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School of Telecommunications Engineering

Augmented Reality and People with Functional Diversity

End of Degree Project

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# Undergraduate Project Report 2023/24

## **Augmented Reality and People with Functional Diversity**

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## **Abstract**

This project, conducted in collaboration with the Polytechnic University of Valencia, Spain, focuses on the development of an Android mobile application utilizing augmented reality (AR) technology to assist individuals with functional diversity. This project also includes a supportive AR book designed to enhance learning and understanding of the environment for its users. The main tasks involved state-of-the-art research on AR apps helping people with functional diversity, the design, implementation, and testing of the app, proposals for improvements based on test results, and the development of a user guide. The application, developed using Unity3D and C# scripts, aims at fostering better understanding of daily work in a workshop context. Key findings from the project underscore the potential of AR technology in improving learning experiences, enhancing social interactions, and boosting self-esteem among individuals with functional diversity. Feedback from users at the “La Torre” occupational center indicates high satisfaction with the application and the supportive book, highlighting the success in meeting its objectives. Despite its achievements, the project identifies areas for improvement, such as enhancing visual aids and expanding content, suggesting directions for future work. Overall, the project is a great success and it illustrates the effective application of AR technology to support individuals with functional diversity, paving the way for further innovations in the field.

## **Keywords**

Augmented Reality; People with functional diversity; Workshop; AR mobile application; AR book

### 摘要

该项目与西班牙瓦伦西亚理工大学合作进行，重点开发了一款利用增强现实（AR）技术辅助功能多样性人群的安卓移动应用程序。该项目还包括一本旨在增强用户对环境理解和学习的支持性 AR 书籍。主要任务包括对帮助功能多样性人群的 AR 应用进行最新研究、应用的设计、实现与测试、基于测试结果的改进建议以及用户指南的开发。该应用使用 Unity3D 和 C#脚本开发，旨在促进用户对日常工作坊环境和工作内容的更好理解。项目的关键发现强调了 AR 技术在改善学习体验、增强社交互动以及提升功能多样性人群自尊心方面的潜力。来自“La Torre”职业中心用户的反馈显示，他们对应用程序和支持书籍表示高度满意，凸显了项目在实现其目标方面的成功。该项目还为未来的工作指明了方向，为多样性人群领域的工作和研究提供了建议。总的来说，该项目是一个巨大的成功，它展示了 AR 技术在支持功能多样性人群方面的有效应用，为该领域的进一步创新铺平了道路。

### 关键词

增强现实；功能多样性人群；工作坊；AR 移动应用；AR 书籍

## Chapter 1: Introduction

This project is an external project with Polytechnic University of Valencia and carried out in Valencia, Spain. The main task is to build an android mobile application using augmented reality(AR) to help people with functional diversity. People with functional diversity are people perform different from the majority people. And the main technical feature of AR is that it can overlay the virtual content onto the real world object. So after design and testing, the eventual outcome is an AR application called “*AR Workshop*” with a supportive book *AR Workshop*. This report will give a thorough description of this project and the expected outcomes and tasks first. Then this report will talk about the project from background, design and implementation, results and discussion to conclusion and further work. The background of this project is about its main technology augmented reality and its main users people with functional diversity, this report will provide definition of both concepts and summary the need of main user then the advantages and disadvantages of AR in the project to deliver the main context of usage of application. In design and implementation part, this report will introduce the design of software system mechanics and supportive book design details then talk about how the design implemented. At the end this report will present the user feedback from people with functional diversity in the occupational center “La Torre” including interviews and questionnaires then drop conclusions and further work to do.

### 1.1 Project Description

This is an implementation project about software development, the main 4 tasks of this projects are:

- (i) State of the art on apps using AR to helping people with functional diversity
- (ii) Design, implementation and testing of the app.
- (iii) Proposals for improvements according to the results of the test.
- (iv) Development of a User Guide. App available for download from a web server.

The main technology used in this project is augmented reality, this software is developed for android environment only and programmed using Unity3D and C# scripts. This software is designed for people with functional diversity and their supervisors only.

#### 1.1.1 Background of the project

Information technologies constitute a valuable tool of daily use for society. In this modern world, people are looking for a society that enable people in every conditions could enjoy their lives. And with a long time of lacking attention of diversity people today’s society has formed a stereotype bias about them which causes low self-esteem in diversity people and low social inclusion in some occasions. So in the case of people with functional diversity, these technologies can boost individual autonomy, thus increasing self-esteem and facilitating greater social inclusion.

#### 1.1.2 Aim of the project

The design, implementation and testing of the app that helps people with functional diversity is proposed in this project. Based on the augmented reality, this app will be able to making the environment much more understandable to the person with functional diversity. After researching and designing, this project will help people with functional diversity in workshop

context for their better understanding of daily work.

## **1.2 Project Goals**

### **1.2.1 Outcome of the project**

The main outcome of this projects are planned as:

- (i) People with functional diversity have an App that enriches their knowledge in real time about the environment where they are.
- (ii) Facilitate social interrelationships and self-esteem of people with functional diversity.
- (iii) Have a downloadable version of the App from a web server or another online platform.

The final outcomes are:

- (i) “*AR Workshop*” mobile application
- (ii) “*AR Workshop*” AR book
- (iii) People with functional diversity in “La Torre” occupational center are well satisfied about this app
- (iii) Supervisors of occupational center are believe this app and book will enrich knowledge of people with functional diversity and facilitate social interrelationships and self-esteem of people with functional diversity

## **Chapter 2: Background**

### **2.1 People with functional diversity**

People with functional diversity is a developing concept, its focus is on the perspective of society and human culture. It has some differences with the concept “disabled” or “handicapped” which are focusing on the body functions and physical performance. Here is an example to show the differences. With the rapid developing of technology, people’s life expectancy are longer than before and in this case the population of elder people is increasing and they are normally considered more likely have functional diversities such as: memory issues, ears and eyes are not shape as majority of people. Elder people are generally considered that they are unable to do such things or perform bad because of their age, so in this case “age” is not a “disability” but still some elder people cannot enjoy public things as the majority people and that is the difference between functional diversity and disability. The public designs are mainly focused on majority of people who have the enough capability to perform in public areas. That’s the main reason the concept of “functional diversity” are developed because an open and healthy society should allow everyone can enjoy the public things but not separate a mount of people from public due to their functional conditions. This report will give you a definition of the concept and analyse their need in the context of this project.

