XR Immersion for teaching and learning with precise visualization in user perspective

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ABSTRACT

User Perspective Learning is a method that stresses the importance of teaching and learning from the user's point of view (POV). A video is usually created from the user's point of view to be viewed on desktop displays, televisions, and mobile devices. Traditional displays could be replaced by Extended Reality (XR) applications and devices in the not-too-distant future. XR is an inclusive term for VR, AR and MR. Teaching learners with the freedom to view and interact can be made much more effective by using this technology. With the help of XR technology, learners can be tracked as they practice, augment Computer-Generated Imagery (CGI) in real-time, or completely teleport to a digital environment. Over the years, handheld device processing advancements have resulted in significant improvements in portable XR technologies. Modern multi-core processors are capable of handling complex computations in a fraction of a second. The adaptation of XR technologies to mobile smart phones has made them more accessible in addition to standalone devices. Our study is aimed at discovering the potential of XR in user-perspective learning and its effect of immersion. An XR application was created for the experiment, which allows participants to navigate in a virtualized environment (VE) with a great degree of freedom. Users can opt for either handheld or head-mounted viewing through the application. By tracking the orientation of practice models, CGI was augmented accurately matching to the model's dimensions and provided a grabbing and learning experience. This provided a precise visualization. A pilot study was conducted with 71 university students to evaluate the degree of immersion. To study the immersion levels of XR technology, a statistical analysis was conducted on the collected data.

CCS CONCEPTS

• **Human-centered Computing**; • **Human-computer Interaction (HCI)**; • **Interaction paradigms**; • **Mixed/augmented reality.**;

KEYWORDS

Extended Reality, Virtual Reality, Augmented Reality, Games Development, Visualization, Immersion, Teaching and Learning

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1 INTRODUCTION

Immersion is a technological concept closely connected to user experience that enhances their presence in virtual environments. Presence is defined as the feeling of being in a virtual environment, according to Slater and Wilbur [1] Witmer and Singer [2], and Craig [3]. Also, Dessing and Craig [4], "Mapping Natural movements in the virtual space is essential as it improves or enhances the level of task behavioural presence of the user". Mapping the user's natural movements has been identified as a potential way to improve immersion. The availability of the Internet and technological solutions allows us to access different hardware and software resources to achieve the necessary immersion in the technologies used for teaching and learning. Most of the research literature that has been reviewed has information on current technologies. In this research, it's essential to find viable solutions to invent new design ideas. This research application uses the tracking hardware in the smartphone to compute rotational and positional degrees of freedom and function as an XR device. MEMS (Micro Electromechanical Sensors) are employed in the rotational tracking process to identify the phone's rotational orientation. To track position, the phone's camera must examine the depth of the environment in its vision to obtain positional orientation. Thus, the study utilized smartphones that have the ideal features for developing XR applications. The XR application was developed by utilizing Google's AR-core libraries and Google Cardboard, as part of the research. By configuring the smartphone's camera with its MEMS sensors, 6-degrees of freedom was achieved using AR-core. Therefore, a user can navigate in the virtual space by tracking the physical space without any constraints on the 3 angles of rotation and 3 angles of position. Besides tracking users in the Virtual environment, AR-core can also be used to track any difficult-to-track moving objects around the user by recognising and updating their new locations. A learner can be immersed in the user perspective of learning by taking advantage of these aspects. Identifying positional orientation can be a challenge due to the processing cost and Doppler's latency when the physical space is free of obstructions to observe depth. To address these limitations, smart phones may need to add more cameras in the future. Measurement of current technology's immersion is crucial to suggest smartphone designers for an efficient and accessible user perspective learning feature through XR. Android was the platform for the development of the research's XR smart phone application,

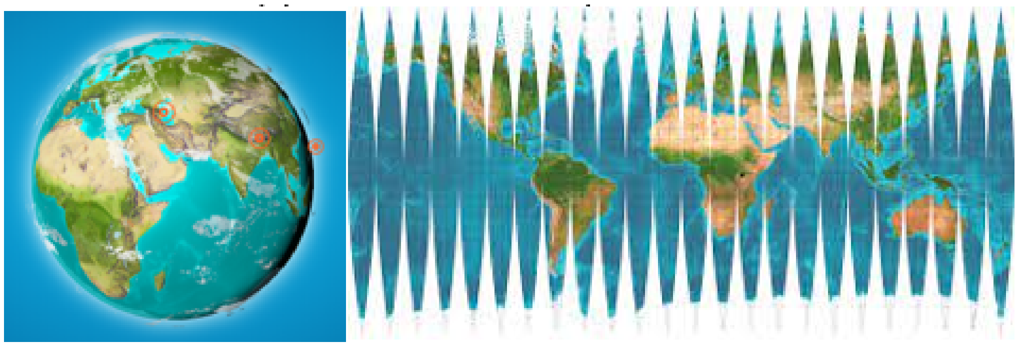

Figure 1: Globe Unwrapping

which was made using both C++ and Unity (Game Engine). According to StatCounter [5] data, Android-supported devices are used by 71.62% of smartphone owners across the globe. As a result, the research focused on the Android platform. In short, the study provided a highly immersive learning experience for the users and assessed their immersion levels. The hypothesis examined a variety of factors that could improve immersion among users by analysing user experience data.

2 BACKGROUND FOR EXPERIMENTATION

Kumar [6] states that XR could boost the engagement of learners who need a long span of attention in one of his education research articles. Heelan [7] published an article that identified that everyone learns differently. As learners require more customization based on their level of understanding, a new approach could be beneficial in improving learning. (i.e., reading/ listening/ viewing/ experiencing). The education system is believed to be being transformed by XR because it can provide effective learning, environmental-friendly learning, and keep students engaged. Element 4D application (apptopia.com, [8]) is a simulation of XR Chemistry. The use of this can aid in learning how elements in the periodic table interact with each other virtually. Google Expedition is another app that incorporates foreign locations into the classroom and provides 360-degree views instead of relying on an image in a textbook. Hyper reality is another form of XR that has the capability to overlay CGI on a moving target. This research investigates the use of hyperreality to achieve physical tasks with precision. For this research, **Unwrapping the 3D** model was used as a case study for teaching and learning games development - Art students. This is a preparatory process for Texturing the 3D models. As a standard procedure in 3D asset development, a 3D model will be clothed using a 2D image. For achieving a globe, the sphere model must be configured to take the 2D world map as a texture as in the Figure 1. This configuration process is called "Unwrapping". This involves skinning, seaming, and stitching the UVs (which are the model's Texturing-coordinates) as a 2D representational reference. Based on these references, painting/Texturing is done on the surface of the 3D model. The "Unwrapping" lessons are difficult to visualize verbally and require imagery to better understand the process. Hence, the researcher believed that the challenges for visualization will be overcome by interactive XR illustrations. In this research, the imagery and animation were displayed precisely to the tracked physical 3D models. This precise accuracy was achieved through a Laser scanning pipeline in the application development.

Students are provided with handheld practice models such as Cube, plate, fidget spinner, tumbler, and teapot along with the head mount Gear VR and smart phones Samsung S9 [9]. The phones have the research application "XR Campus" installed. The XR campus application could track the markers stuck to the top of the models and illustrate the unwrapping process animation above it, as long as the markers are facing to the users' view. The user can rotate the model to interactively view the animation with freedom. The users can quit the application by pressing the quit icon or can shift the viewing mode and toggle between mono and stereoscope based on their usability.

3 LITERATURE REVIEW

The literature review is organized thematically to address a. Usability, User-Preference, Engagement, Flow and Presence for immersion, b. Technology and innovation in teaching and learning through user perspective learning, c. Precise visualization. The table 1 shows the complete list of literature collected.

