TARGETED TEACHING DECISION SUPPORT THROUGH ASYMMETRIC MR COLLABORATIVE LEARNING

A SEMINAR REPORT

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CERTIFICATE

This is to certify that the report entitled " **TARGETED TEACHING DECISION SUPPORT THROUGH ASYMMETRIC MIXED REALITY COLLABORATIVE LEARNING** " Submitted by **"Ms.HANA FATHIMA V"** to the APJ Abdul Kalam Technological University in partial fulfilment of the requirements for the award of the Degree of Bachelor of Technology in Department of Computer Science and EngineerinLook Based Media Player with Hand Gesture Recognitiong is a bonafide record of the Seminar carried out by him under our guidance and supervision .This report in any form has not been submitted to any other University or Institute for any purpose.

Ms.VINITHA V	Ms.SWATHI CHANDRA	Ms.NITHYA V P
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ABSTRACT

The Collaborative Virtual Environments (CVEs) created by Mixed Reality (MR) technologies have been classified as symmetric and asymmetric CVEs. The latter aim to provide different authorities for different collaborator roles utilizing heterogeneous techniques that cover the entire gamut of Milgram's Mixed Reality continuum. As a new type of MR display that generates an auto-stereoscopic viewing experience without head-mounted devices, the Light Field Display (LFD) has been incorporated with Augmented Reality (AR) and Virtual Reality (VR) headsets to create remote and co-located asymmetric collaborative environments. In previous asymmetric CVE research, LFDs were adapted to simultaneously render multi-contents for multiple students to lower average device costs for the MR vet training. However, multiple students sharing one LFD to interact with the teacher may weaken the teacher's understanding of individual students' current learning progress, making teaching decisions even harder. Therefore, paper presents an enhanced solution that supports teaching decisions targeted at each student without increasing the device costs. The context-aware LFD student clients, which render a dynamic viewing zone for each student by face encoding tracking, are implemented and applied for anti-cheat quiz support. By synchronizing each student's tracking data with a Local Area Network (LAN) middleware, the AR teacher client can distinguish different students to in-situ superimpose the quiz progress and targeted-explainable teaching decision support over each corresponding student's head.

ABBREVIATIONS

MR	Mixed Reality
AR	Augmented Reality
VR	Virtual Reality
AV	Augmented Virtuality
LFD	Light Field Display
HLL	Hololens Live
HLR	Hololens Recorded
AI	Arificial Intelligence
LSS	Live Solar System

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Chapter 1

INTRODUCTION

Mixed Reality technology may provide many advantages over traditional teaching methods. Despite its potential, the technology has yet to be used for the formal assessment of clinical competency. This study sought to collect validity evidence and assess the feasibility of using the HoloLens 2 mixed reality headset for the conduct and augmentation of Objective Structured Clinical Examinations (OSCEs).A prospective cohort study was conducted to compare the assessment of undergraduate medical students undertaking OSCEs via HoloLens 2 live (HLL) and recorded (HLR), and gold-standard in-person (IP) methods. An augmented mixed reality scenario was also assessed. Thirteen undergraduate participants completed a total of 65 OSCE stations. Overall inter-modality correla- tion was 0.81 ($p = 0.01$), 0.98 ($p = 0.01$) and 0.82 ($p = 0.01$) for IP vs. HLL, HLL vs. HLR and IP vs. HLR respectively. Skill based correlations for IP vs. HLR were assessed for history taking (0.82, $p = 0.01$), clinical examination (0.81, $p = 0.01$), procedural (0.88, $p = 0.01$) and clinical skills (0.92, $p = 0.01$), and assessment of a virtual mixed reality patient (0.74, $p = 0.01$). The HoloLens device was deemed to be usable and practical (Standard Usability Scale (SUS) , and the technology was thought to deliver greater flexibility and convenience, and have the potential to expand and enhance assessment opportunities.

Chapter 2

LITERATURE SURVEY

2.1 Current Challenges and Future Research Directions in Augmented Reality for Education

The progression and adoption of innovative learning methodologies signify that a respective part of society is open to new technologies and ideas and thus is advancing. The latest innovation in teaching is the use of Augmented Reality (AR). Applications using this technology have been deployed successfully in STEM (Science, Technology, Engineering, and Mathematics) education for delivering the practical and creative parts of teaching. Since AR technology already has a large volume of published studies about education that reports advantages, limitations, effectiveness, and challenges, classifying these projects will allow for a review of the success in the different educational settings and discover current challenges and future research areas. Due to COVID-19, the landscape of technology- enhanced learning has shifted more toward blended learning, personalized learning spaces and user-centered approach with safety measures. The main findings of this paper include a review of the current literature, investigating the challenges, identifying future research areas, and finally, reporting on the development of two case studies that can highlight the first steps needed to address these research areas. The result of this research ultimately details the research gap required to facilitate real-time touchless hand interaction, kinesthetic learning, and machine learning agents with a remote learning pedagogy.

2.1.1 Types of AR learning

AR Learning in Formal Classrooms In the classroom setting, AR allows students to learn through the combination of both real and computer-generated images. It helps to understand the different topics with different scenarios. AR Learning in Special Education AR has the capability to create a learning opportunity for special children by overcoming the physical barriers; it can bring a high-quality educational experience to students with learning and physical disabilities as well as the special education classroom. AR Learning Outside the Classroom Using AR smartphone application, the AR learning experience can be extended outside the formal classroom.AR for Collaborative Learning If an educator is looking to model scientific practice, AR provides the opportunity to support the multifaceted world of scientific exploration.

current research studies are presented in different subsections according to domains and then educational level, which resulted from surveying and documenting projects in this field discovered through an exhaustive search. These research projects will be further examined in a table listing research objectives, educational levels, subjects they trialed the study with, how they have created their AR applications, and what devices and tracking technologies they used. This review gives a high-level overview of the different user interface complexity with the corresponding level of possible collaboration with either a human or some form of Artificial Intelligence (AI) construct. This construct can take the form of a simple script, an agent-based system, or a machine learning algorithm.This section will identify future research areas. where the exploration of these research gaps is presented with the implementation of two case studies, which can better illustrate the proposed research directions and highlight the current state of the art in AR.