#### **2.1.1 Definition**

People with functional diversity refers specifically to people who perform certain functions differently than the average population so they are different than the statistical norm due to some reason[1]. So in this case, the context of people’s performance is of the vital importance .

#### **2.1.2 The need of people with functional diversity**

The concept of “people with functional diversity” appears within the last 2 decades, however the concept for “disabled” or “handicapped” has lasted a very long time. Thus today’s society has discrimination words for people with functional diversity and that decrease their self-esteem and social inclusion. Besides, it is estimated that 15 % of the world’s population[1] and 82% of people with disability who live in developing countries are below poverty threshold employment rate among people with disabilities was 25.9% in 2017[2]. So that promoting the labour integration of people with functional diversity is a key element to achieve their social inclusion[1]. In order to promote people with functional diversity’s labour integration and improvement in social inclusion, this project is designed to give them a better understanding in workshop learning context.

### **2.2 Augmented Reality**

Augmented Reality technology has witnessed significant development, transforming the way we interact with the digital world. This evolution is marked by advancements in hardware, software, and applications, fostering a seamless integration of virtual elements into the real environment. AR has been propelled by innovations in mobile devices, wearable equipment , and spatial computing, enabling immersive user experiences.

### 2.2.1 Definition

We define Augmented Reality as a real-time direct or indirect view of a physical real-world environment that has been enhanced/augmented by adding virtual computer-generated information to it[3]. It is a medium in which digital information is overlaid on the physical world that is in both spatial and temporal registration with the physical world and that is interactive in real time[4].

### 2.2.2 Technological principles

AR technology is depending on computer vision technology and generally it has six steps to deploy in this case and shown in figure 1:

- (i)Collect real-time video through the phone camera and identify symbols;
- (ii)After identifying a target symbol, use it as a reference to determine the position and direction of the animation to be generated in the AR environment and store these parameters in the phone;
- (iii)Digitize the collected video stream into images, and then identify the identification marker through a series of processes such as feature point detection, feature point descriptor generation, and feature point matching mentioned above;
- (iv)Match the identification symbols with the preset target image;
- (v)The animation (virtual information) is rendered into the video stream.
- (vi)The program adjusts the animation based on the position of the marker (virtual information)

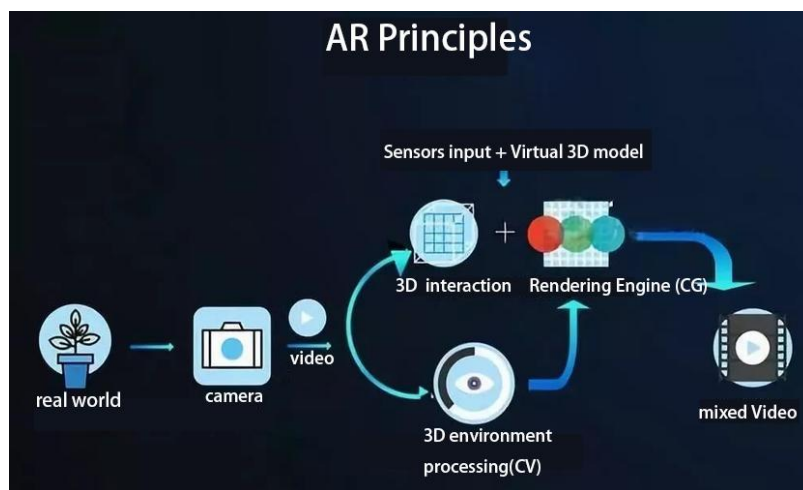


Figure 1 AR principle

### 2.2.3 Advantages and disadvantages

There are lots of researches to help people with functional diversity with their labour integration but little of them are using information technology like AR technology most of the researches are using the tradition ways to transit based on the kind of disability, educational background and duration of the program are dimensions that could have an impact upon intervention[5]. Researches about AR and functional diversity has mentioned that AR has the potential to support individuals with special needs and to enable their development of daily

## Augmented Reality and People with Functional Diversity

living skills[6]. So advantages of AR technology in helping people with functional diversity are:

(i)Enhanced Learning and Comprehension: AR can transform learning experiences for individuals with cognitive or learning disabilities. It can overlay text with images, sounds, and interactive elements that can be tailored to an individual's learning needs, helping to improve understanding and retention.

(ii)Navigation and spatial understanding: For people with visual impairments or spatial orientation challenges, AR can provide real-time, audio-visual navigation cues through smart glasses or mobile devices.

(iii)Communication and social interaction: AR can assist individuals with speech or hearing impairments by providing visual aids or sign language interpretation through smart devices. For those on the autism spectrum, AR can offer social stories and scenarios in a controlled, interactive environment that helps in developing communication skills and understanding social cues.

However, AR technology is strictly dependent on computer vision technology and devices. So that some people still cannot enjoy the benefits from it such as blind people and those with hand-brain coordination issues. So that disadvantages are:

(i)Accessibility and usability issues: AR technology often requires a certain level of motor skills and coordination to interact with. For those with motor impairments or fine motor challenges, the interfaces might not be easily usable. If the technology is not designed with accessibility in mind, it could exclude users with physical disabilities from benefiting from AR applications.

(ii)Dependence on technology: There's a risk that reliance on AR for daily tasks could lead to a dependence on technology, which might inhibit the development or use of personal skills and strategies to navigate the world. For example, constantly relying on AR for navigation could impact one's natural sense of direction or memory of routes.

(iii)Heath issue and 3D vertigo symptoms: The long time usage of AR technology means a long time focus on the screens and electronic devices. For people with functional diversity, their time of attention is much shorter than the majority of people therefore they are more easily affected by screens due to the fixed field of view and spinning environment and causing some health issues.

## Chapter 3: Design and Implementation

The main designs of this project are an android AR app and an AR book. In this project the context of helping people with functional diversity is workshop learning. And after interviews with supervisors in the occupational center, the main direction is to help workshop study in artwork workshop. The main reason to make a book to support this app is that in order to deploy AR technology, it must have an object from real world either to give the reference for the transformation between real world coordinate and camera coordinate or for object detection as for target. In this case, the book is a great choice because it can provide multiple targets in one object. The targets in the book are image targets which are more fault tolerance and stability.