3.1 Usability, User-Preference, Engagement, Flow and Presence for Immersion

The significance of immersion in interactive media, particularly in gaming, is emphasised in this research, focusing on usability, user preference, engagement, flow, and presence. Wirtz [10] describes immersion as the temporary expansion of consciousness into areas of unconsciousness while still maintaining awareness. Immersion goes beyond just engaging, it encompasses user-presence, technology usability, preference, flow, and more. Various elements, such as graphics, audio, voice acting, and storytelling, are needed to create immersive experiences from the context of gaming and interactive applications [11]. Immersion can be positively or negatively impacted by factors such as music choice, which are crucial for users' immersion-ability and preferences [12, 13]. In shaping the immersive experience, usability and user preference are essential components. The effectiveness of an interactive application depends on its design elements, user interfaces, and ease of interaction, which also affects its overall immersive quality. The level of immersion experience can greatly be influenced by user preferences, which can include individual responses to music, graphics, and gameplay dynamics [12–14], at the same time. Engagement is a crucial aspect that is influenced by story, narration, and acting, which has an impact on overall immersion [15, 16]. Poor engagement can be a result of challenges like extreme difficulty, broken mechanics, bugs, and suboptimal level design [17, 18]. Sustainable success requires maintaining player engagement after the game [19]. Flow, which is crucial for engagement and immersion, involves aligning user skills with activity levels [20]. Players may lose their sense of time and disconnect from the outside world when in a state of flow. [21–23]. The psychological factor for immersion called Presence is defined as the sense of belonging [24, 25]. The sense of presence can be disrupted during the virtual experience through realisation of the physical world, as suggested by measurement methods such as Slater and Steed's active approach [26, 27]. The importance of user-avatar spatial awareness is highlighted by experiments like Reeve's virtual theatre experiments [16]. Argelaguet's study of virtual embodiment and Steed et al.'s research on self-avatar for cognition. Virtual experiences had a positive impact on the presence and cognitive skills of users. [28, 29]. In summary, the research underscores the dominant importance of recognizing and evaluating factors related to usability, user-preference, engagement, flow, and presence in the quest of comprehending the overall immersion in interactive systems.

3.2 VR/AR/MR technologies for user perspective teaching and learning in Education.

The integration of Virtual Reality (VR), Augmented Reality (AR), and Mixed Reality (MR) technologies in educational settings has garnered significant attention over the past few decades. This literature review aims to provide a chronological overview of key studies, initiatives, and advancements in this domain, highlighting the applications and evaluation of XR (Extended Reality) in education. In early work with actors rehearsing and performing in shared virtual environments, Reeve [15] highlighted the potential of VR as a social learning space but, at that point in time, one restricted by intrusive interfaces and controls. The potential for intuitive user interfaces in virtual reality simulations can be exemplified in Davis et al.'s [30] research on 'Depth-based 3D Gesture Capture and Virtual Object Manipulation'. The research uses a leap motion sensor to capture hand gestures and measure usability, providing insights into practical applications of gesture control for educational purposes. A 'Vision-based Gesture Technique' is explored by Ishiyama and Kurabayashi [31] in the realm of augmented reality (AR) and virtual reality (VR). The study examines how gestures can be integrated into educational VR scenarios using a glove with structured AR markers. By paving the way for gesture-based interactions in educational settings, this research opens up avenues for more natural and immersive learning experiences. Challenor et al.'s [32] study of 'Merged Reality Learning Experience' involves introducing augmented reality features in a head-mounted display (HMD) and simulating educational scenarios with Microsoft's HoloLens. By studying information retention in a museum context, the study highlights the value of XR technologies in enhancing memory and learning. This research combines augmented and virtual reality to create engaging and effective learning environments using extended reality. Emma research in 2022 [33] contributed studies with haptic technology for XR to touch and learn from the museum artefacts. Collectively, these studies underline the potential of XR technologies to improve user interactions, create immersive learning experiences, and revolutionize teaching and learning methods. In 2004, Yau Yuen Yeung [34] presented pioneering work on the utilization of VR technologies in science education. Through innovative learning media such as 3D and VR technologies, science educators at The Hong Kong Institute of Education developed resource kits to support effective teacher training. These resources, accessible online, demonstrated the potential of VR in creating immersive learning experiences, particularly in subjects like physics and molecular biology. In 2020, Jose and Zain [35] described an initiative aimed at bridging the gap between academia and industry through XR-based learning. This approach facilitated interactive learning experiences which blurred the boundaries between classroom instruction and real-world applications. Additionally, Johannan [36] and colleagues addressed post-COVID challenges in education through XR technologies. Their work-in-progress paper introduced a platform for hybrid classrooms, enabling real-time analytics to evaluate student engagement. By providing teachers with insights into student participation and attentiveness, this technology aimed to enhance the management of hybrid learning environments. In 2023, Lázaro and Duart [37] argue that, in online education, extended reality makes education "accessible, effective, engaging, collaborative, self-paced, and adapted to diverse academic trajectories". Finally, Stefano, Ana, and Eleni [38, 39] emphasized the need for tools facilitating the creation of XR experiences for education. Their work in the H2020 ARETE project aimed to fill this gap by developing tools to streamline the creation of XR-based educational content, fostering collaboration between researchers and enterprises. In conclusion, the literature review showcases the diverse applications of XR technologies in education. While significant progress has been made, further research is needed to harness the full potential of XR in enhancing teaching and learning outcomes.

3.3 Precise Visualization

The purpose of Yongmin Zhong's 2002 [40] is to address how Virtual Reality (VR) systems can be used for precise 3D interactions and solid modelling without constraints. The paper introduces manipulations that are based on constraints and are automatically recognized and satisfied, allowing for intuitive and precise interactions in VR environments. By incorporating allowable motions in a mathematical matrix and using a procedural approach for 3D constraint solving, a systematic method for deriving allowable motions from constraints is presented. The challenge of imprecise user interaction in virtual environments is addressed by Scott Frees' research [41] since 2005. The study presents PRISM, a new method of interactions that adjusts the 'control/display' ratio dynamically with the user's behaviour. PRISM recognizes whether users have precise or imprecise goals and adjusts hand movements, accordingly, resulting in less sensitivity to hand movements for increased precision. A

