AUGMENTED REALITY APPLICATION FOR PULMONARY AUSCULTATION LEARNING AID

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ABSTRACT

During some applied anatomy lessons, physiotherapist students must develop a skill of locating and recognizing underlying anatomical elements, from surface palpations, or through clinical tools on their classmates. For this, precise procedures exist and students have to mobilize knowledge acquired from different types of resources: support documents from the teacher, anatomical charts (books, drawings, diagrams), dissection videos or even internet resources. They also need more practical time and exercises. The issues facing students relate to the availability of these resources during the procedure, their relevance, the mobilisation of resources to practice and the applicability in a real situation.

This project stems from a desire to make Augmented Reality technology available to students, to help in learning precise clinical procedure, in our case the location of the auscultation points using a stethoscope. The aim would be to supplement the real environment of the student during his learning on a person, by the possibilities of having additional resources according to its needs (auscultation points superimposed on a 3D representation of the lungs).

Keywords: Design education, User centred design, Innovation

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1 INTRODUCTION

1.1 Context of the study

With the advancement of technology geared around Augmented Reality (AR), several fields can be a real value-added in modern stakes. AR applications can be founded in different cases, like tourism: the virtual guide available at the Garnier Palace, Paris for example. During the visit through an IPad a character appears, added to the real scene, when the device recognizes the localisation it shares with the user historical information, the character is digitally implemented into the real scene. AR serves many more domains, in a more scientific application. The tool like ATLAS can be highlighted, it is a mobile application which targets health professionals. This application allows users to visualize anatomical models in a real environment which you can rotate, zoom or dissect (Figure 1).

In the past decades, AR has increased interest in applying to create unique educational settings in different fields. According to Zhu et al. (2014), "AR provides rich contextual learning for medical students to aid in achieving core competencies, such as decision making, effective teamwork and creative adaptation of global resources towards addressing local priorities". This technology can be a capital gain in the educational domain.

During some applied practical session at school, physiotherapist students have to develop an ability to locate and recognize the underlying anatomical elements, from surface palpations or using clinical tools. In these classes, they must learn new specific procedures but also call their knowledge acquired previously thanks to specific resources: anatomical charts (books, drawings, diagrams), dissection videos, supports from professors, etc.

Discussions with physiotherapists' teachers allow to point out that students are facing problems mobilizing these resources during the procedure, because of their availability and relevance in the course of the practical session.

Thereby, this research project aims to help physiotherapist students in learning new clinical procedures, in our case the pulmonary auscultation, by making a learning aid application with AR technology. The objective would be to supplement the real environment of the student during his learning, by the possibility to add additional resources to the real environment related to its needs. The main objective of this research is to supplement auscultation points superimposed on a 3D representation of the lungs on the back of the patient. The contributions of the present research are one the on hand the progression of the use of intelligent technology in healthcare department to evaluate a different learning process for students and on the other hand the contribution to the development of a new software application dedicated to pulmonary auscultation exam.

In fine our project tends to extend the scientific knowledge of AR domain for educational purposes in the physiotherapy context and for students in others fields of education. Indeed, this domain being quite new, the progress is also limited. Therefore, having another experience in the context of physiotherapy can be beneficial in the overall contribution in AR, especially when our project is in close collaboration with physiotherapy specialists.

This project is part of a collaboration between the G-SCOP lab, the TIMC interdisciplinary lab and the physiotherapy formation department of the Grenoble University Hospital (IFPS).

1.2 Objectives of the research and structure of the document

The objectives of this research project are to enhance the scientific knowledge in the AR domain in a physiotherapist context. Equipped with a mixed reality headset, the student will have the possibility to supplement his real environment with holograms of pulmonary auscultation points superimposed on a 3D representation of the lungs. Furthermore, the developed application coupled with the use of the headset aims to ensure the possibility for the user to have access to the external resources that they consider useful for the good completion of the session.