### 3.1 Software application design

This report will show the application design from the development environment including: programming editors, programming language and programming tools.

#### 3.1.1 Development environment

This application is developed using Unity3D as shown in figure 2:

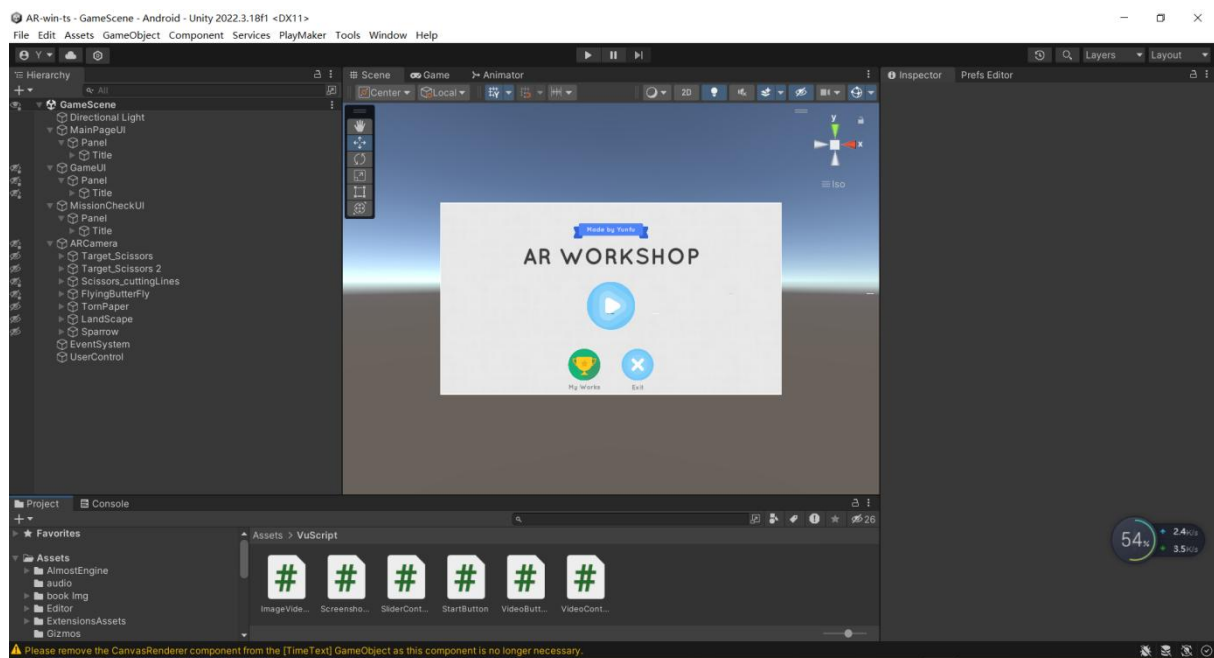
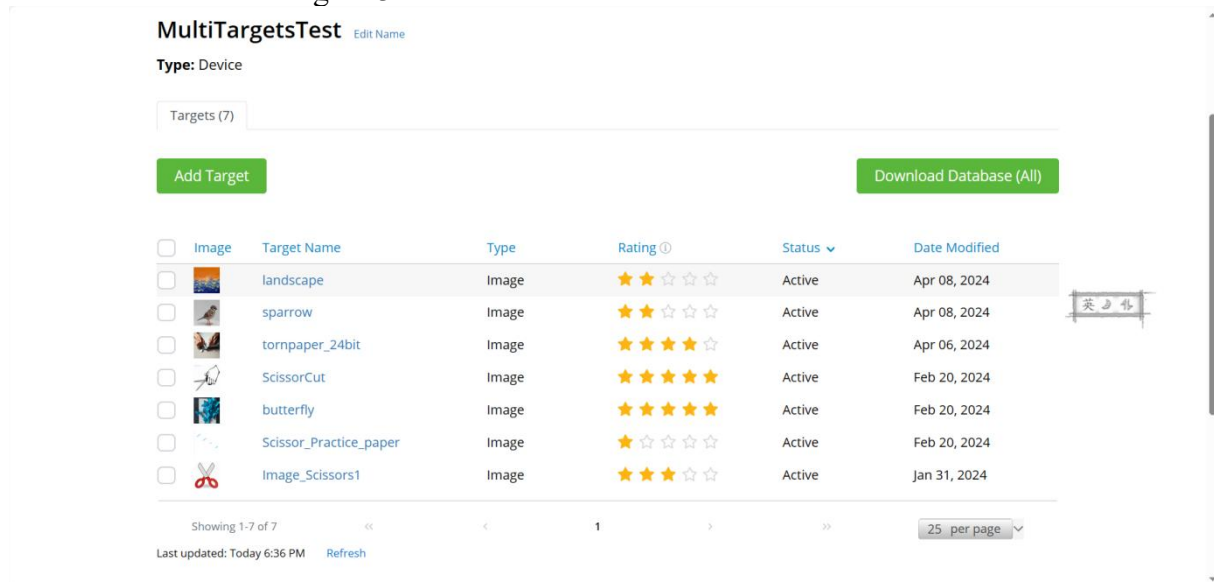


Figure 2 unity3D development

Unity3D is a popular cross-platform game engine, it can be used to develop two-dimensional(2D), three-dimensional(3D) and interactive simulations like VR and AR. Compared to other game engines and editors such as Unreal Engine, unity3D has more support in AR field and less costs for indie developers. So that it is a well tool for this project. Unity3D solutions are compiled in C# languages and so C# scripts are used to create functions for applications. AR technology is deployed by AR Core and Vuforia Engine software development kit(SDK) in Unity 3D. AR Core is an open source tool developed by Google company for creating AR applications in android environment, also it is a vital essence for android AR application. Vuforia is an AR SDK for mobile devices that enables the creation of augmented reality applications. Its main features is the easy access for targets



detection as shown in figure 3:



**Figure 3 Vuforia targets database**

It uses computer vision technology to recognize and track planar images and 3D objects in real time. This image registration capability enables developers to position and orient virtual objects, such as 3D models and other media, in relation to real world objects when they are viewed through the camera of a mobile device. The virtual object then tracks the position and orientation of the image in real-time so that the viewer's perspective on the object corresponds with the perspective on the target. It thus appears that the virtual object is a part of the real-world scene. Because this project is about Android environment development and image target detection so that AR Core and Vuforia are used in developing this application.