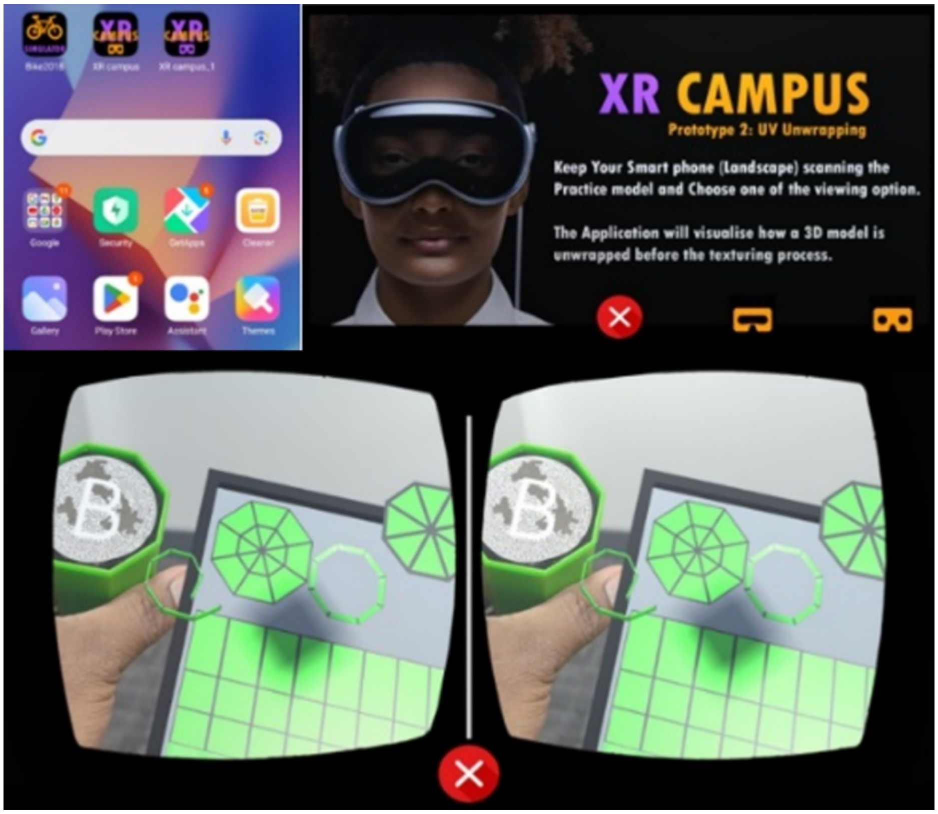

Figure 2: Research XR application

user study presented in the paper showed that PRISM outperforms traditional direct manipulation approaches, providing a solution to enhance precise interaction in immersive virtual environments. Alejandro Martin-Gomez's 2019 study [42] examines how effective augmented, virtual, and mixed reality is for object placement tasks, with particular emphasis on static visualization techniques for exact alignment. The paper provides a comparison of four static visualization methods that are utilized to render virtual objects when precise alignment in 6 degrees of freedom is necessary. During the alignment task, the visual guides cause an amount of occlusion that is considered in the study. It assesses user performance and gives insights into which visualization technique is most suitable for supporting users while accurately aligning objects in virtual environments. Lixiang Zhao's 2024 study [43] presents three innovative spatial data selection strategies for choosing particle data in VR visualization environments. Target and context are taken into consideration when designing these techniques, making them suitable for different data, features and complex scenarios. Based on the evaluation, it has been determined that they are effective in managing diverse scenarios and permitting users to choose data based on their understanding of important features. The literature on precise visualization emphasizes a diverse methodology that incorporates constraints-based manipulations, dynamic adjustment techniques, occlusion level considerations, static visualization techniques, and spatial data selection techniques. The incorporation of Zhong's constraint-based VR environment [40], Martin-Gomez's evaluation of static visualization techniques [42], Frees' PRISM technique [41], and Zhao's spatial data selection [43] ruminatively contributes to advancing the field of precise visualization for various tasks in virtual environments. Figure 2 shows our precise visualization application.

4 PROPOSED DESIGN

In Proposed System Architecture form Figure 3, the system architecture uses a phone camera's vision-based analysis to identify its location as well as to track another object using image recognition technology. Google's AR core does this by being a library to configure the Vision based tracking system. The Architecture also has used IMU (inertial measuring unit) tracking from the phone sensors. Google's Carboard facilitates this feature for mobile phone applications. Hence, the middleware consists of both AR core and Cardboard libraries. The system tracks another object by recognising the patterns in the stickers on it. Hence, the phone's camera must be focusing on the patterns until the image gets recognised. Thus, the system requires a compatible camera with a high refresh rate and a powerful processor to give a better experience in positional tracking. Due to the lack of multiple cameras to track ubiquitously, the phone experience could drop tracking when the single rear camera is away from the object to track. However, the consistency of the IMU tracking is robust and provides 3 degrees of freedom.

Table 1: Knowledge from Literatures

Categories	Knowledge	Categories	Knowledge
Experimentation by User Testing	(Sanders and Cairns, 2010); (Zhang and Fu, 2015); (Slater and Steed, 2000); (Argelaguet, 2016); (Steed et al., 2016); (Witmer and Singer, 1998).	Experiments on factors for immersion	(Lee et al., 2016); (Kim and Daher, 2016); (Bailenson and Yee, 2005); (Costa, Robb, and Nacke, 2015).
VR/AR/MR technologies for user perspective teaching and learning in Education	(Davis et al.'s, 2016); (Ishiyama and Kurabayashi, 2016); (Challenor et al.'s, 2023); (Yau Yuen et al., 2004); (Jose and Zain., 2020); (Stefano, Ana and Eleni., 2020); (Reeve, 2009); (Johannan et al., 2004); (Lázaro and Duart, 2023).	Precise Visualization	(Yongmin Zhong et al.'s, 2002); (S. Frees et al.'s, 2005); (A. Martin-Gomez et al.'s, 2019); (L. Zhao et al.'s, 2019);

The phone must be mounted to a head mounted frame for mobile VR. The frame must not cover the rear camera. In this experiment, Samsung gear-VR frames were used which didn't cover the phones from the backside. However, the experience was tweaked to be used, not the gear-VR system by cutting down the connection to the USB-C. The practice models (4 physical objects - Cube, plate, fidget spinner, tumbler, and teapot) were stuck with the octagonal laser cut marker pieces. The designs on the AR markers are customised to be unique for quick tracking. Regarding the phones, Samsung S9 phones were used for the experiment which had the recommended sensors and processor (Qualcomm Snapdragon 845 SoC) for the mobile XR. The term XR was used to mention the Research application, since the application provides Monoscope Augmented reality and had viewing mode to toggle stereoscope to feature in a wearable VR Head Mount. The research didn't study comparing the viewing modes. However, the viewing modes were provided for the user usability. Therefore, Architecture is comprised of units such as 1. (PU) Practice Units; 2. (TU) Tracking Unit; 3. (HMU) Head Mount Unit; 4. (MU) Middleware Unit; 5. (APDU), Application, Processing and Display Unit in the observation suite. **(PU) Practice Units**: The Practice units consist of a set of 3D physical models with Octagonal-AR markers. The set consists of A. Teapot; B. Tumbler; C. 5-lobed fidget-spinner; E. Basic cube; D. Plate. It also consists of a user perspective tutorial video played on the classroom display on how to use it. **(TU) Tracking Unit**: Tracking Unit is Mobile based and comprised of sensors which are built in the mobile. The unit mainly relies on the phone's rear camera and onboard IMU (Inertial measuring Unit) which configures a magnetometer, accelerometer, and a gyroscope via sensor fusion algorithm [44]. **(HMU) Head Mount Unit**: The HMU is made of a plastic casing to attach to a mobile phone. Samsung's Gear-VR HMU was used in the experiments. Generally, HMU are manufactured for VR ergonomics with cushion around the goggle's socket and get strapped to the head. The HMU comes with a pair of lenses that have had adjustors to move the lens. **(MU) Middleware Unit**: A Middleware Unit is the software which configures the application to use hardware through the operating system. "ARcore" was used to access the phones' cameras for tracking whereas "Cardboard" was used for the Stereo display and head rotation tracking. These two packages are installed in the Unity Game Engine to build the Application for the experimentation which combined Unity's 3D objects, interaction, animation, and UI System for the augmentation in real-time for the APDU. (APDU), Application, Processing and Display Unit: Dragon processor which the state-of-the-art technology dated 2023 and used Android firmware. This executed the research's XR application which is XR Campus. The XR campus application has had the homepage with a picture [50], the instructions and iconography for touch-controlled UI (User Interfaces) with the OLED display. The icons are for Quitting, Monoscope view and Stereoscope view. The stereoscope option splits the screen into two halves for the VR-HMU lenses and permitted the AR application to behave as a Merged reality application by merging VR and AR.