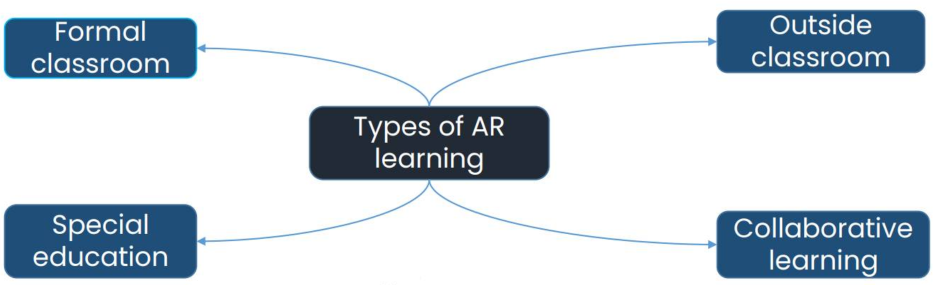

Figure 2.1: Personalization Model

2.1.2 Science Technology Engineering & Mathematics

One of the first use cases of AR learning in secondary education is for STEM subjects. AR allows teachers to incorporate new technology and techniques in the classroom, which is one of the primary scenarios outlined in Section . STEM is taught in secondary and tertiary level education, which will be discussed in the overview of Education Level given in Section . Given the link between the technologies that enable AR and STEM, it naturally has become one of the primary domains where AR learning is present, as discussed in Section . Some of the best examples of AR learning come from looking into the possible use cases in Chemistry. Chen et al. investigated how students interact with AR models as compared to physical models to learn amino acids structure in the 3D environment. Learning chemistry with ARChemist and through gestures tested in CHEMOTION provide a virtual interaction with chemicals using hand-tracking technology. Similarly to Chemistry, one of the first topics to be covered using AR learning is Astronomy. The use of the AR to learn the Earth–Sun relationship , Earth–Moon System and Live Solar System (LSS) helped to enhance meaningful engagement in learning astronomy concepts and conceptual thinking. AR can assist in learning gravity and planetary motion with an interactive simulation, which increased the learning gain significantly and increased the positive attitudes of the students . Visualization techniques of biology processes within AR allow students to understand better processes that are impossible in real time. Nickels et al. developed an AR framework ProteinScanAR as an assistive tool for engaging lessons on molecular biology topics using AR. Science Center To Go (SCeTGo) investigated the role of teachers' and students' acceptance and found AR pedagogical efficiency very constructive. Likewise, at the high school level, there are many AR studies at university level for learning anatomy. For example, refs. developed AR anatomy learning systems to learn the exterior to interior of the body by introducing an innovative, hands-on study of the human musculoskeletal system. In addition, the use of leapmotion for 3D body anatomy learning was tested to use hand tracking for interacting with 3D models . The teaching of engineering subjects is a cornerstone of STEM, and as such, there are multiple examples of AR learning in this area. One summary to view these innovations used 3D web tools in technical and engineering education to help the multidimensional augmentation of teaching materials used in technology and design engineering. Learning Physics through Play Project (LPP) helps to learn concepts of physics about force and motion and LightUp is used for learning concepts of electronics such as circuit boards, magnets, and plastic sheets. By combining modern mobile AR technology and pedagogical inquiry activities, Chang et al. used AR for teaching Nuclear Power Plant activities with more productive digital visualization. Adding more to learning electronics concepts, ElectARmanual and an AR-based flipped learning system helped to achieve better learning outcomes by using the AR guiding mechanism. Collaboration within an AR environment is an important AR learning scenario as outlined In keeping with the Chemistry theme, one example of a tangible interaction study that focused on chemistry was conducted using a Tangible User Interface (TUI) called The tangible user interface could be one area that helps collaborative learning, but the nature of tangible interaction can require additional resources, and in the current COVID crises, alternative touchless interaction approaches could be a better solution to this, which will be discussed in and further in Section with a Chemistry related case study. Other prominent examples of collaboration using Situated Multimedia Arts Learning Lab (SMALLab) found extensive evidence as a powerful approach to learn in a design experiment with secondary earth science students . There is also the collaboration ability of AR and Internet of Things (IoTs) to create productivity in Engineering education with different scenarios . Finally, AR as a learning tool in the mathematics tested with Construct 3D and GeoAR to support learning the geometry showed a highly positive impact concerning its educational potential. Field trips are one example of STEM scenarios that require leaving the formal learning environment to suit the outdoor AR use case mentioned in Embodied experiences at the field trips for the science classrooms with situated simulations obtained valuable and effective results about student engagement and their connection with the experiential learning from the curriculum . This potential for kinesthetic learning or hands-on learning by performing tasks has been adopted for AR technical training for people to learn new maintenance and assembly skills for various industries . For a trainee, interaction with real-world objects and machinery parts while obtaining the virtual information for learning is the actual advantage of using AR for training.

2.1.3 Language and Vocabulary Learning

The use of AR for learning languages is concerned with the formal classroom learning in which has been tested successfully in different studies. To test the ubiquitous games in the learning approach for language learning, HELLO (Handheld English Language Learning Organization) and another handheld language learning approach showed improved retention of words, which increased student satisfaction and attention . Similarly, Teacher using kinect is used for teaching basic English words (colors, shapes, and prepositions) and game-based foreign language learning . The use of Microsoft Hololens for vocabulary learning, as compared with traditional flashcard-based learning, produced higher productivity and effectiveness in learning outcomes . For language learning at higher classes, a mobile learning tool Explorez used interacting with objects to improve their French language skills which received acceptance as “useful” and “motivating for students”.

2.1.4 Collaborative Learning

The collaborative learning approach,provides an opportunity of collaboration: either teacher-to-student or student-to-student. AR as collaborative learning with SMALLab, which is a Student-Centered Learning Environment (SCLE) that uses interactive digital media in a multi modal sensing framework, reported promising results in social and collaboration aspects. Furthermore, in the collaborative learning approach, used AR ClassNote, which is an AR application that allows users to save and share handwritten notes over optical see-through HMDs. It makes it easier to communicate between instructors and students by sharing written class materials. An AR game concept, “Locatory”, was introduced by combining a game logic with collaborative gameplay and personalized mobile AR visualization, which provides different perspectives of the interactive 3D visualization to learn the content with AR and identify positive experiences . LookingGlass and Hololens between students and teachers to collaborate is adopted in METAL where users can share 3D content between devices.

2.1.5 Main Insights and Future Research Agenda

Examining current and past projects based on educational level, domain, tracking, collaboration capacity, agents, and interaction level leads naturally to identifying specific future research areas. The AR application design requirements suggested in include being flexible of the content that the teacher can adapt according to the children’s needs, guiding in the exploration to maximize the learning opportunities, in a limited time, and attention to curriculum needs. This analysis involves 25 studies from primary and elementary levels, 26 from secondary school levels, and 27 from university levels. In devices-based analysis, a desktop is used in 498 percentage.

2.1.6 Education level

The analysis shows that AR has been tested and proved equally effective at three educational levels: early (Primary and Elementary School), secondary (High School) and tertiary education (University) presented. Furthermore, there is a trend toward AR use in medical education ; however, there is a lack of focus on technical or vocational evaluation of its use in teaching. Figure explains distribution based on educational level.

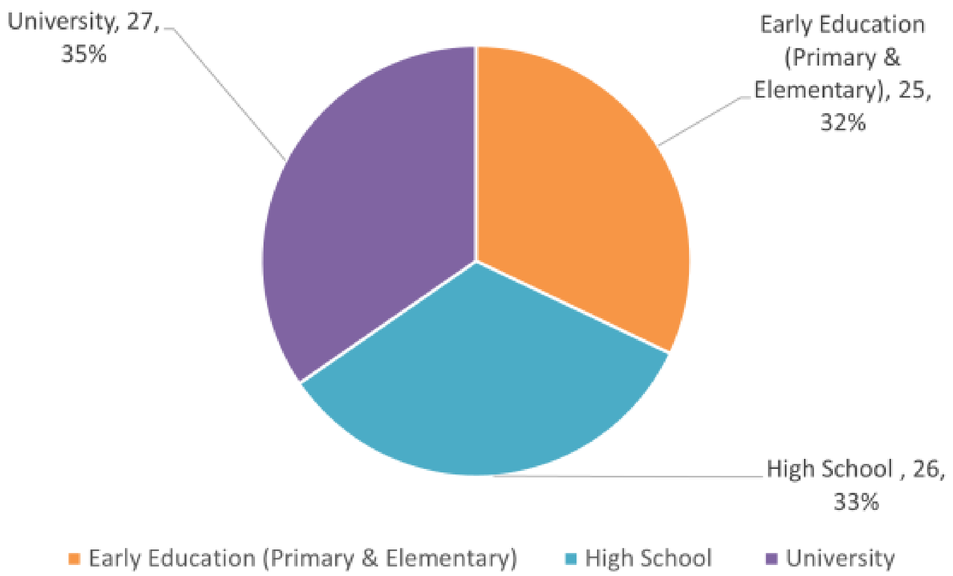

Figure 2.2: AR studies distribution according to educational level

2.1.7 Domain

At early level education (Primary and Elementary schools), most of the studies are using AR for alphabet learning such as , vocabulary learning, or early level science topics as . At the secondary level (High School) and tertiary level (University), it has been used as a learning enhancement source for STEM subjects, as discussed in Section STEM has emerging future opportunities in the immersive learning technology. To teach those topics or skill training where actual material is not affordable or not possible in the class setting, the use of AR technology can be an effective resource for students.