Overall this document is articulated as follows, after this first part of introduction of the general content to understand the context, stakes and objectives of this research project, it will be questioned to frame the project with a development of a state of the art. Then, the research question takes place to bring out the aspect that this research tends to enhance due to the gap previously seen with the state of the art and the general content. Related to the latter the research methodology is next in this document and it plans to describe the methodology used throughout this project and the different approaches

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applied. Then a development of the previously cited point will take place as well as the result obtained. To conclude, it is a feedback from the most important results and novelty found within this project to bring it to scientific knowledge in the AR domain.

2 STATE OF THE ART

This state of the art will allow us to identify the existing technologies in AR that are the closest to the one that this project aims to develop. Thereby it tends to establish the limitation of the technology available and the lack of some aspect in modern research.

Regarding the structure of this section, it is articulated in the following way. First the global concept of this technology is discussed. Then the context is specified with the AR in education part, with several examples of application in education and the AR in Healthcare Education part. The last part is about the Usability and Acceptance of the proposed solution.

2.1 AR: the concept

AR is a technology or a concept define by the collaboration between the real world with virtual objects (e.g., sound, text, video and 3D object), it is a direct or indirect view of a physical environment that is improved by the layering of computer-generated information to it (Klopfer and Squire, 2008; Yuen et al., 2011). This technology is both interactive and registered in 3D. In other words, the real environment is enriched with virtual objects or information generated by computer-based technologies (Carmigniani and Furht, 2011). AR can, in some cases, be defined by default as an artefact that needs to be used through a Head-Mounted Displays (HMDs). Therefore, to avoid the limitation of a domain of application, a survey defines AR as a system that has three features: « (1) Combines real and virtual (2) Interactive in real time (3) Registered in 3-D » (Azuma, 1997).

To talk about the global stake of AR, it aims to simplify the user's life by bringing virtual information not only to his immediate surroundings, but also to any indirect view of the real-world environment. It also helps to enhance the user's perception of and interaction with the real world. Indeed, AR is a technology that enables the interaction between the real world and virtual objects. Compared to the Virtual Reality technology, it completely immerses users in a synthetic world without seeing the real world.

Regarding AR technologies, it augments the sense of reality by superimposing virtual objects and cues upon the real world in real time. Some applications allow to work differently with AR, depending on the case, sometimes the application requires removing real objects from the environment in addition to adding virtual objects. Indeed, removing objects from the real world corresponds to covering the object with virtual information that matches the background in order to give the user the impression that the object is not there. Virtual objects added to the real environment show information to the user that the user cannot directly detect with his senses. The information passed on by the virtual object can help the user in performing daily-tasks work. It can also simply have an entertainment purpose, such as Wikitude (2016) or another mobile AR. There are many other classes of AR applications, such as entertainment, advertising, maintenance and repair, annotation, robot path planning, or even medical visualization related to our physiotherapy context.

2.2 AR in education

A research led by Fidan and Tuncel (2018), has highlighted the specific features of the articles on AR published in the journals of education indexed in the SSCI database between 2012 and 2017. In total 83 articles in 22 journals were inspected by a content analysis. They were analysed by their years of publication, number of authors, countries, educational disciplines/fields, types of AR, variables and methodological features. As determined in the survey, the number of studies related to AR increased in 2014 and 2017 and they were predominantly carried out in the field of education science. During the study the most examined variables in the articles were achievement and attitude. After collecting the literature this study exposed that the majority of the studies on AR were done by scientists working at universities in Taiwan. In this paper it considered that AR is one of the potentially promising technologies in education. Indeed, it has been used for the aid of learning inaccessible or dangerous objects, the concretization of abstract concepts or even the learning of invisible objects or events.