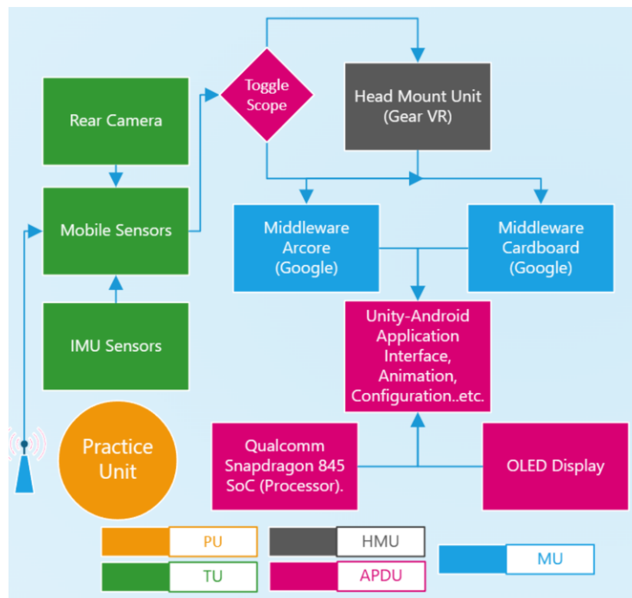

Figure 3: System Architecture and application

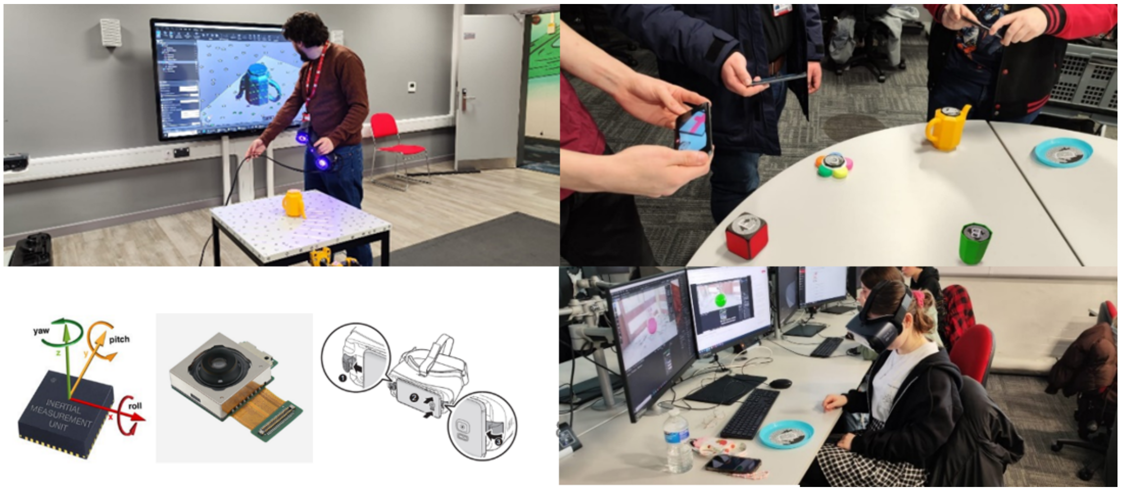

Figure 4: Precise visualization and User-testing

4.1 Precise Visualization developments and Experimentation Arrangements

The visualization was made precisely with the dimension of the practice model as in Figure 4. This was enabled by involving laser scanning to the pipeline. The laser-scanned 3D models are re-topologized and used in the production of the research's XR application. All the mentioned units in the system architecture are transported inside the classroom provided at Staffordshire university during the "Unwrapping" lessons. The teaching workstation has two projectors and screens. The facility was lighted favorably for the best XR camera-based tracking. All the desks are provided with regular workstations with learning materials, practice models with AR markers, Samsung S9 mobile phones with XR Campus application and Samsung Gear VR – Head Mount. The questionnaire is provided to the participants during the experiment as an online survey.

5 MODELS AND FRAMEWORK

The evaluation aims to develop a framework involving the factors which fall under the categories such as Achieved Technology, Usability and User Individual Characteristics. The framework will demonstrate the relationship between the Human and the Immersive System. The arrows give the researcher hypothesis on the factors which could be influenced by the other factors.

5.1 Reflective Models in Teaching Practice

The research investigated reflective practice [45–47] for enhanced teaching and learning experiences via Brookfield lens theory [46]. This involved collecting feedback through the lens of colleagues, learners, authors, and literature. The feedback was collected from the participants as a post experiment survey. Here are the questions below: Do you think this practice with XR during the class would improve Teaching?; How many times, will you be needing Tutor support when learning *with XR assistance*?; How many times, will you be needing Tutor support when learning *without XR assistance*?; How much time taken to understand the concept, when solving *with XR assistance*?; How much time taken to understand the concept, when solving *without XR assistance*?;.

6 EVALUATION EXPERIMENTATION

The aim of this user experience experiment considers three major traits. 1. Evaluating the XR system developed for teaching and learning; 2. Examining the methods of the framework's heuristic; 3. Recording student feedback; The framework was examined from the questionnaires based on the influencing factors thereby attempting to prove the reliability and the effectiveness of the questionnaire data through statistical evaluation. The factors under categories are: **Achieved Technology**: Hardware-development; Software-development; Compatibility between Hardware and Software. **Usability**: Simulation-illness; Engagement of the Application; Perception of Presence. **User Individual Characteristics**: Personality; Interest and Motivation; Abilities and Skill (Flow); other preferences. Evaluation of the research's XR immersion are achieved by an assessment based on the technology overview in a form of quantified-qualitative measure. Participants tried learning using XR mode and filled the immersion survey during the experience by ticking the check boxes. The questionnaires provided a series of questions which are designed using the 7-point Likert scale and can be moderated rigorously during the experiment. Before the simulation experiment, the participants are examined to identify for any sickness and for their immersive tendency. The responses are stored to get their immersive tendency score and to check whether they are in a category to get immersed in the experience. The Standard Simulation illness questionnaire was utilized before and after the simulation. The studies are also made from observations of the practice session apart from the questionnaire. An assessment of the technology achieved in this research was done by playing in two modes. **Mode 1**: Users try to understand when teaching and learning with imageries. **Mode 2**: Users try to understand with imageries and class activities through precise XR visualizations and interactions. The significance of these user-experiences was calculated along with the mean, median and mode via variables from the questionnaires. For this research, the reliability of the user data was also determined by repeating the experiments again to measure the consistency by performing a Cronbach's coefficient alpha.

6.1 Questionnaires

Qualitative measures are taken from the answers provided by the participants. This aims to gain subjective knowledge of the response of the participants. This study carries three sets of questionnaires. 1. Pre-Experiment Immersive Tendency Questionnaire which considers measuring the participants' individual characteristics; 2. VR Experiment Immersion Questionnaire which measures the user experience from improved technology and the presence felt; 3. Pre and Post Experiment standard Simulation Sickness Questionnaire by Kennedy's Questionnaire that measures the sickness from the simulation. [48]. In this procedure, the Kennedy's Questionnaire is given before and after the VR Experiments. Therefore, the difference between the two data determines the Sicknesses due to the simulation.