2.1.8 Second Case Study—Learning Chemical Reactions

Moving away from the desktop environment and HMDs with hand tracking in smartphones is a long-awaited technology that is now possible with Google Mediapipe and Manomotion using the neural network and machine learning algorithms. This concept from the virtual chemistry lab is influenced by the second case study, which is influenced by and the STEM-related case studies presented in Section Moving the display device from a desktop to a smartphone, this case study was implemented using the latest interventions in the vision-based SDK Manomotion with ARFoundation and ARCore XR Plugin. Manomotion provides real-time 2D and 3D hand tracking without using any external hardware with the smartphone with minimal computing power. The architecture diagram and process of learning flow have been explained Figure shows the hand tracking in smartphones and touchless hand interaction, which allows the user to create chemical reactions by interacting with cubic elements. Using the depth camera, custom-made hand, and collaborating with defined gestures of Manomation, it allows the implementation real-time hand interaction with the virtual objects (chemicals/elements). Real-time hand interaction is natural and is a great solution for a health-centric digital interaction. In this case study, machine learning agents are used to implement the user trainer and self-assessment learning scenarios.

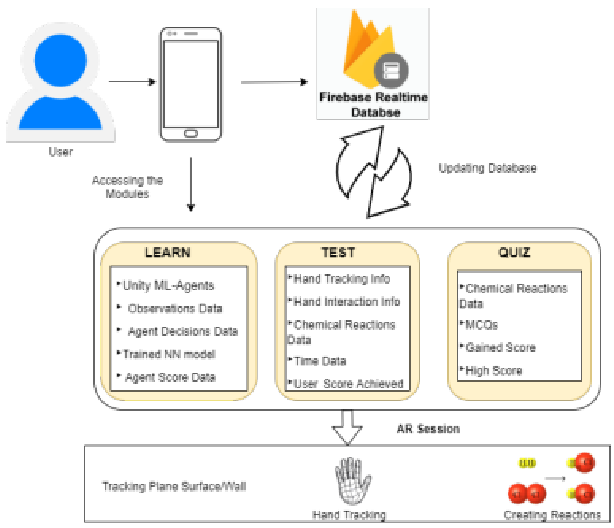

Figure 2.3: Architecture diagram and working flow of recommended approach in second case study

2.1.9 Advantages

- Multi-agent system
- Authoring Tools

2.1.10 Disadvantages

- It is not following a systematic review approach because intelligent agents and kinesthetic learning using hand tracking technology is not widely adopted yet.
- Lack of intelligent agent
- Limitations in hand tracking
- limitation in real-time hand interaction

2.2 Exploring Augmented reality in Collaborative Learning

A fascinating, intense, and critical challenge is the new technological revolution, the so-called Fourth Industrial Revolution or Industry 4.0. This digital revolution represents new ways technology is integrated into societies and even the human body. Its arrival is undeniable, affecting all social and economic sectors, which must begin digital transformations regardless of their nature. Education has embraced this transformation early, but there is still a long way to go. Among the most significant trends in digital education, augmented reality (AR) probably occupies the most prominent position due to the tremendous didactic advantages provided by this immersive tool. Augmented reality offers powerful visualization to support learning scientific concepts. Currently, collaborative group work is essential in all learning activities. However, creating teams and performance expectations is one of the most complex tasks faced in the classroom and work–life. So in this work, they applied augmented reality to strengthen students' disciplinary and transversal competencies in an initiative to transform work groups into collaborative teams and achieve meaningful learning. Educational resources with augmented reality technology were designed with the blender tool and made compatible with mobile devices. They observed students' performance in the work team. We assessed qualitative aspects such as acceptance, interest, and mastery of the didactic tools and conducted quantitative and comparative analyses of their grades.

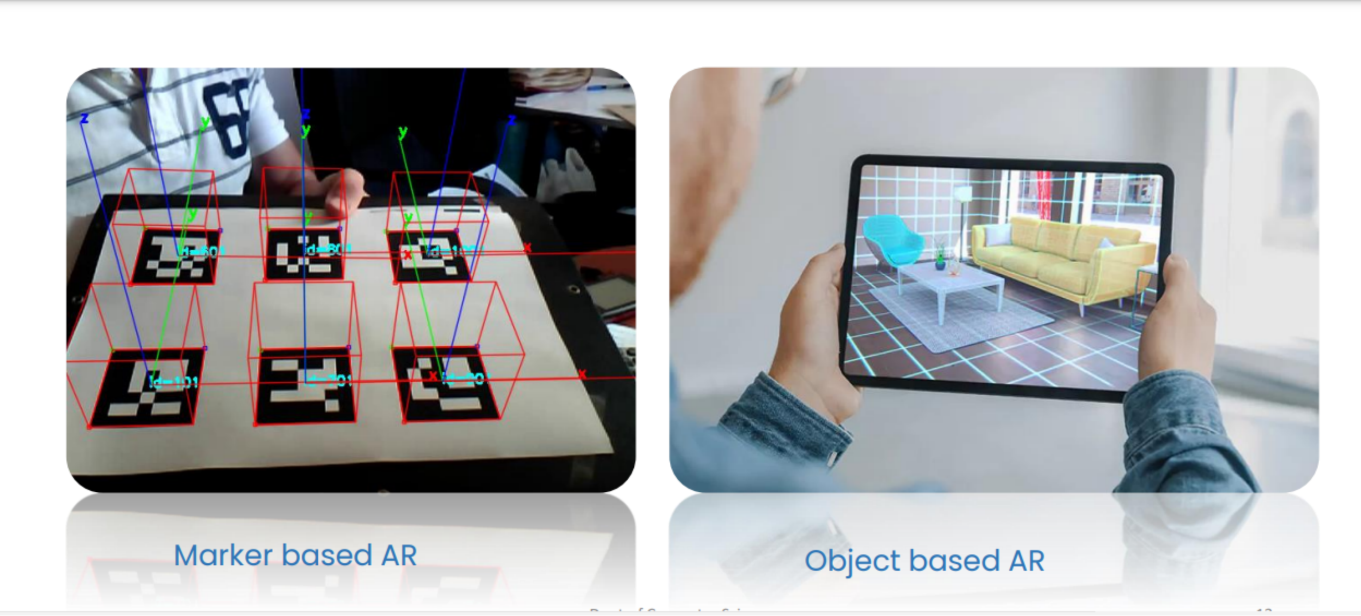

Figure 2.4: Types of AR

2.2.1 Marker Based AR

Maker-based AR works by scanning a marker which triggers an augmented experience (whether an object, text, video or animation) to appear on the device. It usually requires software in the form of an app, which enables users to scan markers from their device using its camera feed.