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The state of the art highlights some studies in various fields such as language (Ho et al., 2017), maths, science, medicine (Ferrer-Torregrosa et al., 2015) and geography.
To have an idea of some devices set with AR, the example of a study led in Taiwan to activate English learning (Ho et al., 2017) can be chosen, indeed this research highlighted two objectives. The first one is developing a Ubiquitous Learning Instruction System with AR features (UL-IAR) to improve the performance of the EFL (English as a Foreign Language) learning with real-life situations. Second, we examined whether different learning strategies and cognitive styles affect learning performance in using UL-IAR. This system integrates AR and Wikitude World Browser (Wikitude, 2018). The Wikitude World Browser was a mobile software that integrated AR technologies, GPS, and mobile networks which allowed users to retrieve the information relevant to their surroundings. The primary features of UL-IAR include GPS positioning, the highlighting of local features, mark-up, scaffolding instruction, and real-time tests.
To go back to the study questioning AR in education research (Fidan and Tuncel, 2018), several points have been highlighted, for example from 2012 to 2017 a high level of increase in the number of studies about AR in 2017 has been noticed. Regarding the type of AR, the marker-based AR applications were used predominantly with 70,45%, the rest of the global repetition were decided between, location-based AR, and gesture/motion based.
To shed light on the marker-based concept, it's a field of AR where the experiences require a static image also referred to as a trigger photo that a person can scan using their mobile device via an AR application. The mobile scan will trigger the additional content (video, animaLon, 3D or other) prepared in advance to appear on top of the marker (Zvejnieks, 2019).
Regarding the research method used, in parallel with the studies, it came up that the researchers preferred the quantitative research method (68.67%) more favourably than the qualitative (22.89%) and mixed (8.43%) research methods (Fidan and Tuncel, 2018).

2.3 AR in healthcare education

In the domain of healthcare, Zhu et al. (2014) has highlighted 25 selective study papers that are related and pertinent to AR in healthcare education. It showed that AR was applied in a wide range of topics in healthcare education such as, joint injection, thoracic pedicle screw placement, laparoscopic surgery, administering local anaesthesia.
Regarding the concept, medical education it's described by the glossary of medical education terms from AMEE (Association for Medical Education in Europe) as "the process of teaching, learning and training of students with an ongoing integration of knowledge, experience, skills, qualities, responsibility and values which qualify an individual to practice medicine" (Wojtczak, 2002).
AR in healthcare education needs more than the testing and improvement of a prototype product, but also needs to identify appropriate learning theories and methods to better guide application of AR in healthcare education.
In the last decades, there is a clear need to further study the use of AR in healthcare education, indeed students and medical professionals need more situational experiences in clinical care/healthcare education, all the more to preserve for the sake of patient safety. Therefore, the wide interest in studying AR has highlighted the following beliefs:

- AR provides rich contextual learning for medical students to aid in achieving core competencies, such as decision making, effective teamwork and creative adaptation of global resources towards addressing local priorities
- AR provides opportunities for more authentic learning and appeals to multiple learning styles, providing students a more personalized and explorative learning experience.
- The patients' safety is safeguarded if mistakes are made during skills training with AR (Zhu et al., 2014).

Due to the distinct learning advantages that AR offers, such as remote learning and interactive simulations, AR-based teaching programs are also increasingly being adopted within medical schools across the world (Dhar et al., 2021). Authors explain that there are mainly three domains of medical students experiences and learning outcomes that are enhanced by AR-based programs: knowledge & understanding, practical skills and social skills.
AR learning is commonly associated with highly positive subjective personal experiences, and can be fun and interesting to use. It is for similar reasons that AR games such as Pokemon Go have been so successful (Ewell, 2020). AR-based training provides a vast potential to effectively and efficiently

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prepare medical professionals for the real world of practice (Mikhail et al., 2019). Along with offering a safe educational environment and addressing specific professional skills, AR programs for learning in medicine are employed to enhance learners' experiences, as described by Salehahmadi and Hajialiasgari (2019). The main goals of AR based learning are (1) to simplify the delivery of complex information, (2) to advance communication skills, (3) to enhance sense of reality, (4) to facilitate the use of large datasets, (5) to integrate virtual objects into physical space and (6) to enrich comprehension of medical imaging.