6.2 Process and Results:

The UML (Unified Modelling Language) in Figure 5 explains the experiment procedures: The illustration culminates the proceeding of the experiment from the consent to the concluding questionnaire survey. The entire assessments are conducted within an hour. The session of 60 minutes was segregated into 4 sub sessions they are: Introduction/Lecture; Coaching; Experiment; Questionnaire-survey. In the first group of the evaluation, an experiment was conducted at the university. The studies compared the learning modes with 7 participants. The participants were studied based on their pre-experiment immersive tendency data and identified as 1. Non-immersed; 2. Partially immersed and 3. Completely immersed;

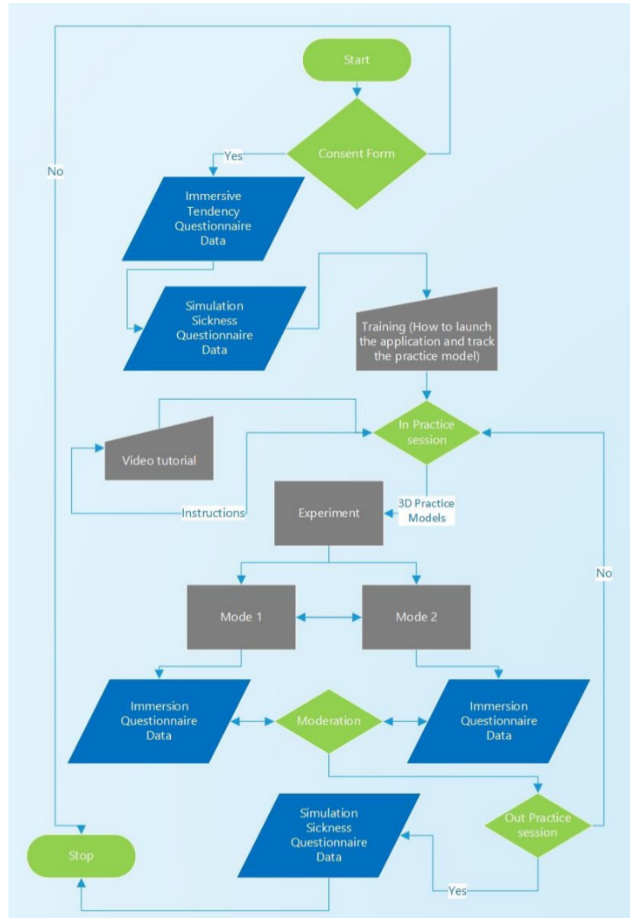

Figure 5: Experiment Procedures

6.3 Quantitative Analysis on Groups: Results from 7, 16, 21 and 27 Participants:

The result based on participants' immersive tendency has shown specific significant between learning modes. This due to the group of partially immersed and completely immersed took less time for learning using XR virtualization. Whereas the non-immersed couldn't be formed into a group due to no participants. Figure 6 shows the Pi-charts for immersive tendency scores.

Hence, none was non immersed due to most of the game's development students are immersed. Also, when considering the overall class efficiency. A significant improvement in practice timing has been observed due to the use of XR practice. Culminating all the groups, the regular practice took an average second of 508s, 456.6s, 360s, 252s in group 1,2, 3 and 4 to learn, while XR assistance took an average second of 425s, 258s, 306.6s, 234.6 in group 1,2, 3 and 4. Therefore, the use of XR assistance leads to a reduction of 83s, 198.6s, 53.4s, 17.4s in all groups in understanding the concept. **Assistance from tutor intervention**: Assistance from the teacher/human is another metric which was observed during the experiment. **In group 1**, the overall tutorial assistance taken by the participants to complete the activity hasn't shown any significance in partially immersed group since the participants have asked help on equal occasions during each mode of activities. However, the participants in the completely immersed group required less human assistance when learning through XR practice during the class activities. Hence, in Immersive tendency and learning studies for the group 1, the completely immersed group needed 0.5 less teacher's assistance while taking XR assistance whereas partially immersed group haven't shown any differences. **In group 2**, the overall tutorial assistance taken by the participants to complete the activity has shown reduction when practicing through XR assistance. The tutoring need has reduced vaguely to 0.36 and 0.4 when taking XR assistance for both categories. Therefore, with respect to Immersive-tendency studies when using XR, the completely immersed group has taken less help from a teacher than the partially immersed participants. **In group 3**, The overall tutorial assistance taken by the participants to complete the activity has shown improvement when practicing through XR assistance. The below bar chart in Figure 7 shows the qualitative measures comparative analysis.

The tutoring needs reduced slightly when taking XR assistance for partially immersed category which is 0.33. Whereas a significant reduction of 1.61 is seen from the completely immersed category. Therefore, with respect to Immersive-tendency studies when using