2.2.2 Object Based AR

Augmented Reality (AR) object recognition attaches a digital 3D model to a real-world object. By attaching a 3D model to a real-world object, learners can pick up the object or manipulate it by taking it apart, exploring its parts, and reassembling it.

2.2.3 Visual Learning Style

Visual learners, or those who utilizes a visual learning style most effectively learn when presented with visual stimuli such as concepts, data and information are associated with visual imagery (i.e. graphs, concept maps, idea maps, illustrations such as Venn diagrams and infographic). The visual learning style encompasses everything that learners can see; if the information is presented visually, then visual learners are able to conceptualize information much more effectively than if the information was presented in another form.

2.2.4 Auditory Learning Style

Auditory learning simply refers to the act of learning through listening (to auditory stimuli). Although individuals who prefer auditory learning may learn through text-based or visual stimuli, learning is more effective for these individuals when they can hear information, be it a lecture or examples of a target language. In that sense, auditory learners may benefit from speech recognition tools found on most operating systems. It is interesting to note that auditory learners can often ascertain information through particular cues, such as changes in tone. When attempting to retain information, an auditory learner would repeat the information out aloud first, relying on the recollection of audio in order to remember the information. Auditory learners excel at recollecting lectures and other information presented to them through audio, and tend to perform very well in oral-based examination. However, it is believed that audio learners find difficulty in comprehending information without some form of audio or sound, even in the background of their learning environment. As such, auditory stimuli such as background music aids audio learners processing and understanding information. Auditory learners can be defined by their preference to learn via speaking and listening.

2.2.5 Kinesthetic Learning Style

Unlike both visual and auditory learners, kinesthetic or tactile learners learn through physical activity and action, rather than through instruction or lecturer commands. Kinesthetic learners primarily rely on their skill of recall, realizing through the act of doing instead of inputting thought. Learning is associated with emotion and takes place through interactions such as debates, drama and role play. This learning style links to cognitive retention within the earlier, due to its association with emotion, such as excitement, success and curiosity. Kinesthetic learners excel in fields such as sport, chemistry and acting. It is also common for kinesthetic learners to focus on two or more activities or functions simultaneously. It is important to distinguish between augmented and virtual reality, with the former concerned with the creation of a totally computer generated environment into which the user is immersed and interacts with the virtual world. Augmented Reality (AR) on the other hand involves the virtual and real functioning in concert, with computer generated imagery interlaced with the real world to form a composite reality that blurs the lines between the two realms. The main difference between augmented and virtual realities concerns the user's connection to the real world. With augmented reality, the user is still very much anchored to the real world, unlike the virtual world where the user is purposely isolated from reality. This creates challenge for virtual world designers, as a convincing virtual world requires a painstaking detail to attention it if is to feel 'real' to the user. Another major challenge in AR lies in ensuring that computer generated imagery are seamlessly integrated with its real surroundings. This is the issue of accuracy, whereby images must appear in real time so as not to negatively affect the user's experience.

In general, three major concerns in developing AR applications include supporting a seamless interaction between real and virtual environments, using tangible interface metaphors for object manipulation as well as smooth transitional interfaces between reality and virtually. Nonetheless, research in AR has reached a level of maturity which allows for its application in a wide variety of arenas and domains. There are obvious application areas such as education and training, given the seamlessness with which the virtual and the real can be amalgamated and objects in both domains. Some domains highlighted in this paper include medical, entertainment, military, engineering, robotics, and manufacturing,to classify edge and non-edge pixels.

2.2.6 Advantages

- This paper proposed an Augmented Reality (AR) system called the ArduTech that integrates AR in a collaborative learning setting at higher education level.

- single marker detection for all the objects by utilizing object-based AR rather than marker-based.
- It also promotes the use of marker-free AR which means there is no specific marker for system, hence users can use any marker as they wish but the system is still able to detect and define any marker accordingly.

2.2.7 Disadvantages

- Lack of Content in the Software
- The system only supports Object based AR and doesn.t support Marker based AR.

2.3 The use of mixed reality technology for the objective assessment of clinical skills: a validation study

Innovative mixed reality (MR) technologies have the potential to transform the delivery of medical education, and may confer some advantages over traditional teaching methods by merging real and virtual worlds. The technology has the potential to help tackle many of the challenges currently faced in the delivery of high-quality medical education globally including quality, consistency, accessibility and cost . The HoloLens 2 (HL2) is a commercially available MR headset produced by Microsoft (Microsoft Corporation, Redmond, WA, USA) that allows for remote first-person visualisation, multi-directional audio and visual com- munication, and the integration and manipulation of interactive 3-dimensional (3D) holographic content into real-world scenarios . The device has been deployed into a range of clinical settings including ward-based care, pre-operative planning, and intra-operative visu- alisation . The technology has also been successfully integrated into medical schools' curricula, principally to support the delivery of anatomy teaching through a range of commercial and bespoke applications . More recent developments have allowed the development of integrated clinical skills teaching sessions in which immersive multi-sensory (audio, visual, tactile) content can be created to imitate real-world scenarios. Despite rapid progress in the creation educational content, there is only limited experience in its use for objective assessment or examination.

The HL2 device may facilitate remote assessment both in real-time and via recorded content. This approach may not only reduce cost and improve access to quali- fied assessors, but may also facilitate assessments to be taken out of the abstract structured environment of formal examinations and into real-life opportunistic clinical interactions. In addition, the use of interactive MR con- tent provides opportunities to augment the assessment process through the use of holographic assets, or the use of interactive instructional material and clinical information . Despite the clear potential to augment and enhance approaches to assessment, no institution has yet evidenced use of the technology in formal examinations, nor has it been validated as an effective and robust assessment tool.

2.3.1 Methods

The study sought to examine the feasibility and validity of using the HL2 MR headset for objective assessment and augmentation of Objective Structured Clinical Examina- tions (OSCEs) across a range of core undergraduate clini- cal competencies.

Participants

Thirteen undergraduate medical student participants were recruited. All were at, or above the level of pro- ficiency required to complete the study, and none had prior experience of using a HL2 device. The study received institutional educational ethical approval (EERP2021-055) and written informed consent was obtained from all participants.

Study design

This prospective cohort study was conducted to collect validity evidence for the use of MR technology as a tool for the objective assessment of undergraduate clinical competencies by comparing it to the current gold-stand- ard in-person method of examination. Study accrual was based on convenience sampling comparable to similar studies as no power calculation was practicable due to the novel data being assessed. Participants undertook an OSCE examination consisting of five stations representa- tive of their assessed curriculum. Each station examined a different domain of mandatory core clinical competen- cies encompassing clinical examination, history, and pro- cedural and skills-based assessment, and utilised actors and synthetic benchtop models. A final station intro- duced a virtual simulated COVID-19 patient provided publicly for free by GigXR (GigXR Inc, Venice, CA, USA) that created an immersive learning environment simulat- ing a deteriorating patient [16] to examine the potential for MR technology to transform or augment the assess- ment process Fig(2.5).