Clinical care is also interested in AR because it provides doctors with an internal view of the patient, without the need for invasive procedure. As an example, it's interesting to have an overview of the scientific journals concerning a new tool based on AR focusing on the anatomy of the lower limb. The concept of this technology is to collab a standard part of descriptive anatomy of the lower limb including osteology, arthrology, and other clinical application, with a card for each anatomical part that can be recognized by a digital webcam that is connected to a computer. Then, the virtual AR image appears in the computer screen of the student workplace (Ferrer-Torregrosa et al., 2015).

Another stake in the AR in the healthcare education context is the representation of the patient. In some cases, it can be a real patient, in others a mock-up of the clinical part or a model, but it also exists the concept of the 'HoloPatient'. The American company GigXR (Zvejnieks, 2019) launched the concept of the "HoloPatient". The goal here is to simulate real life scenarios explored in real time. They use immersive technologies to reinvent instructor-led training and learning. The project in collaboration with the Michigan University of Medicine works on a remote learning aid for a HoloPatient who has respiratory problems (GIGXR). There is a precursor in this field, which works in collaboration with researchers to create models that look extremely real, Ziva Dynamics (Ziva Dynamics).

A typical example of the use of the Hololens mixed-reality headset is detailed by Al Janabi et al. (2020). This research study aims to demonstrate that the development improved outcomes of performance in novices and was widely accepted as a surgical visual aid by all groups. Moreover, experiments showed that it is a feasible alternative to the conventional setup.

2.4 Conclusion

To conclude, the state-of-the-art shows that the AR is largely used in healthcare education. Numbers of research studies have validated the advantages of the use of the AR based learning for students. Moreover, in the reviews previously cited, the subject of the survey can be either a model or a hologram. In other words, with the Hololens technology, the one used in the current project, one of the limitations is to work with a real subject that can be in motion because with only this technology there is no possibilities to do body tracking.

Indeed, AR in a learning context aims to increase the learning effect by acquisition of skills and knowledge, understanding of spatial relationships and medical concepts. It also improves the learning retention and performance on cognitive-psychomotor tasks, providing devices in a convenient and timely manner that shortens the learning path, and simulating authentic experiences (Zhu et al. 2014). So, to complete the scientific knowledge in AR in the healthcare domain, this project can improve the advancement done in this domain in a new field.

3 RESEARCH QUESTION, METHODS AND MATERIALS

3.1 Research question

In order to provide improvement toward the gap raised previously and expand the scientific knowledge in this context, the research question asked in the current research can be: "How Augmented Reality application can be set up in a physiotherapy learning process?". Then, two different sub questions can be formalized as:

- Can the AR be a way to facilitate the learning process of students in physiotherapy school?
- Is there design methods or tools to favour the acceptability and usability of a learning tool using AR?

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3.2 Materials

The installation of the practical sessions' workspace is as follows: ten medical examination tables placed horizontally to the whiteboard and two other tables in the centre. The central tables are reserved for the teacher to show the practical exercise of the day on a student. In regards to the exercise, they can be performed on the examination table or standing, in motion or static, with or without the need of a clinic tool, all these parameters depend on the localisation of the palpatory exercise and what kind of observation do they need to establish their prognosis. The next figure (Figure 1) shows the disposition of a practical session including 21 students sitting behind their medical examination table and the teacher in front of the whiteboard and their table.

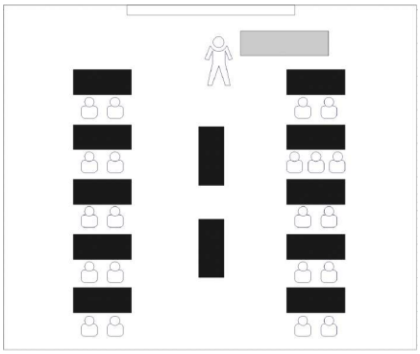

Figure 1. Disposition of a practical session for a medical examination course.