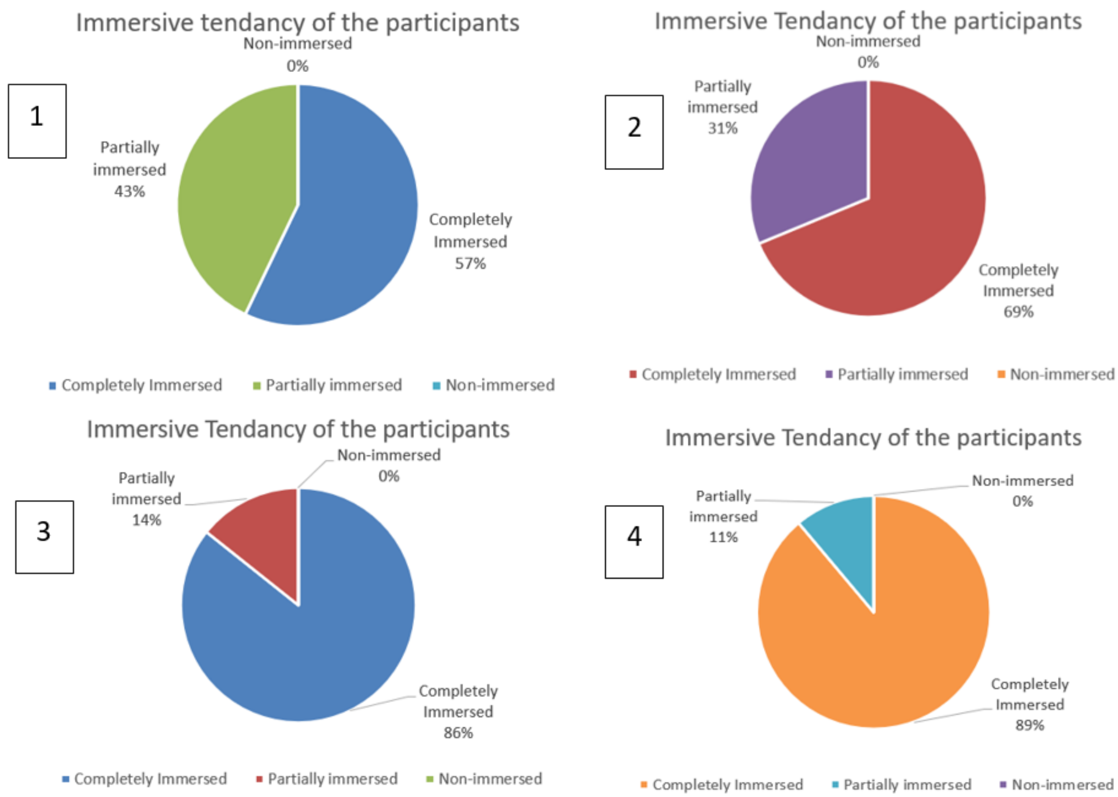

Figure 6: Participants' immersive tendencies

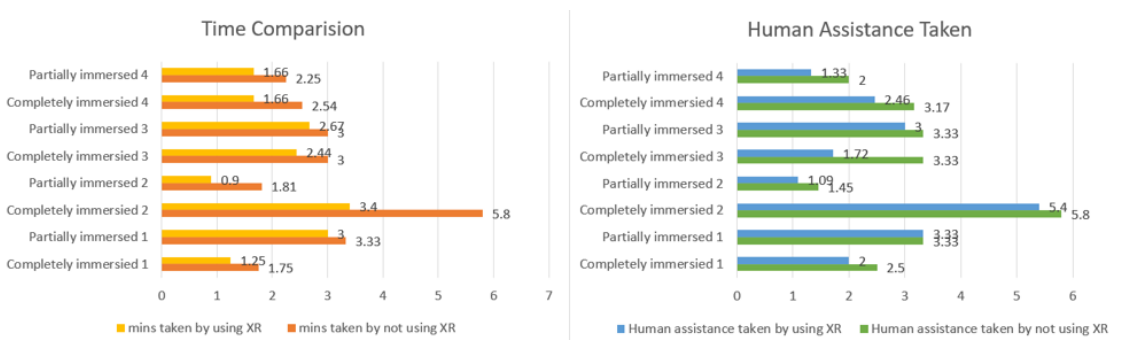

Figure 7: Comparison charts based on Quantitative measures

XR, the completely immersed group has taken less help from a teacher than the partially immersed participants. In group 4, The overall tutorial assistance taken by the participants to complete the activity has shown improvement when practicing through XR assistance. The tutoring reduced significantly when taking XR assistance for partially immersed category which is 0.67 and for completely immersed category which is 0.71. Therefore, with respect to Immersive-tendency studies when using XR, the completely immersed group participants are taken less help from a teacher than the partially immersed group participants.

6.4 Immersion Analysis on Groups:

The main questionnaire data are collected during the experiment after moderation from the participants. This questionnaire is a shortest version of the author's 21 item immersion questionnaire (Jayaraj et al., 2017). The questionnaire is reduced to 5 items to determine flow, presence, usability, engagement, and learnability-preferences.

Group 1: Usability factors are rated highest with the average, median and mode score of 95.94%, 100 and 100. Engagement factors are rated with the average, median and mode score of 79.64%, 71.5 and 71.5. The user sense of presence factors comes next to the average, median and mode score of 67.38%, 57.2 and 42.9. The Flow factors are rated with the average, median and mode score of 67.38%, 57.2 and 57.2. Finally, the Learnability-preference factors are rated lowest with the average, median and mode score of 64.35%, 71.5 and 57.2. Hence, the developed immersive technology lags in establishing the “Learnability-preference” from the user. However, the usability of this technology for XR learning was recommended with the highest rating. The reliability coefficient of the group 1 was determined using Cronbach’s alpha and found 0.85 (Very Reliable). **Group 2:** In this group of participants, the Engagement factors are rated highest with the average, median and mode score of 77.73%, 78.65 and 57.2 along with the user sense of Flow factors is rated with the average, median and mode score of 77.73%, 85.8 and 85.8. Presence factors are rated with the average, median and mode score of 75.06%, 78.65 and 85.8. The Usability comes next to the median and mode score of 74.17%, 71.5 and 57.2. Finally, the User preference factors are rated lowest with the average, median and mode score of 68.81%, 71.5 and 71.5. Hence, there is conclusive evidence from the overall experiments (Group 1 and 2) that there must be improvements needed for elevating the User-preference factors for increasing the immersion. Regarding the reliability alpha of this 2nd group, Cronbach’s alpha was found to be 0.76 (Reliable). Whereas the Cronbach’s alpha of the 1st group was 0.85 (Very Reliable) in terms of distribution of data. **Group 3:** In this group of participants, the Usability factors are rated highest with the average, median and mode score of 81.68%, 85.8 and 100. The user Engagement factors are rated with the average, median and mode score of 78.29%, 71.5 and 71.5. The Flow factors are rated with the average, median and mode score of 69.44%, 71.5 and 71.5. The user sense of Presence comes next to the median and mode score of 68.08%, 71.5 and 57.2. Finally, the User preference factors are rated lowest with the average, median and mode score of 67.4%, 71.5 and 71.5. Hence, there is conclusive evidence from the overall experiments (Group 1, 2 and 3) that there must be improvements needed for elevating the User-preference factors for increasing immersion. Regarding the reliability alpha of this 3rd group, the Cronbach’s alpha was found to be 0.83 (Very Reliable). Whereas the Cronbach’s alpha of the 1st group was 0.85 (Very Reliable) and 2nd was 0.76 (Reliable) in terms of distribution of data. **Group 4:** In this group of participants, the Usability factors are rated highest with the average, median and mode score of 76.78%, 85.8 and 85.8. The Flow factors are rated with the average, median and mode score of 73.61%, 71.5 and 71.5. The User Preference factors are rated with the average, median and mode score of 69.38%, 71.5 and 85.8. The user Engagement comes next to the median and mode score of 68.85%, 71.5 and 71.5. Finally, the User Presence factors are rated lowest with the average, median and mode score of 63.02%, 71.5 and 71.5. Hence, there is conclusive evidence from the overall experiments (Group 1, 2, 3 and 4) that the XR usability with the smartphone implementations are rated high. However, there must be improvements needed for elevating the User-preference factors for increasing immersion. This will be addressed by bringing surplus XR Learning applications in the market for the students’ accessibility. Regarding the reliability alpha of this 4th group, the Cronbach’s alpha was found to be 0.76 (Reliable). Whereas the Cronbach’s alpha of the 1st group was 0.85 (Very Reliable), 2nd was 0.76 (Reliable) and 3rd was 0.83 (Very Reliable) in terms of distribution of data. Group 1 has 7 participants, which is lesser compared to the other groups. However, the research didn’t discluded the group from the study behalf, the results are crucial for an interpertion on how a small group data varies from the larger groups. Also, the researchers chose to reveal data bar charts from 7 individuals who experienced factors that cascade Immersion, as shown in Figure 8 and its prominance in Figure 9.

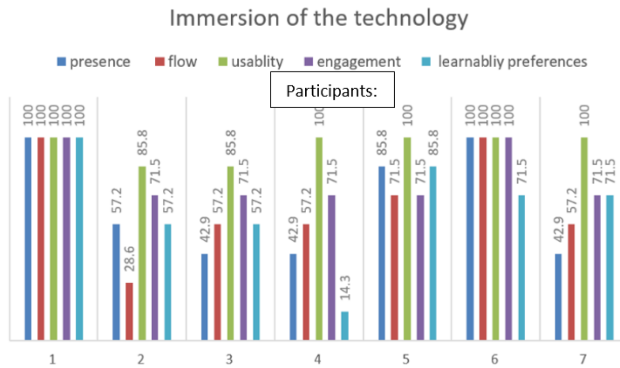

Figure 8: Example chart of immersion analysis for Group 1 participants

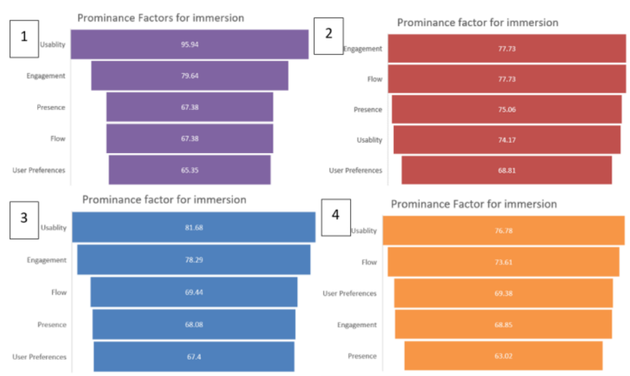

Figure 9: Prominence factors for immersion in all group

6.5 Simulation illness Analysis for all groups:

The questionnaire for pre-experiment and post-experiment simulation illness identified very minor discomfort averages which are less than 0.11% due to the tracking instability. The sickness for categories “Difficulty in Focusing and Difficulty in concentrating” was significantly reduced due to learning in XR with the sickness score of -0.14% and -0.11%. The results are contributing major effects for eyestrain (0.09%), Nausea (0.11%), Dizziness with eyes closed (0.08%), Vertigo (0.09%), and Stomach Awareness (0.08%). The sicknesses data are collected before and after the experiments for all the four groups of participants. Figure 10 are the averages evaluated for each group. When analysing the participants’ illness caused due to the experience, it was found that the participants have had various degrees of immunity for XR sicknesses.