Figure 2.5: 3rd person view of the HoloPatient being deployed as a simulated patient for the purposes of examining clinical competencies in assessing a critically unwell patient

Participants undertook all five stations on rotation. Ten minutes were provided to complete each station with one-minute intervals between, mimicking the local standardised clinical OSCE examination format. A HL2 device was worn by each student whilst completing the study following a period of standardised training on how to wear and operate the device. Each station was assessed via three modalities: the current gold-standard in person assessment by a trained examiner in the room (IP), virtu- ally in real-time using the HL2 device linked to a trained examiner (HLL), via the Microsoft Remote Assist soft- ware platform (Microsoft Corporation, Redmond, WA, USA) and finally via a recording of the scenario obtained from the HL2 device (HLR). All examiners were quali- fied doctors with proficiency to assess the core compe- tencies examined as part of the study. Examiners rated all three arms of the study and intra-modality variability was assessed to ensure consistency of performance. Indicative mark schemes for each station are provided in Additional file 1. Participant feedback data were also collected, and usability of the device assessed vis the Standard Usabil- ity Scale (SUS). The primary outcome was the inter- modality correlation and inter-rater variability with the current gold-standard in-person method of assessment. The study was conducted in accordance with all relevant guidelines, regulations and the principles of the Declara- tion of Helsinki

Statistical analysis

Standard descriptive statistics were employed. Normal- ity of data were assessed via Shapiro–Wilk tests and two Tailed Pearson's and Spearman Rank Correlation Coef- ficients were calculated. Inter-modality variability was examined by Cronbach Alpha Intra Class Coefficient. Correlations were classified according to the correla- tion coefficient.

2.3.2 Advantages

- Virtual patients
- Higher quality supervision
- Remote guidance
- Real time training

2.3.3 Disadvantages

- Limitation of current hardware and software
- Number of applications that can be run at any point in time without the device crashing.
- Limited field of view(FoV)

Chapter 3

PROPOSED SYSTEM

3.1 The reality-virtuality continuum

There are a fair few terms in the immersive media world, and admittedly it can get confusing at times, especially when technology moves fast. There are three main terms used in this field that you should have an understanding of…

Mixed Reality is AR and VR's lesser-known cousin; but is probably just as important. Why? Because mixed reality describes the entire continuum from AR all the way to VR. That space in between AR and VR is a pretty exciting and creative place. This step will introduce you to mixed reality and the reality–virtuality continuum.

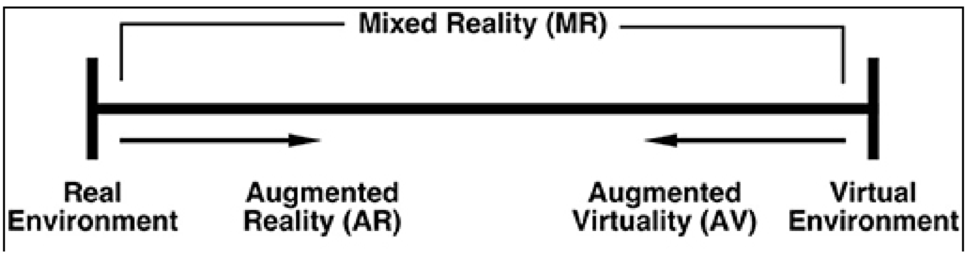

Figure 3.1: The reality-virtuality continuum

3.1.1 Virtual Reality

Virtual reality (VR) is a simulated experience that employs pose tracking and 3D near-eye displays to give the user an immersive feel of a virtual world. Applications of virtual reality include entertainment (particularly video games), education (such as medical or military training) and business (such as virtual meetings). Other distinct types of VR-style technology include augmented reality and mixed reality, sometimes referred to as extended reality or XR, although definitions are currently changing due to the nascence of the industry.

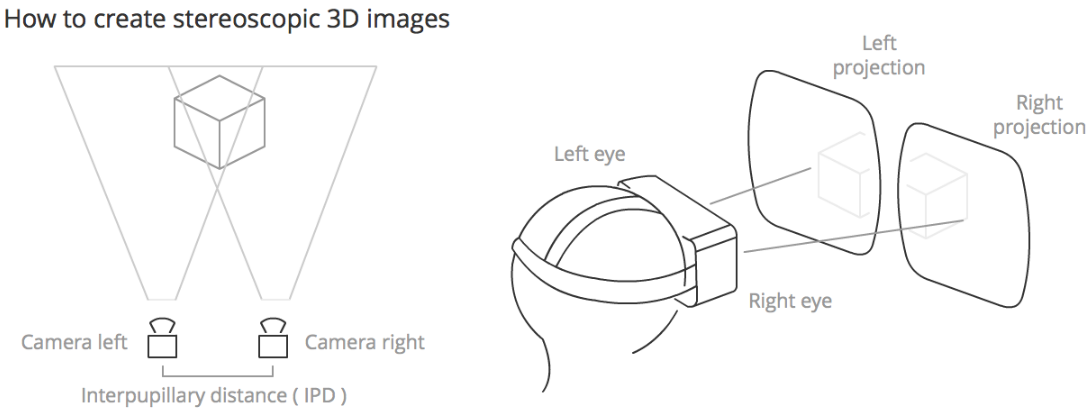

Figure 3.2: 3D view in VR

Currently, standard virtual reality systems use either virtual reality headsets or multi-projected environments to generate realistic images, sounds and other sensations that simulate a user's physical presence in a virtual environment. A person using virtual reality equipment is able to look around the artificial world, move around in it, and interact with virtual features or items. The effect is commonly created by VR headsets consisting of a head-mounted display with a small screen in front of the eyes, but can also be created through specially designed rooms with multiple large screens. Virtual reality typically incorporates auditory and video feedback, but may also allow other types of sensory and force feedback through haptic technology

3.1.2 Augmented Reality

Augmented reality (AR) is the real-time use of information in the form of text, graphics, audio and other virtual enhancements integrated with real-world objects. It is this "real world" element that differentiates AR from virtual reality. AR integrates and adds value to the user's interaction with the real world, versus a simulation.

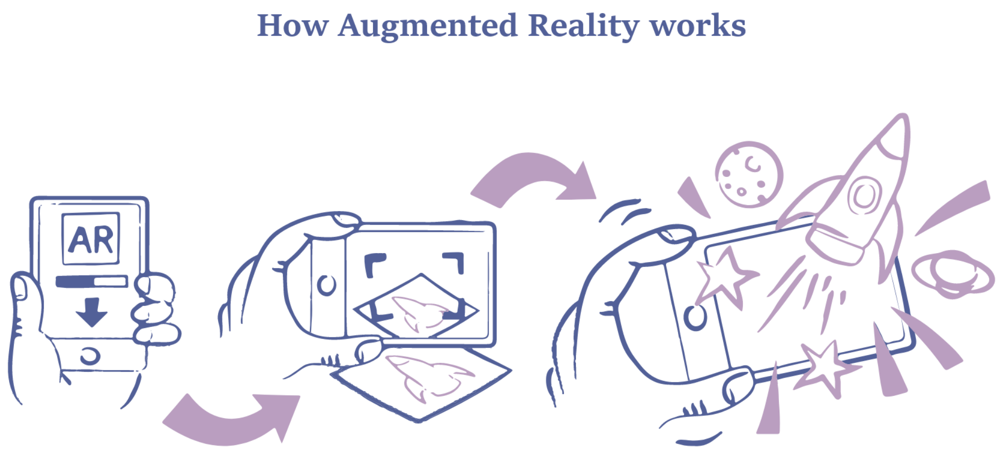

Figure 3.3: How Augmented Reality Works

3.1.3 Mixed Reality

Mixed reality is the next wave in computing followed by mainframes, PCs, and smartphones. Mixed reality is going mainstream for consumers and businesses. It liberates us from screen-bound experiences by offering instinctual interactions with data in our living spaces and with our friends. Online explorers, in hundreds of millions around the world, have experienced mixed reality through their handheld devices. Mobile AR offers the most mainstream mixed reality solutions today on social media. People may not even realize that the AR filters they use on Instagram are mixed reality experiences. Windows Mixed Reality takes all these user experiences to the next level with stunning holographic representations of people, high fidelity holographic 3D models, and the real world around them.