The Practical session takes place right after the theoretical courses, in order to enhance their clinical knowledge. Although some professors find it useful to support their practical courses with theoretical slides, they aim to support their practical exercises to make sure that they understand all the stake of a good mobilization or the following of a clinical protocol. In some sessions where is about to learn a new clinical protocol, it can be question to use a clinical tool like a stethoscope.

Concerning the course of the session there are two distinct phases, it alternates between phases led by the teacher as well as practical phases where it's about the student participation at the practical exercise. The phases of the session led by the teacher are times consecrated at the presentation of the exercise, presentation of the practical situation, question and answer session between teacher/students. Concerning the students' phases, it appears to be the practical session for students where they practice the teacher's explanation phase. Once these teacher phases are over, it is time for the students to practice the palpation exercises in pairs, so they put their stuff (notebook, computer) on the side of the tables, there is no appropriate space to store their belongings. Another point observed during this session is the lack of time for some students to write everything down during the allotted time. So, they don't have enough time to practice in the second phase.

The technical application is developed based on the use of a headset AR technology the Hololens2. All the development and the options are done using the application developer Unity, using Windows on a dedicated computer, into a technical platform dedicated to design science experiments. Agile method was used where design, development, and tests were iteratively realized.

To use the Hololens2 helmet, first put it on the head and adjust correctly so that the images are well aligned with the real world. Next, user has to launch an AR application that will display digital content on the helmet. It allows to run a computer program coded in C++ or C# from Unity.

Unity is a game engine and game development platform video that allows developers to create games and applications for different platforms, such as computers, game consoles, smartphones and tablets. It is used in different fields, such as animation, architecture, engineering and training, to create virtual reality (VR) and AR applications. Unity is a real-time game engine that allows developers to create 3D virtual worlds and make them interactive using code and integrated development tools. It offers great flexibility and great computing power, making it a popular solution for creating games and VR and AR applications.

3.3 Methods

Concerning the research methods, it refers to a specific procedure of collecting and analysing data essential for the project. The methods must be considered while planning the course of the project. Accordingly, the methodology used during this project will be presented follows (Figure 2).

The first phase is dedicated to observation and literature review. It takes place with two contexts, a technological one with AR aspect and a medical one with the physiotherapist aspect. On one hand, the AR technology will be detailed and understood to select the one that is the closest to the research study. On the other hand, with the objective to acquire pedagogical knowledge in a physiotherapy context, practical physiotherapist sessions have been observed.

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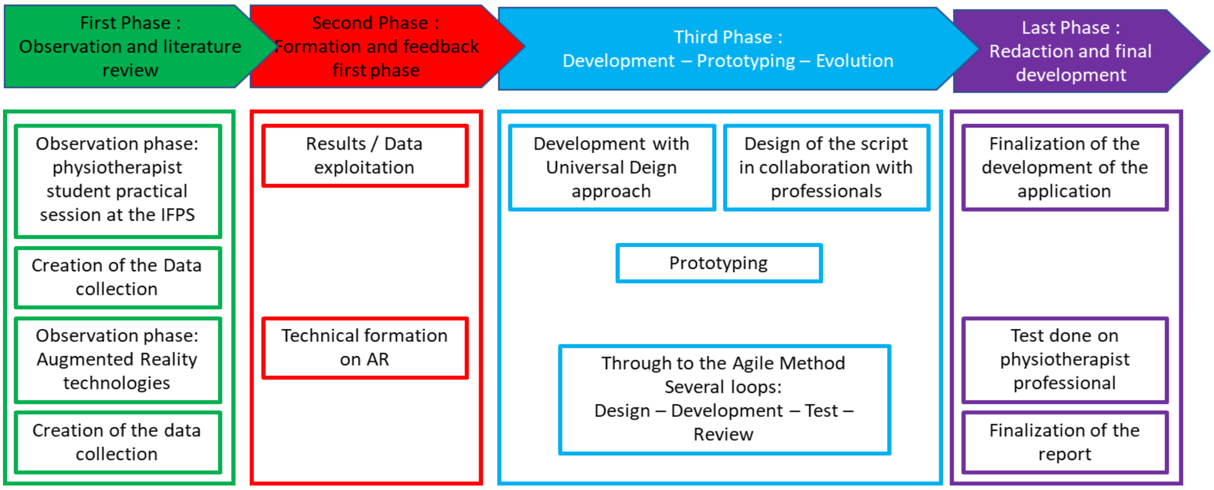

