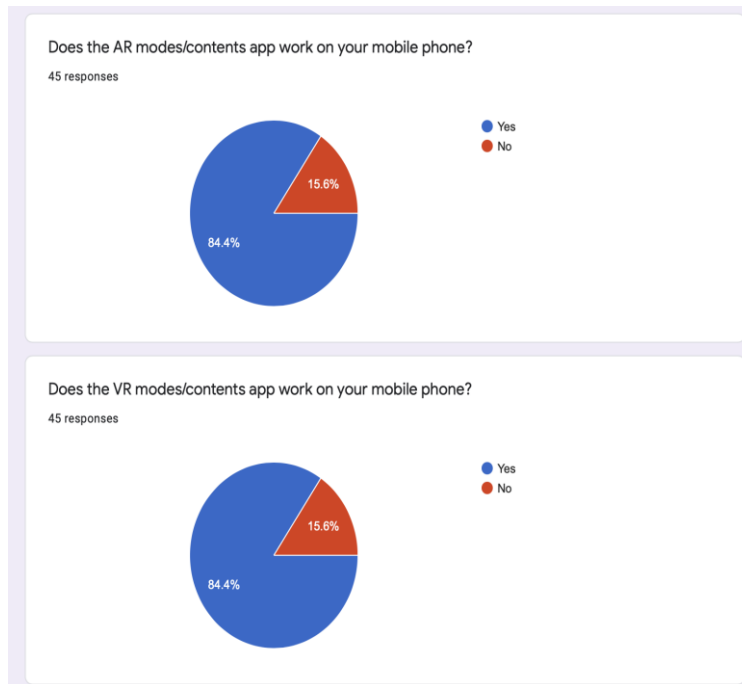
Moreover, connectivity is also extremely challenging as seen in Figure 16, where most students suffer from slow internet speed. It is helpful to note that Figure 16 is the

most updated version of students’ feedback from several iterations where the Stock Knowledge team adjusted their core technologies to make the application more accessible and affordable. This general public feedback was gathered last July 2021 from students of Manila Science High School, Makati Science High School, Pitogo High School, and other high school students in the Philippines. It is important to note that the 99.0% of students who provided the feedback come from the relatively rich local governments of Manila and Makati where they could provide Internet to them.

Lastly, although Stock Knowledge XR app is designed user-friendly, teachers and students training is also

necessary due to the seemingly complex nature of the technology.

**Fig 15.** The student responses when asked about the accessibility of the AR and VR features on their phone.



**Fig 16.** Internet speed and download time during the earlier version, v. 13-6 [15].



## 5. Conclusions and Recommendations

Based on the results above, we conclude that:

1. Using the XR classroom gives the students the opportunity to explore new worlds and experience a

fun, enjoyable, and immersive classroom experience which would otherwise be impossible to demonstrate in a real world, e.g. travelling to the solar system.

2. Gamification and app-interaction increases student engagement and participation.

3. Students who experienced the digital classroom show interest in the emerging technologies and the future of digital classes.
4. Combining entertainment to serious topics such as education sparks the student's attention, interest, and increases academic performance.

### Recommendations

The software development of the XR ran for a year, and its open-beta is almost finished towards the end of 2020-2021 school year, thus we strongly recommend a more quantitative approach when students and teachers become available to assess:

1. More educators' insights about the positive effects of gamification and XR. Traditional learning experiences should incorporate 3D gamification
2. Teachers adaption on the use of gamification and game-based learning as part of their classroom experience in the distance learning environment. This promotes student engagements and improvements in performance.
3. Student academic performance through a thorough pre-test and post-test comparison when using immersive gamified learning platforms like Stock Knowledge.
4. Much needed collaborations among policy makers, relevant government agencies and stakeholders, telecommunication industries, private companies, and EdTech startups, especially locals who have more understanding of the Philippine education landscape since digital and remote learning is inevitable today and the coming future.
5. Parallel studies can be made by future researchers to validate the findings of this study. These studies may be done with other grade levels, in a longer time frame, or may include other variables that they wish to explore.

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