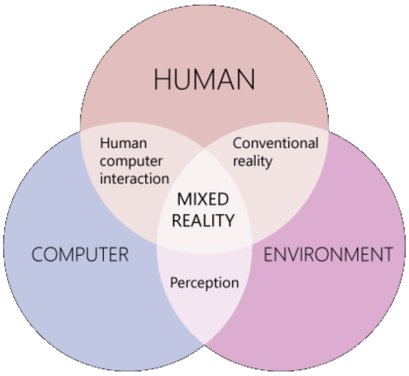

Figure 3.4: The interactions between computers, humans, and environments.

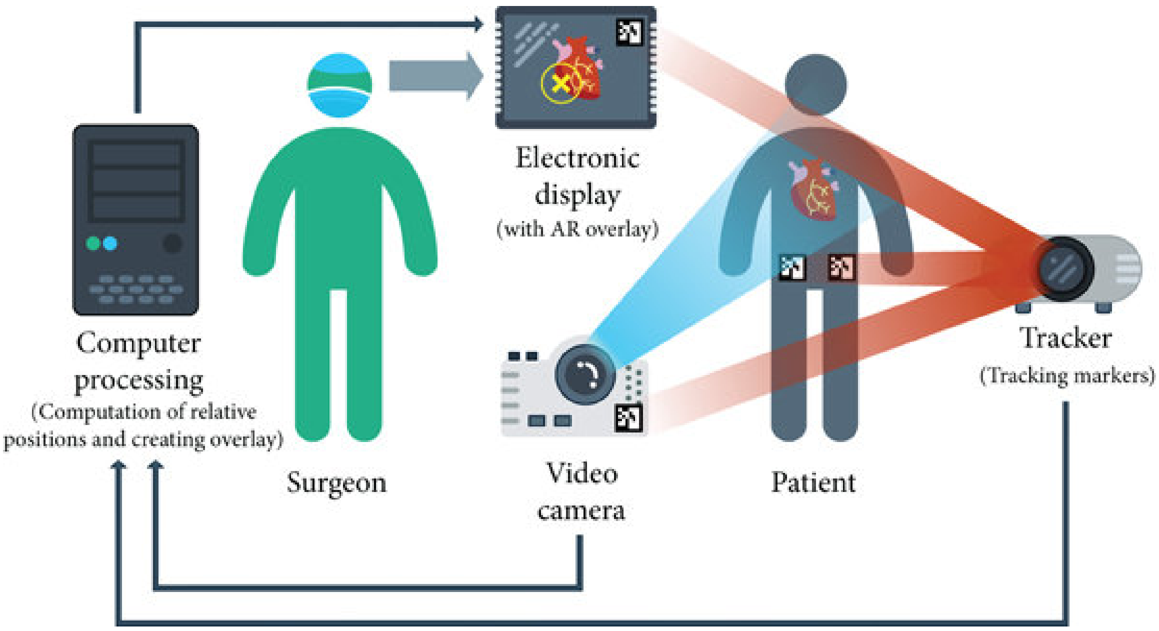

Figure 3.5: A scheme showing the basic principles of Mixed reality.

3.2 System Setup

Figure 3.6: System Setup.

The terminal device of the teacher client is a Microsoft Hololens 2 headset; each student client is powered by a high-performance desktop PC connected with an 8.9-inch Looking Glass LFD for displaying. A Microsoft Azure Kinect depth camera is attached to LFD to track the students (Fig.3.6). This whole system is developed using the Unity3D engine. For the student client, the latest version of Azure Kinect Unity Plugin1 is applied for the gesture and position tracking; the Looking Glass rendering Unity SDK2 is adapted to render dynamic viewing zones on the LFDs. MixedRealityToolkit3 is applied to implement the interface of the HoloLens teacher client, and Vuforia Unity SDK4 is applied to track the QR code attached to each LFD.

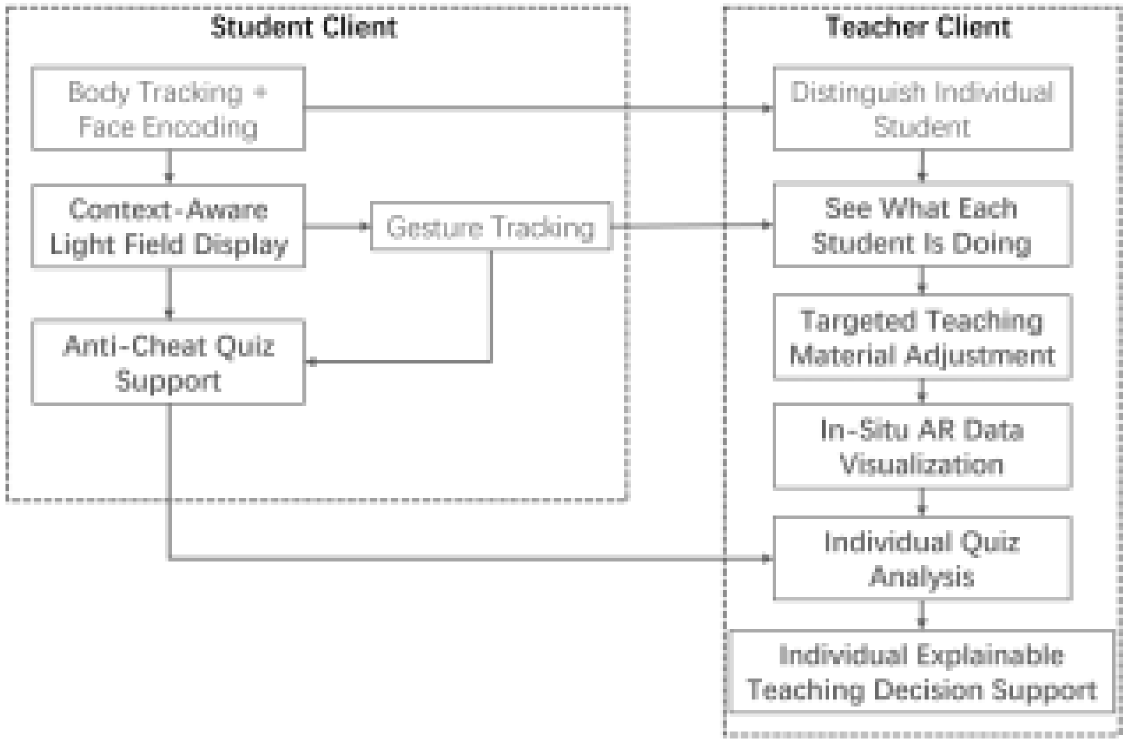

Figure 3.7: Concepts behind the system design.