Figure 2. Research methodology for the development of an AR Application in a physiotherapy learning process

To validate this first phase, questionnaires have been given to students and teachers at the end of the practical sessions observed to recover information around the following problematics:

- What kind of resources do they use during practical session
- The limitation they are facing to mobilize a resource
- Experiences and opinion on the Augmented Reality technology.

Another approach in this first phase was interviewing physiotherapist students and teachers. This step allowed us to have a direct feedback of the students concerning the practical session and choose to have the aspect that seems to bring an added value for students and to increase their learning according to them. Quick interviews with teachers at the end of the class are also important to first of all evaluate their interest in the project and to evaluate if a real stake might be present. This approach combines primary and qualitative data collection to obtain a clearer and deep understanding of aims and stakes of the research.

The second phase aimed to acquire technical competences in AR and to develop the application. In this second phase the data collected previously will be exploited.

The third phase, it's the longest: the development and prototyping of the AR application. Several scenarios have been created in collaboration with professionals to arrive at an optimal one which have been developed afterward. This study will allow researchers to use agile method that is specifically dedicated to iterate the prototype with the different loops which content design, development and test phases. An after-development feedback and modifications in purpose to enhance the prototype and to repeat the loop again until obtaining an adapted result.

The last phase of the research project gathers different steps. The finalization of the development consists of presenting the application to physiotherapist professionals, organizing test sessions to have a user opinion on it. Then feedback about their experience will be asked to have a first idea of the potential acceptance of the project within their practical session.

4 RESULTS

4.1 Integration of the application within the practical sessions

Because the objective is to try to integrate the Hololens2 into the current disposition of the practical session, it is important to fully understand how the learning of this new protocol takes place during the session. The Table 1 shows the current organization of the pulmonary auscultation session planned in four phases. Two phases are in alternance: the theoretical phases led by the teacher and the practical phases led by the students with the help if needed of the teacher.

The way planned to integrate the proposed application to the current organization of the practical session is presented in Table 2. No changes are planned concerning the theoretical phases: the application won't be present in the student environment.

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Table 1. Organization of current sessions

Theoretical phase	Practical phase	Theoretical phase	Practical phase
Teacher phase	Students phase	Teacher phase	Students phase
Beginning of the course until the explanation of Normal Breath Sounds	Allows the students to become familiar with the stethoscope and to observe, identify the Normal Breath Sounds	Resumption of classes with listening to the soundtracks Explanation of auscultation protocol	Putting the pulmonary auscultation protocol into practice Posterior, Anterior and lateral sequence
Duration: 23 min	5 min 23 sec	27 min	9 min

The second phase is about the practical aspect of the session for the student. The AR application is planned to be integrate here. Equipped with the headset Hololens2, the student will have the possibility to visualize the lung and the auscultation points during the step suitable to this information. The last phase is the exercise, where it is ideal to set an exercise with the Hololens2.