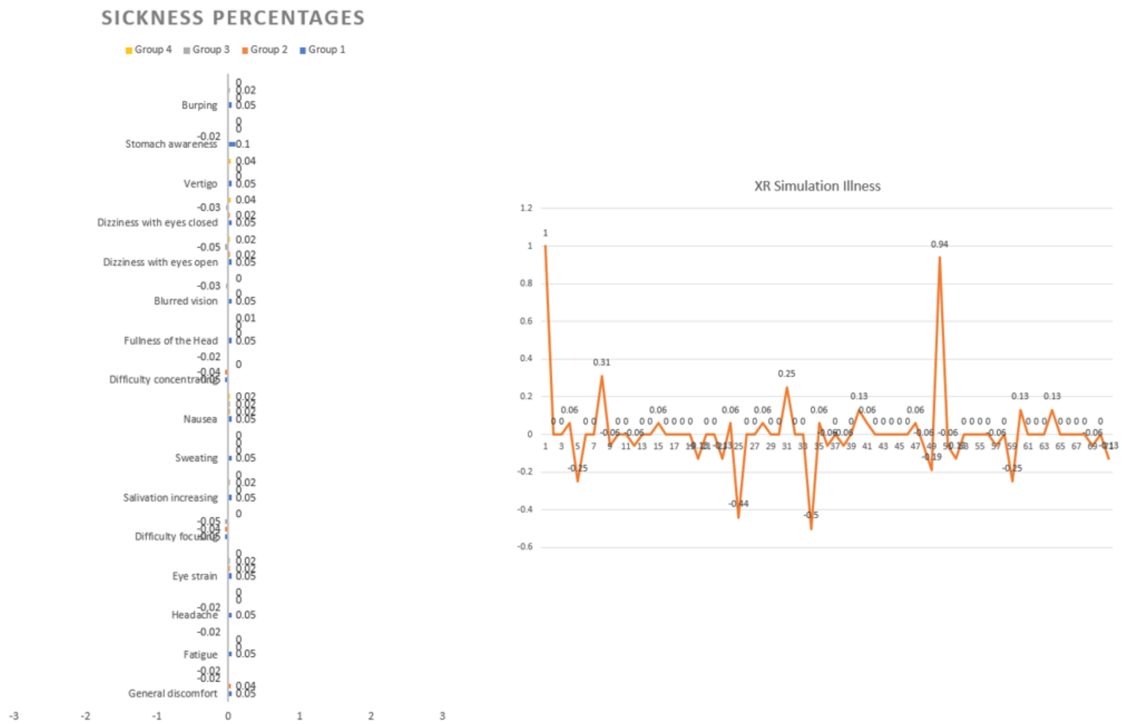

Figure 10: Sickness evaluation and Participants' illness chart

Evaluating the individual's illness levels data, among 71 students it's found that participant number 1 and 51 are vulnerable to XR sickness whereas participant number 26 and 35 are more immune to XR sickness. From the complete data, the research found that most of the university students were immune to simulation sicknesses when using XR.

6.6 Immersion Framework and Teaching Model Analysis:

The Immersion studies identified data for the top 3 reliable group data via Cronbach's alpha. Literature says that immersion is directly related to the flow, presence, usability, engagement, and user preference factors. However, the hypothesis would like to investigate whether these factors would influence each other using exploratory data analysis as shown in Figure 11. **Presence influences:** The result shows that the Presence increment and decrement or get influenced by the Flow and Preference of the user. However, the results from Usability and engagement factors are not influencing the presence. **Flow influences:** The result shows that the Flow hasn't influenced the Usability results and Engagement in inclinations and declinations. However, the Flow has a certain influence over the presence as the data were proportional. Hence Flow can relate to Presence factors if proven in other research assessments. Similarly, the Flow influences or gets influenced by the Preferences of the users according to this research findings. **Usability influences:** The research application's Usability, influences or get influenced due to the Engagement of the users. However, the evaluation shows that the Usability results were not proportional to any other factors. **Engagement influences:** Similarly, Engagement factors results are proportional to Usability factor results but not with other factors. Hence, Usability and Engagement must be independent from the Presence, Flow and User-Preference factors. **Preferences of the user influences:** The result shows the User preference factors are in line with the User sense of Presence and Flow factors since the results were proportional. However, Engagement and Usability results from this research findings were not influenced by the Preference factors. Hence, a new framework was developed based on this research findings. The framework identifies 2 independent sets of factors contributing to the System's Immersion.

The author's class sessions were evaluated and validated in this study based on peer and student feedback. To determine whether the feedback has reflected and improved teaching, the classes are reviewed again over time. After the peer feedback and reflection, the 4 sessions of experimentation classes were taught over an interval of 3 months for 71 Games art students. The groups are of various sizes and demographics. The first group had 7 students, the second group had 16 students, the third and fourth group had 21 and 27 students respectively. The teaching materials and exercise are based on the Intro to 3D modelling - workshop for practicing unwrapping the basic 3D primitive shapes using 3DS Max. The objectives also investigated optimizations in Game development and how effective the unwrapping procedure can be managed to maximize the resources. Student followed the Lecture and PowerPoint slides which had theories and Illustrational animations explaining the process. For Practice, Students are provided with Android phones