3.3 System Overview

3.3.1 System Architecture

This system is developed based on prior METAL co-located content sharing system; thus, this section only focuses on the extra features and innovations while omitting the existed METAL implementations. This system still maintains the high-level METAL setup for one AR teacher client and multiple LFD student clients. While instead of communi- cating both clients using a Wide Area Network (WAN), a Local Area Network (LAN) synchronization middleware is developed for speedy and secure network communication between the co-located teacher and student clients (Fig. 3.8). In addition, as Fig. 3.7 illustrates, to allow for teaching deci- sions targeted at each student, an LFD provides each student with a context-aware dynamic privacy viewing zone that follows their real-time movement. By doing so, the teacher client can distinguish different students and adjust the teach- ing materials targeted at each student. Exploiting such a dynamic privacy viewing zone, we integrated an anti-cheat quiz support to both clients, allowing for the in-situ visual- ization of the explainable teaching decision targeted at each student.

3.3.2 Dynamic Privacy Light Field Display Viewing Zones for Context-Aware Visualization

As Fig. 3.7 illustrates, the student client created a context-aware LFD visualization by dividing each LFD into multiple dynamic viewing zones according to students' real-time posi- tions. To accurately track each student's face without violat- ing their privacy, an Azure Kinect depth camera is attached to the LFD to real-time track each student's relative head position (phead) and face encoding. Using these tracking data along with the LFD field of view (FOV fov) and its total number of views (nview), the specific views that can be seen by each student (Vstu- dent) can be calculated from the Equation. 1. For every moment, a dynamic centering view is calculated from this equation to form a dynamic viewing zone along with its two adjacent views, which is always bound to the corresponding student's face encoding and therefore is never visible to any other students. Based on this mech- anism, the anti-cheat feature is imple- mented for the quiz phase (Section IV-C). This dynamic viewing zone controls the 3D contents displayed for the bound student in the whole rendering procedure no matter how this student moves, here- upon supports different 3D content viewing with the entire FOV for each tracked student. Compared to the static viewing zones calculated by FOV divisions, such dynamic viewing zones allow more students to use one same LFD without FOV decreases simultane- ously. In particular, if two or more students' viewing zones overlap, the rendering SDK will render nothing to prevent students from seeing overlapping scenes. Additionally, by tracking students' gestures using the depth camera, all students using the context-aware LFD are also allowed to manipulate the 3D model and answer the quiz with gesture controls.

As Fig. 3.8 illustrates, each student's real-time head position and gesture data are both sent to the teacher client for syn- chronization. Using each student's head position, we create an avatar following each student to allow the teacher to distinguish them from each other (Fig. 3.7). Therefore, the teacher can share a 3D anatomy model and quiz with the cor- responding student by simply dropping the virtual contents to their head, Simultaneously, the assigned anatomy model is also displayed in the corresponding LFD viewing zone box for the teacher to know what each student is viewing. Moreover, by synchronizing each student's gesture data to the teacher client, the 3D anatomy model in the corresponding viewing zone box will show the real-time rotation and scale changes made by this student, which allows the teacher to see what each student is doing with their 3D model (Fig. 3.7).

3.3.3 Anti-Cheat Quiz Support

As a critical strategy for the teacher to understand students' current learning outcomes, in-class quizzes usually take teachers or teaching assistants considerable effort and time to maintain quiz rules and mark the paper. To make this proce- dure more efficient, we integrated an anti-cheat quiz support into each student client, which is also simultaneously tracked by the teacher client. First, the teacher can select a quiz from the quiz pool and assign it to any student by dropping it to their avatar.

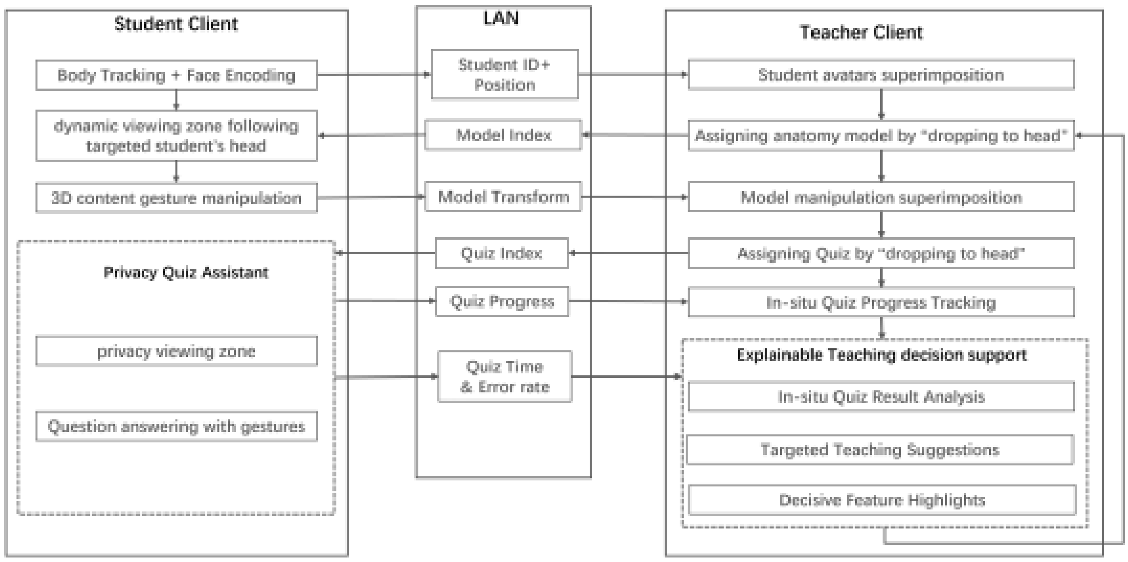

Figure 3.8: System architecture.

Immediately when the quiz index is sent to the targeted student client, as Fig. 3.8 illustrates, the student may start answering the assigned quiz from their corresponding LFD viewing zone by simply hovering one cursor over an option for 2 seconds with gestures . As is explained in subsection IV-B, each student is assigned a dynamic privacy viewing zone which is always and only visible to themselves. Therefore, students can never see others' quiz contents and answers even though they are sharing the same LFD. This mechanism prevents possible cheating behaviors during the quiz phase. Simultaneously, on the teacher client, a quiz progress bar is superimposed over each student in a quiz to show the teacher their quiz progress in real-time.

3.3.4 Targeted Teaching Decision Support with Explanation

After any student finishes the quiz, their quiz result will be immediately sent to the teacher client to start a detailed quiz result analysis for this student (Fig. 3.7). As is shown in Fig. 3.10, the completion time and the error rates achieved in different quiz parts are both in-situ visualized over the corresponding student's head. However, drawing a conclusion based on these pie charts and histograms might be time-consuming for the teacher. Therefore, the AR teacher client directly high- lights the weakest part and strongest part from all quiz parts by calculating the Rate of the Correct Scores (RCS) for each quiz part, based on which the brief teaching sugges- tions can also be displayed. For example, according to the suggestions displayed in Fig. 3.11, the stomach components in the pie chart and the histogram are both highlighted in red, with the accompanying suggestion indicating more practice is needed for this part due to its lowest RCS. Additionally, a knowledge deficiency degree is also displayed at the end of the suggestion to indicate how much the RCS of this part is lower than the average level. Instead of simply providing suggestions about teaching plans, the student's knowledge deficiency and the deficiency degree are also highlighted as the decisive input values to explain the provided suggestion. Such decision explanation may not only increase the teacher's trust towards the given suggestion but more importantly, allow the teacher to provide detailed guidance targeted at each student's knowledge deficiencies. Compared to checking each student's quiz analysis from the computer or mobile phone, with quiz analysis in-situ superimposed over each student's head, the teacher is saved from searching for those students who may need more help among the whole class by calling their names. Instead, the teacher may quickly identify which students showed significant knowledge defi- ciency by a glance and directly walk to these students to provide personalized guidance.