Table 2. Plan of the integration of the application

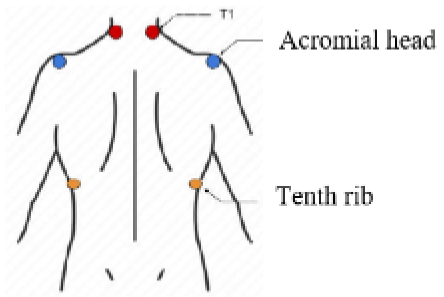
Theoretical phase	Practical phase	Exercise phase
Protocol history Description of breath sound Lung pathologies	Handling the stethoscope Learning lung auscultation points	Linking breath sounds to pathologies Recognizing the characteristics of breath sounds
Current disposition of the session No handling of the Hololens2	Visualisation of the lungs and the auscultation points	Access to the soundtracks depending on the auscultation point Setting up the questions

4.2 Development of the scenario

In the proposed scenario, widows will appear to configure the program:

- To configure user hand choice
- To configure the gender of the patient: in the anterior sequence, the protocol changes depending on the gender of the patient because of the chest.

Once these parameters are entered, the most important step of future development is the calibration.



This step took a lot of essays to finally suit our expectations. By pointing specific points with his finger, represented below on Figure 3, the user will give the voice command 'Take position' and a point of calibration will appear. There is a special order to position the points, the user must begin from the top right point and to continue with each indication given. If the user wants to delete the last point taken he has to give the vocal command 'delete point'.

Figure 3. Calibration points

Once the calibration step is done the lungs and the auscultation point will appear in superposition on top of the patient's back.

4.3 Development of the technical application

The figures 4 to 6 below have been taken from the original video of the final application prototype taken with the Hololens2.
Figures 4 are configuration panels. Figures 5 are Calibration Instruction / Manipulation panels and the figure 6 shows the final placement of the lungs on the patient body.

Figure 4. Configurations panel

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Figures 5. Calibration Instruction / Manipulation

Figure 6: Final prototype

On the Figure 7.a. the calibration phase is shown. The Figure 7.b. represents the user applying the pulmonary auscultation protocol on the patient.

Figures 7a and 7b. User applying the pulmonary auscultation protocol

5 DISUCSSION

The observation phase gave information about the organization and the disposition of the practical sessions. View from the outside the organization of the sessions does not seem optimal for the students.
We can cite the fact that the teacher phase lasts longer than the students' phase where the student must be practicing the mobilization or the protocol previously seen. In some cases, the student doesn't have enough time during their phases to completely reproduce the gesture seen beforehand. It can be explained by the fact that sometimes students are in a trio rather than in pairs, but they have the same time as other groups that are in pairs. Also, when a student doesn't fully understand a gesture it can take more time for him to reproduce it, and then less time for the mate to practice the gesture so he's a bit less trained for the gesture. In other cases, the student doesn't get enough time to take notes during the teacher phase so they continue during their phase.
Concerning the note taking, during the sessions the students are placed on medical examination tables to take their notes. The majority of students take manuscript notes during the sessions. Indeed, the medical table where is low compared to a normal lesson table, so in term it can be painful for their back. The disposition of the tables is also not worked for a good observation of the exercise during qualitative note taking. As previously said and represented on Figure 1 when the teacher shows the mobilization on the central table, some students are not in good disposition to completely see. They stand up to get closer to the teacher and take their note standing which is not adequate for good note taking.
The questionnaire showed us that 42.2% of the students say they use external resources during the practical session. However, during the sessions observed no external resources were mobilized by students except for the direct notes that they took during the teacher phase. It can be explained by the fact that the sample of sessions observed does not represent all the practical sessions. The resources that came out were anatomical manuals so we can imagine that these external resources are more used in basic practical sessions of the anatomy like localisation of anatomic elements. Actually, the questionnaire is a good way to get quick and quantitative answers to help us afterward with the design and development of the application. It also allowed students to express themselves more freely knowing that the questionnaire was anonymous. So they were more free to respond and to give their opinion.

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Trials were originally planned with students as well as physiotherapy professionals to validate the first development design within this project. Unfortunately, because of exam period, students could not test the application. Until now, only physiotherapist tried the Hololens2 Application. At the beginning of the test, pre-exercise was done to acclimatize user to the technology and to calibrate the headset to its eyes. In total these tests lasted 10 minutes. It's an important point to clarify if the objective is to integrate this application into a practical session with students.
Concerning the test done, the user didn't understand the order of the calibration point. Indeed, the order is not precise in the photo presented to the user. So, this step had to be redone by the user. We can then retain that it's important to give clear and concrete instructions to the user to have an optimal experience with the proposed application. Moreover, the calibration point didn't appear exactly on the location pointed with the index of the user. One of the possible explanations of this problem is that the application doesn't recognize the tip of the right finger.