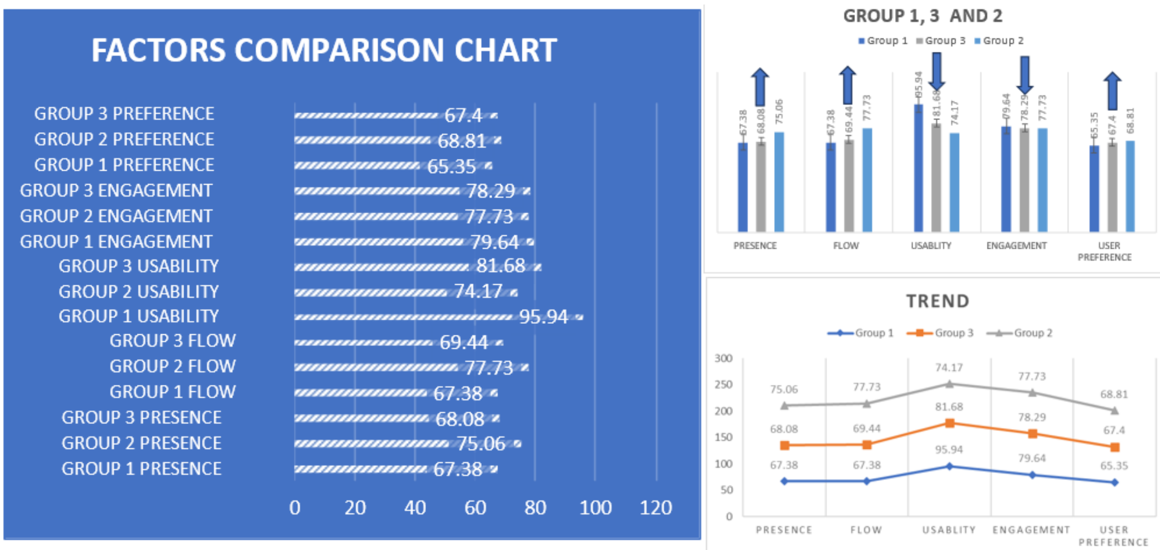

Figure 11: Exploratory Data Analysis

with the XR applications installed. Gear VR phone mounts were also provided to students who wished to mount it on their head. For research, a QR code was displayed in a slide for those who are willing to participate and give their data. The QR code led the students in the consent form followed by the research questionnaire. A few teaching slides used for the research are in Figure 12. After the user-experience questionnaire, the students' feedback about the teaching are collected in a form of survey, which is the final section in the research questionnaire **Theoretical Literature**: The reflection models' theories are discussed under literature review. **Author's Eye**: The Author felt that the engagement level in the classroom can be enhanced by the implementing novel in-class activities. However, concerned about the duration of activities. This is based on the colleagues' review, and suggestions to implement a model to manage timing for a novel and challenging class activity. Hence, the XR was implemented, and time/seconds are used as a metric in the analysis. After the evaluation, it identified that XR implementation has saved 3 min 15 seconds in the delivery of the class activity despite students required training for using XR. **Colleague's Eye**: (Over all Summary) "*Overall, the session was managed well throughout the PowerPoint delivery. The students were actively engaged throughout and sharing their own thoughts and experiences on the topics being covered. There was a lot covered and due to the enthusiasm of students wanting to share their knowledge and experiences and ask questions, this did cause the session to overrun in parts. Management of this will come with experience. I enjoyed the session, and it was clear the students did too.*" Learners Eye: Query: Do you think the researcher practice with XR during the class would improve his Teaching? The data are collected in the survey and the following Pi chart is plotted based on the survey. 86% of the students liked this approach as in Figure 13.

7 IMMERSION QUESTIONNAIRE

1. Please rate how well the movement of the XR instruction match your own movements i.e., your sense of being with the Augmented instructions:

2. Please rate your level of satisfaction with the accuracy of interactions while solving the model i.e., being comfortable with interactions:

3. Please rate the portability of the hardware used for XR i.e., usability ease

4. Please rate the engagement level with the hardware and applications:

5. Please rate your learning preference of using the system:

Use the phrase below to plot your answers:
Much harder/ Strongly disagree/ Extremely negative.
Harder/ Disagree/ Negative
Mildly harder/ Slightly disagree/ Partially Negative
Between hard and easy/ No idea/ Neutral
Mildly easier/ Slightly agree/ Partially positive.
Easy/ Agree/ Positive
Much easier/ Strongly agree/ Extremely positive.

8 CONCLUSIONS

The overall research aimed to develop the XR user perspective learning experience and applied the literature for designing a framework model to measure immersion. The hypothesis of the study is to measure the user-experienced factors which improve the technology's immersion in teaching and learning. Presently, the evaluation with 71 student data marginally analyzed the relation between the influencing factors for immersion, since a detailed would require a substantial amount of data set and more experimentation. However, this research paper evaluated a limited number of test-users and identified that XR improves the user perspective learning among the University students which is reinforced by evidence from the evaluations. The experiment will be continued in future for further

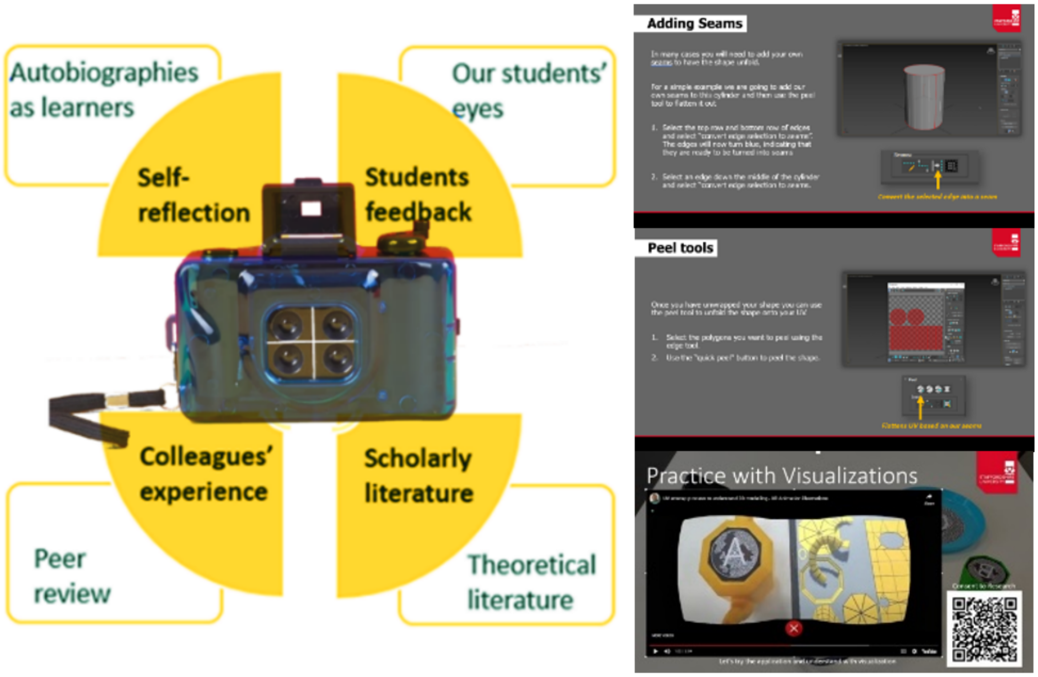

Figure 12: Brookfield's four Lenses and Teaching Slides

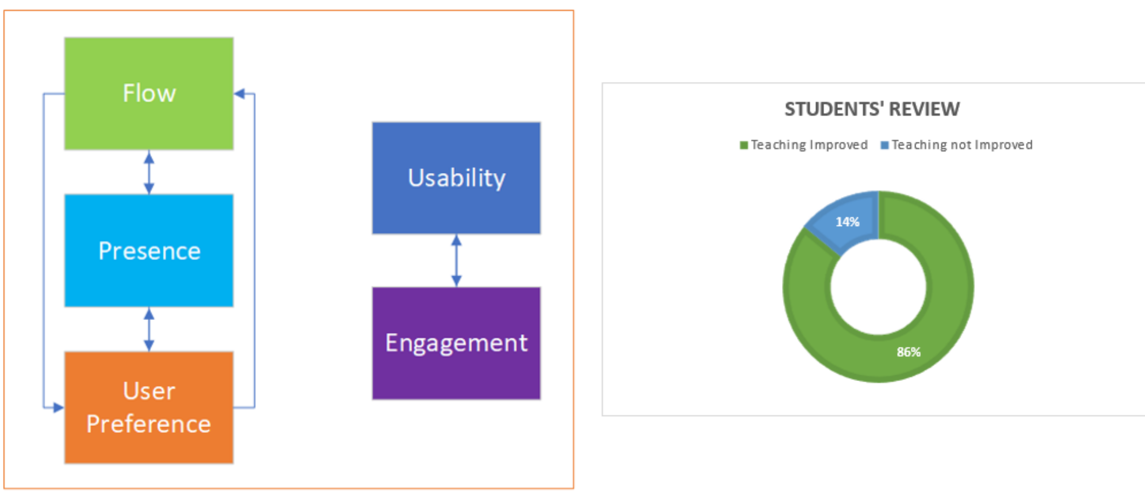

Figure 13: This research's immersion Framework and students' review

interpretation. Rather tweaking XR to be used in mobile VR, the future works of this research will consider applying this methodology for standalone devices i.e., the new Oculus Quest 3 and Apple Vision Pro to measure the degrees of immersion for teaching and learning applications.

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