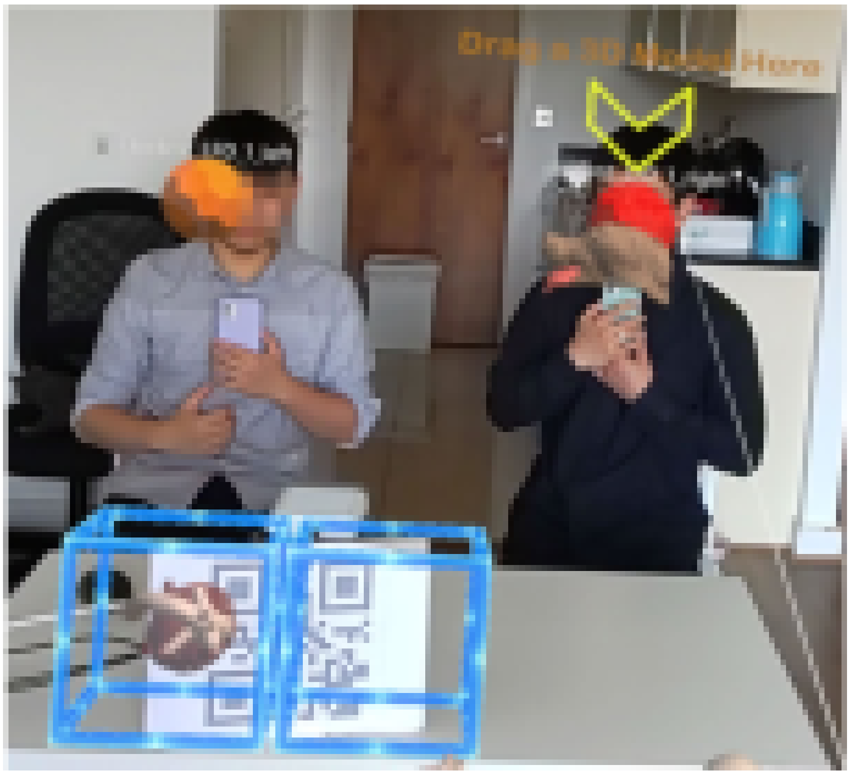

Figure 3.9: Targeted content sharing: dropping an anatomy model to a student's head avatar for content sharing.

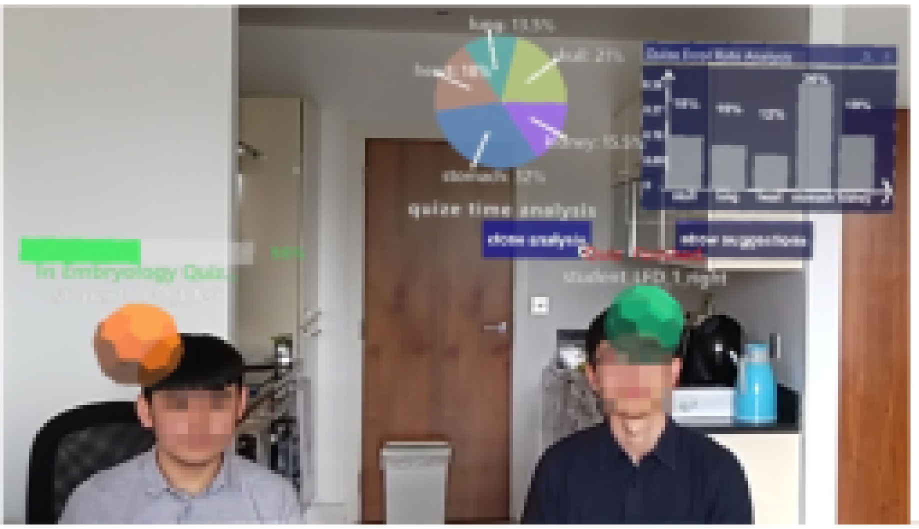

Figure 3.10: Quiz progress tracking & quiz result analysis.

Figure 3.11: Targeted teaching suggestions: highlighting weakest part and strongest part.

3.3.5 LAN Synchronization Middleware

As this system aims to support co-located teaching activ- ities in labs and classrooms, this network middleware is designed to provide fast connection among the clients within a classroom. For such a co-located teaching system, any network latency will be significantly noticeable due to the mismatch between the user movement and virtual objects. Therefore, we chose to utilize a LAN-based network middleware to minimize the network latency. However, among the off-the-shelf network engines, no suitable solu- tion can transmit customized information between Universal Windows Platform (UWP) applications and desktop appli- cations via LAN. Thus, a dedicated socket-based LAN network synchronization middleware (Fig. 3.8) is implemented to satisfy these customized communication require- ments. To ensure data security and network efficiency, only non-essential messages that are irrelevant to students' identi- ties are transmitted via the LAN, which include the sender client type, client code, message type, the auto-generated student code and transform, as well as the 3D anatomy model/quiz code and transforms. Then the information is packaged using our customized application-layer protocol and transmitted to the destination using UDP to reduce the latency. In a practice scenario, as soon as a student client boots, it will regularly broadcast its client code within the LAN to look for the teacher client. When the teacher client receives the message, including the student client code and its IP address, this message will be cached into the teacher client's address book. Consequently, a LAN connection is automati- cally established between the teacher client and this specific student client.

3.4 Advantages

- Small-size LFDs to demonstrate the system framework with limited costs.
- Allow even more students to share one large LFD, resulting in a superior user experience to the current generation

3.5 Drawbacks

- HoloLens screen record limitations, the resolutions and frame rates of the demo video looked much more lagging and unstable than actual normal experiences, which might have made some features in the teacher client look unclear, especially in such a short video.

Chapter 4

CONCLUSION

This paper is the first to report on the incorporation of context-aware Light Field Displays and the in-situ Aug- mented Reality data visualization to support targeted teaching decisions in a vet tutorial/lab collaborative learning embodi- ment. By illustrating the dynamic privacy LFD viewing zone and its application in anti-cheat quiz support, this paper aims to inspire future explorations towards diverse combinations of Mixed Reality devices including context-aware LFDs. They offer the ability to create ubiquitous applications in people's daily life beyond the use case of immersive learning outlined in this paper. Moreover, this paper not only demonstrated the first in-situ AR teaching decision support system, but more importantly, presented an example of decisive-input- value-based explanations as an important part of the AR DSS to bridge the gap that existed in previous AR DSS research. Despite the limitations of the remote video-based expert review study, expert participants still gave high ratings to the demonstrator system based on their past teaching expe- riences. The expert review highlighted the abilities to create intuitive-targeted teaching materials, quiz progress analysis, and targeted teaching suggestions.

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