6 CONCLUSION AND PERSPECTIVES

Our ambition in this project is to implement in the vision of the physiotherapy student a visualization of the underlying anatomical elements, in our case the lungs, but also to add the auscultatory protocol of the posterior sequence of the pulmonary auscultation. Another stake was to provide access to educational resources that can be pertinent to the learning during the practical session.
At the end of this project, we succeeded in implementing in the real environment of the physiotherapy student a visualization of the clinical protocol to follow and a 3D view of the lungs.

REFERENCES

Al Janabi HF, Aydin A, Palaneer S, Macchione N, Al-Jabir A, Khan MS, Dasgupta P, Ahmed K. Effectiveness of the HoloLens mixed-reality headset in minimally invasive surgery: a simulation-based feasibility study, Surgical Endoscopy (2020) 34:1143–1149. https://doi.org/10.1007/s00464-019-06862-3

Azuma, R. T. (1997). A survey of AR. Presence: Teleoperators and Virtual Environments, 6(4), 355–385 https://doi.org/10.1162/pres.1997.6.4.355

Carmigniani J., Furht B. (2011) AR: An Overview. In: Furht B. (eds) Handbook of AR. Springer, New York, NY. https://doi.org/10.1007/978-1-4614-0064-6_1

Dhar P, Rocks T, Samarasinghe RM, Stephenson G, and Smith C, (2021). Augmented reality in medical education: students' experiences and learning outcomes, Med Educ Online. 2021; 26(1): 1953953. https://doi.org/10.1080/10872981.2021.1953953

Ferrer-Torregrosa, J., Torralba, J., Jimenez, M. A., Garcia, S. & Barcia, J. M. (2015). ARBOOK: Development and assessment of a tool based on AR for anatomy. Journal of Science Education and Technology, 24, 119–124. https://doi.org/10.1007/s10956-014-9526-4

Fidan, M. and Tuncel, M. (2018). AR in education researchers (2012–2017): A content analysis. https://doi.org/10.18844/cjes.v13i4.3487

Ho, S. C., Hsieh, S. W., Sun, P. C. & Chen, C. M. (2017). To activate English learning: listen and speak in real life context with an AR featured u-learning system. Educational Technology & Society, 20(2), 176–187.

Klopfer, E. & Squire, K. (2008). Environmental detectives—the development of an AR platform for environmental simulations. Educational Technology Research and Development, 56(2), 203–228. https://doi.org/0.1007/s11423-007-9037-6

Mikhail M, Mithani K, Ibrahim GM, et al. (2019). Presurgical and intraoperative augmented reality in neuro-oncologic surgery: clinical experiences and limitations. World Neurosurg. 2019; 128:268–276. https://doi.org/10.1016/j.wneu.2019.04.256

Salehahmadi F, Hajialiasgari F. (2019). Grand adventure of augmented reality in landscape of surgery. World J Plast Surg. 2019; 8(2):135–145. https://doi.org/10.29252/wjps.8.2.135

Wikitude. (2016). Wikitude world browser official website. Retrieved from http://www.wikitude.com/tour/wikitude-world- browser

Yuen, S., Yaoyuneyong, G. & Johnson, E. (2011). AR: an overview and five directions for AR in education. Journal of Educational Technology Development and Exchange, 4(1), 119–140. https://doi.org/10.18785/jetde.0401.10

Zhu E, Hadadgar A, Masiello I, Zary N. (2014). AR in healthcare education: an integrative review. Peer J., 2014, 2: e469. https://doi.org/10.7717/peerj.469

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