### 3.1.2 Software system mechanics design

Software mechanics will be divided by functions and users need:

#### i) Work shop learning

The application is designed to cooperate with a book to learn contents in particular workshop so that its main function is to scan on a image to show content that will be used in particular sessions including: video, text, animations as shown in figure 4:

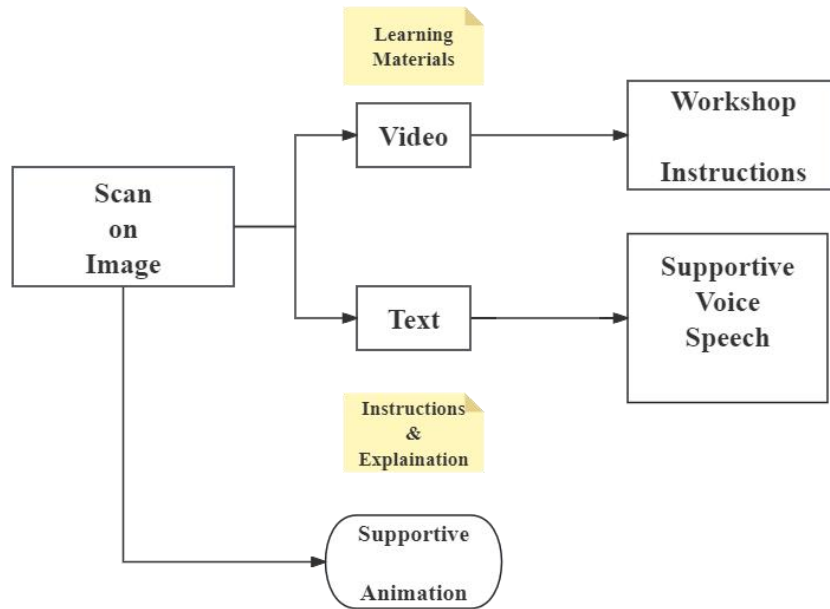


Figure 4 Scan image diagram

The idea is that it can show learning materials and instructions in workshop study.

ii) Learning process recording

And another important part of learning is recording what you have learned and in this case this application should have a screenshot function that will record the content in the current camera. Then there should be a system to show screenshots as to review learning process. So the mechanics is shown in figure 5:

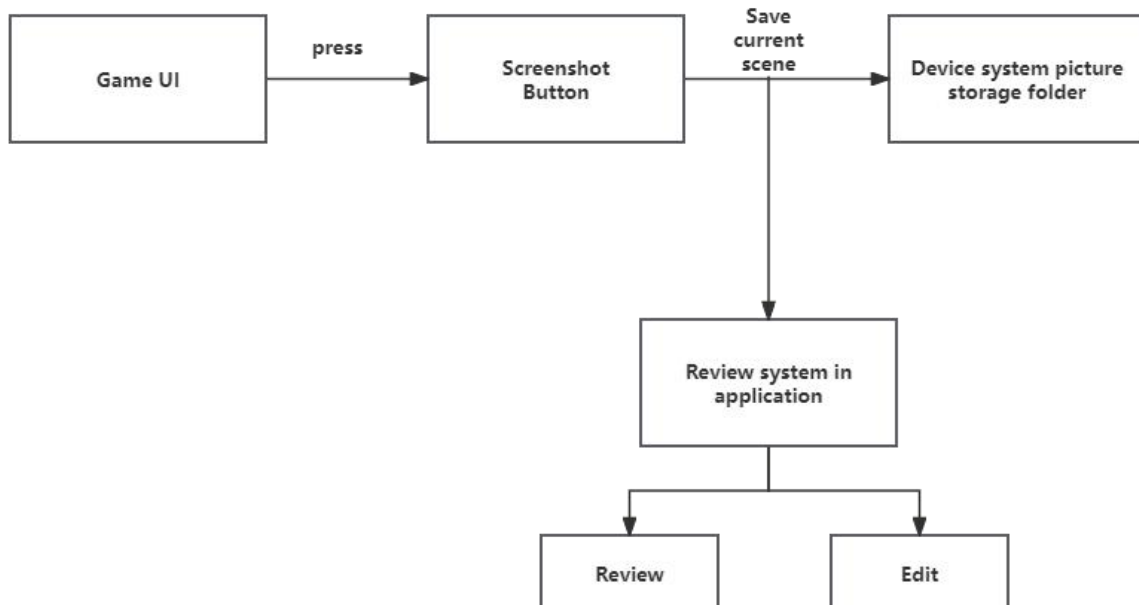


Figure 5 Review system diagram

### 3.1.3 User-interface design

This application is designed for people with functional diversity so that the user-interface(UI) design should be as simple as possible to make it clear to people. And here is the UI design diagram shown in figure 6:

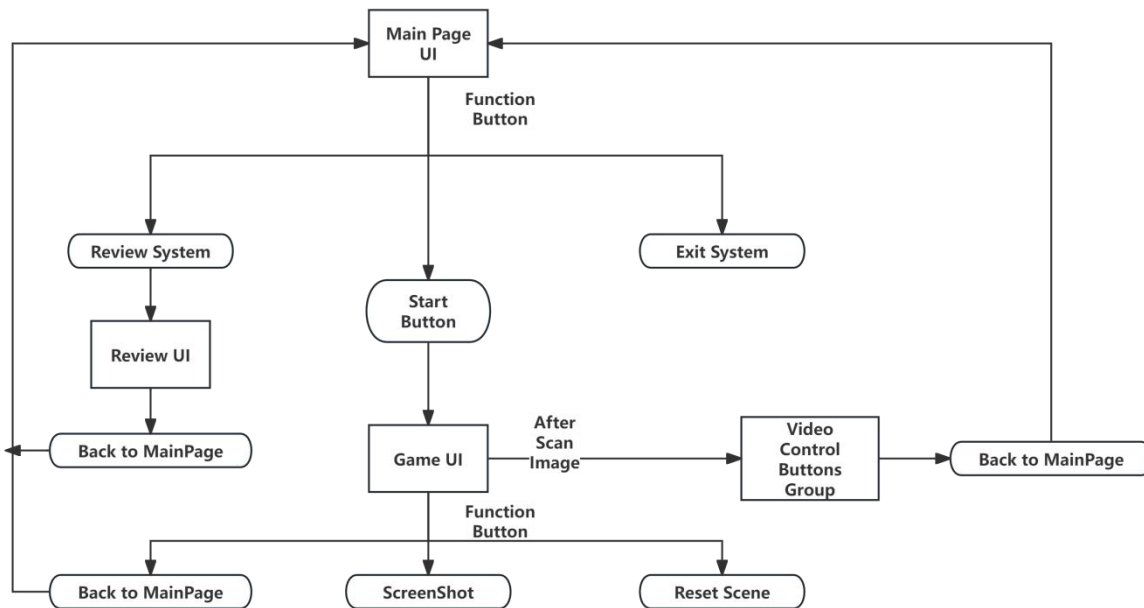


Figure 6 UI diagram

As shown in the figure 6, there is only 3 UI in this application to do all the things including: main page UI, review system UI and game UI . And they all have some function buttons. In main page there are three function buttons: start button, exit button and review button. Start button will lead to the Game UI and review button will lead to review UI and exit button will shut down the whole system to exit application. In the game UI there are three buttons at first including: back button, screenshot button and reset button. The back button will shut down the current UI and back to the main page UI. The reset button is to reset objects in the current scene in case something unexpected occurred and as for the screenshot button, it is simply take a screenshot and play a sound effect. And when a image is scanned and the full screen mode is active in video plane the game UI will active its video control buttons group to control buttons including: pause, play, forward, backward and replay. In review UI there is a buttons group to control image including: next image, previous image and delete image with a back button.

## 3.2 Supportive book design

The book is design to provide image targets for the application and instructions about the workshop learning. So that these are two main functions about this book. In this case the name of the book is *AR Workshop*.

### 3.2.1 Reading logic design

In order to help people with functional diversity in workshop learning, it is very important to have a proper level setting. So that the reading logic is focused on level of learning based on how hard to perform and how to lead them to use their imagination which is extremely hard

for them and to create artwork themselves without instructions in the book. The reading logic is shown in figure 7:

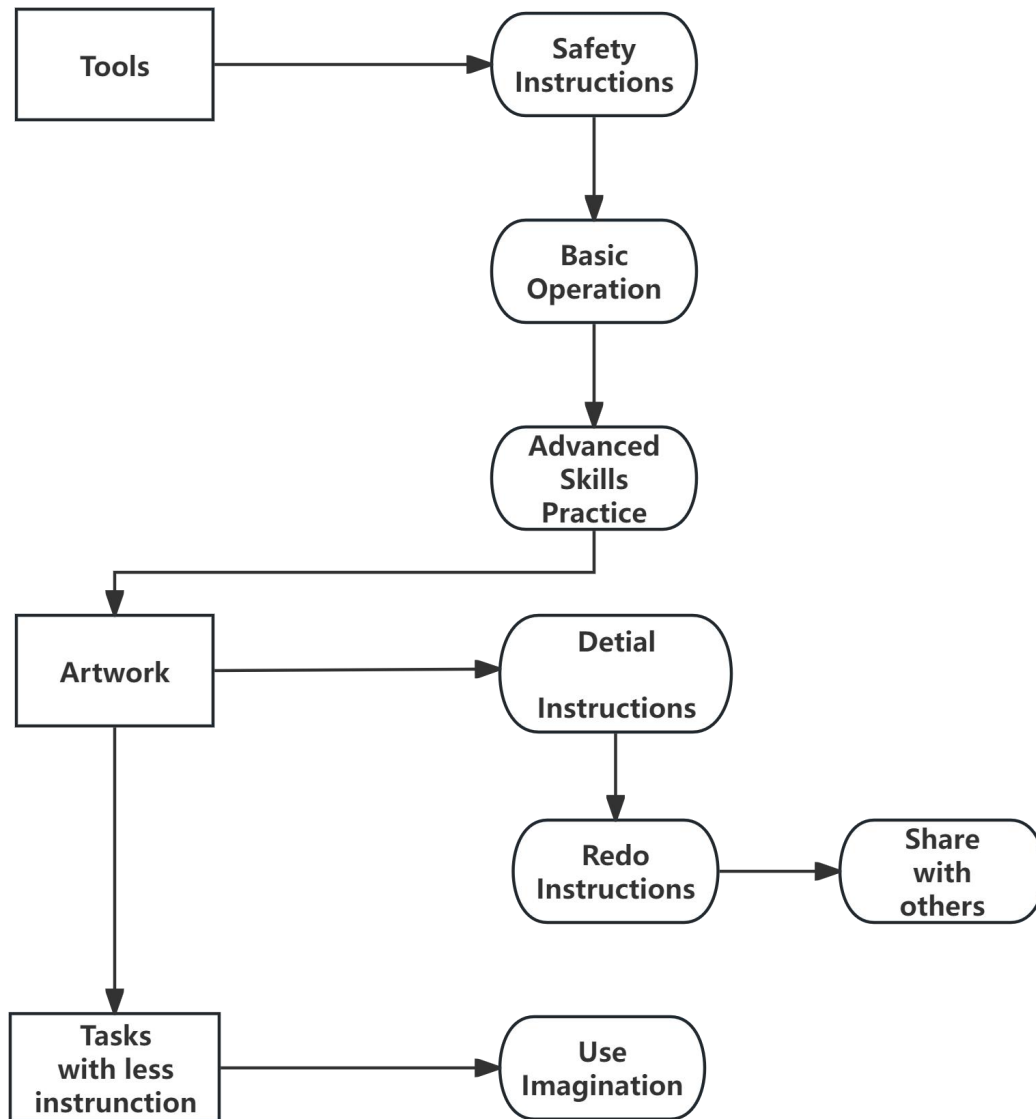
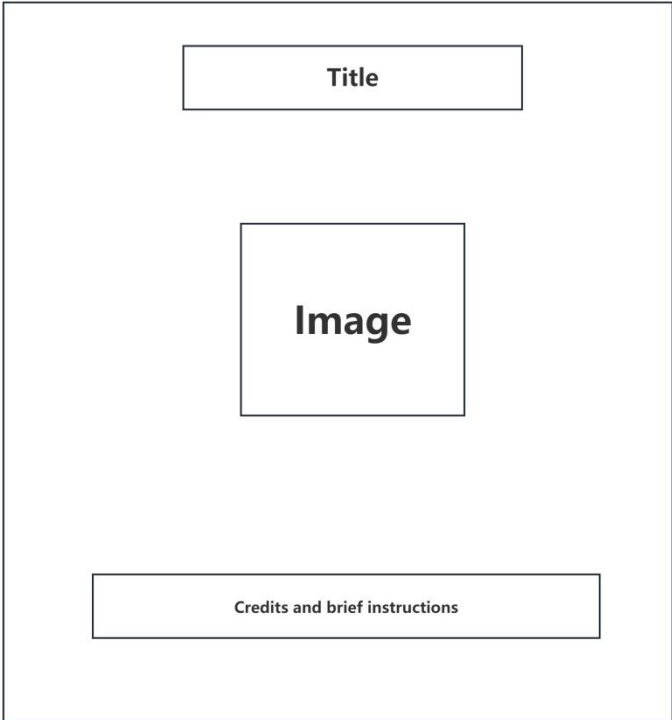


Figure 7 Reading logic diagram

The basic logic to learn about a workshop is to learn the tools first and make artworks in the book then create something with their imagination with less instructions. As for tools learning, safety is always the number one concern and especially for people with functional diversity because some of them having bad controls of hand or left-handed and most tools are designed for right-handed people. After learning how to use tools safely, then learning how to operate basic behaviors using a particular tool then advanced skills practice. As for artwork, the book will provide images and texts instructions but some of people with functional diversity cannot read characters in any language or comprehend the logic between words so that it is important to make it clear with enough visual and sound support. After redo the instructions in the book, the book will encourage users to share with their friends. One of the ways to inspire imagination is to discuss with other people. The final aim of this book is to make people with functional diversity could create and inspire their imagination into reality.

**3.2.2 Appearance design**

The book is designed for people with functional diversity so that the content must be clear and easy to comprehend. And in this case the design of the cover page is shown in figure 8:



**Figure 8 Cover page design**

The book will be in A4 format so that it is possible for people in the occupational center to print in anytime. Here is the general page design shown in figure 9 :

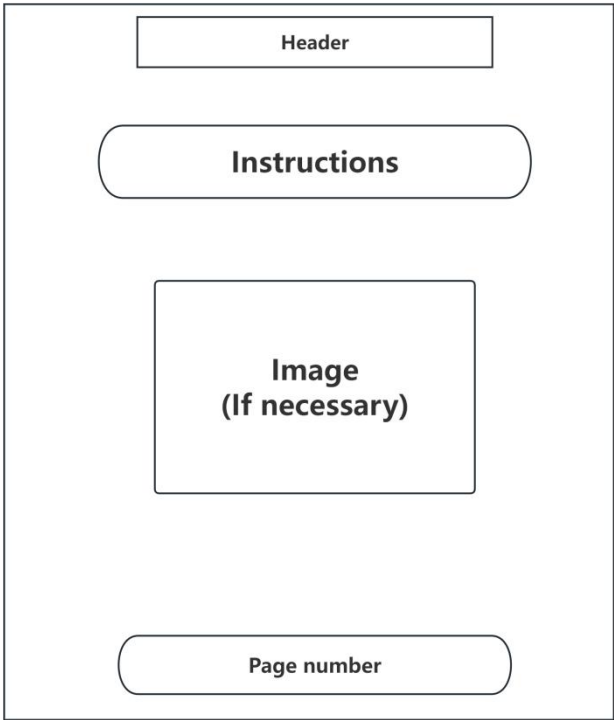


Figure 9 General page design

### 3.2.3 Software-book interactive mechanics design

This project is the combination work of software and book in order to deploy AR technology so the interactive mechanics design is shown in figure 10:

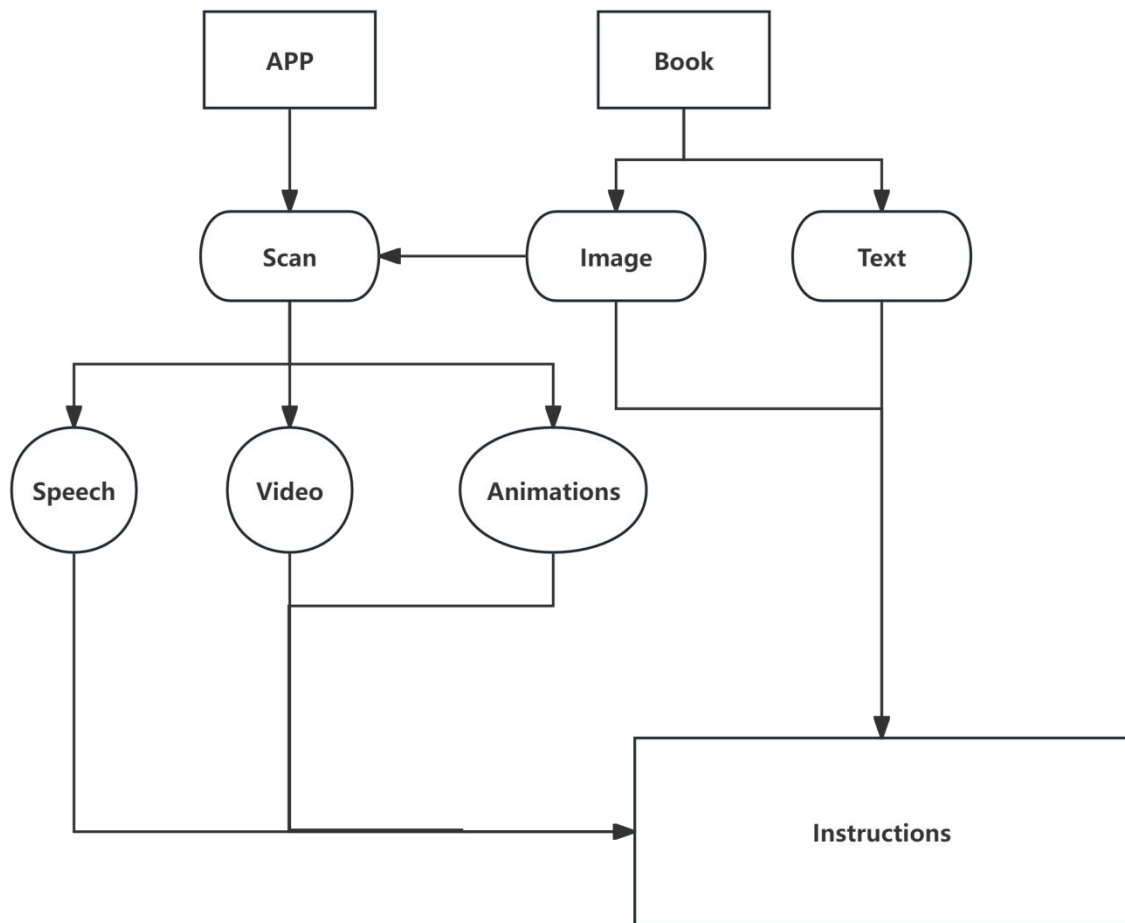


Figure 10 Software-book design

The book provide image targets for the application to scan and the application will provide voice speech, video and animations according to the particular content. The book will provide image and text instructions at the same time. This combination of multimedia instructions create a thorough instructions about workshop.

## 3.3 Project implementation

Project implementation including two parts which are book implementation and software implementation. In book implementation will show the book page and content. In software implementation will show the implementation in editors and in-game experience.

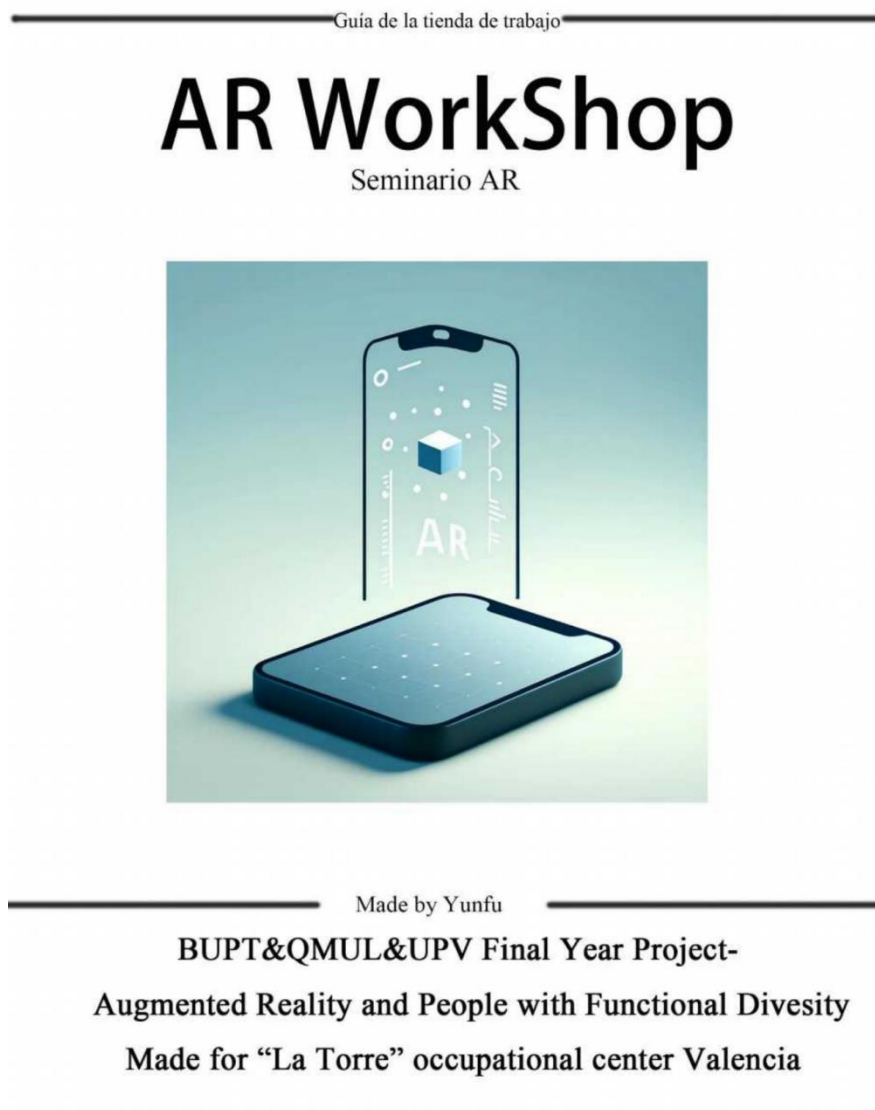
### 3.3.1 Book implementation

After discussion with supervisors in the occupational center where the core users living and working. The main theme of this book is about paper work including paper cutting and torn

Augmented Reality and People with Functional Diversity

paper to create art.

The cover page implementation is shown in figure 11:



**Figure 11 Cover page**

The general page with instructions and images implementation is shown in figure 12:

Los talleres artesanales comienzan  
**Tijeras**  
Antes de hacer algo, veamos cómo  
**¡Cuidado!**  
Siga las siguientes instrucciones:  
1. ahora abra la aplicación "ar workshop"  
2. escanee las siguientes imágenes para  
verlas  
Instrucciones de Seguridad  
**¡Vamos!**

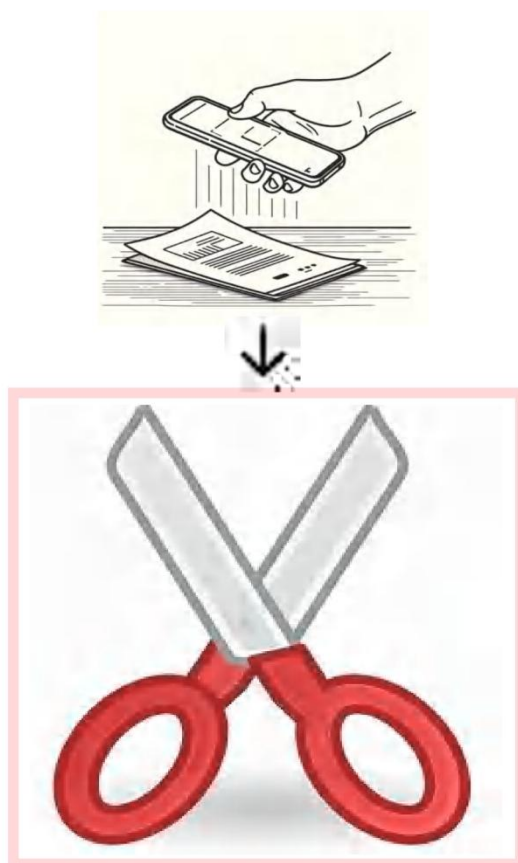


-1-

**Figure 12 General instructions page**

The general page with instructions and images for people that cannot read implementation is shown in figure 13:





-2-

**Figure 13 General page for people cannot read**

The general page for animations implementation is shown in figure 14:

Debes haber dominado las herramientas.  
Ahora hagamos algunas tareas desafiantes.

## Mariposa voladora



-8-

**Figure 14 Page for animations**

In order to practice advanced skills the book provide special page for practice use as shown in figure 15:

Scissors  
Practice  
Use  
Paper

-6-

**Figure 15 Scissors practice paper**

This page need the app to scan on it to show the lines for practice and in this case the book provide sample papers for people that cannot operate such moves as shown in figure 16:

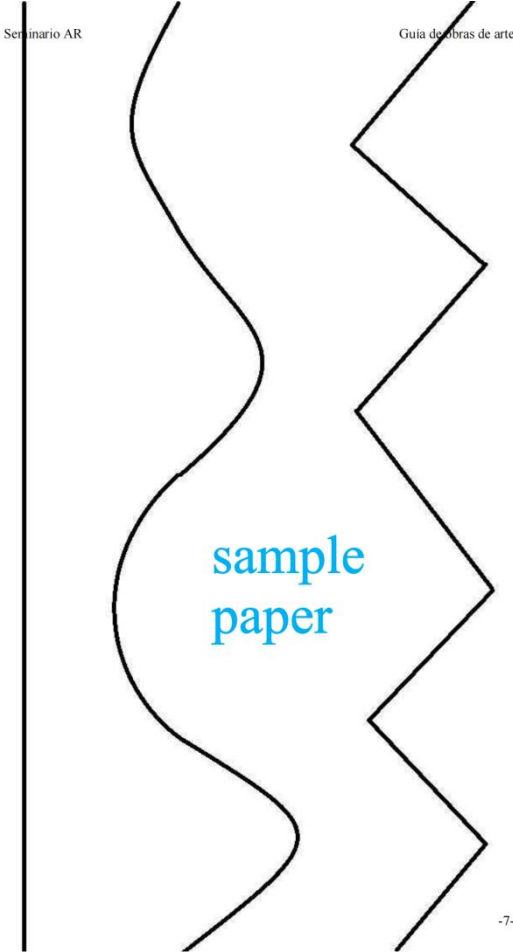


Figure 16 Scissors sample paper

The practice practice for people that cannot read is shown in figure 17:



-5-

**Figure 17 Practice instructions for people cannot read**

This version of book has 24 pages and provide practice sessions for 2 tools which are scissors and paper-torn, also provide instructions for 3 artworks of 3 different kinds including: painting(landscape), paper cut(flying butterfly) and the complex combination of both(paper sparrow). As shown in figure 18, figure 19, figure 20 and figure 21:

# Augmented Reality and People with Functional Diversity

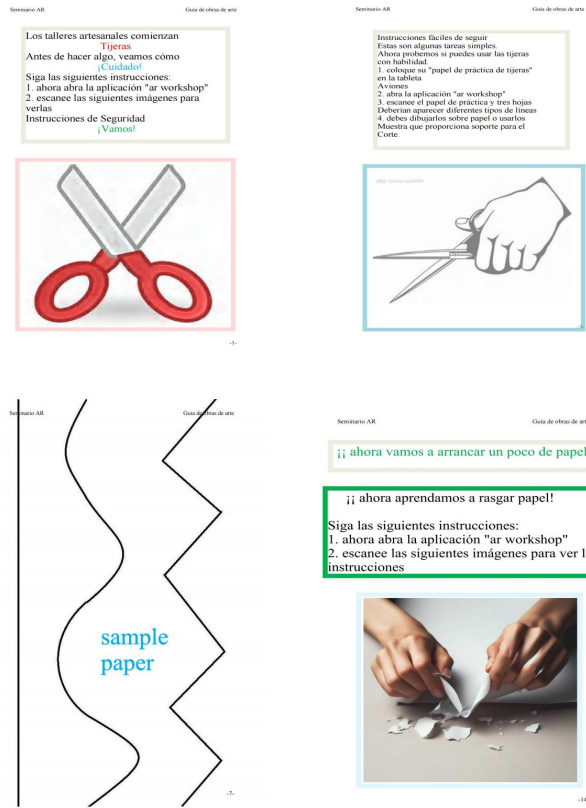


Figure 18 Tool learning pages



Figure 19 Artwork-Landscape

# Augmented Reality and People with Functional Diversity

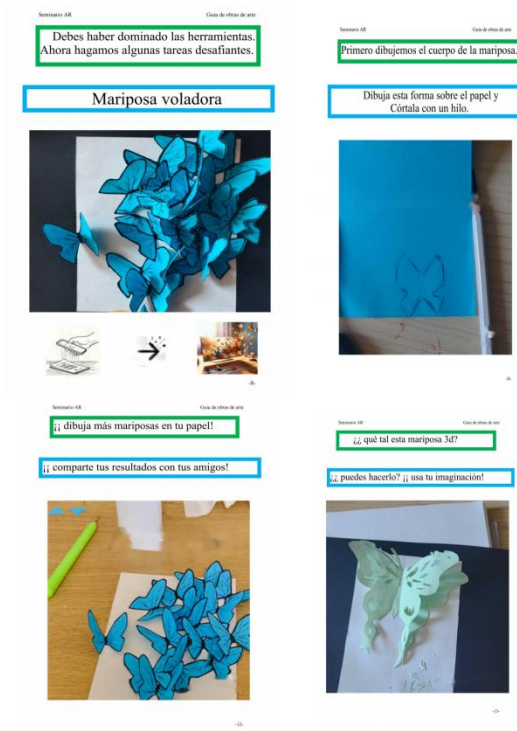


Figure 20 Artwork-flying butterfly



Figure 21 Complex artwork- paper sparrow

## 3.3.2 Software implementation

First introduce the functions implementations in software design:

i) Video functions

The video plane designs in Unity3D editor is shown in figure 22:

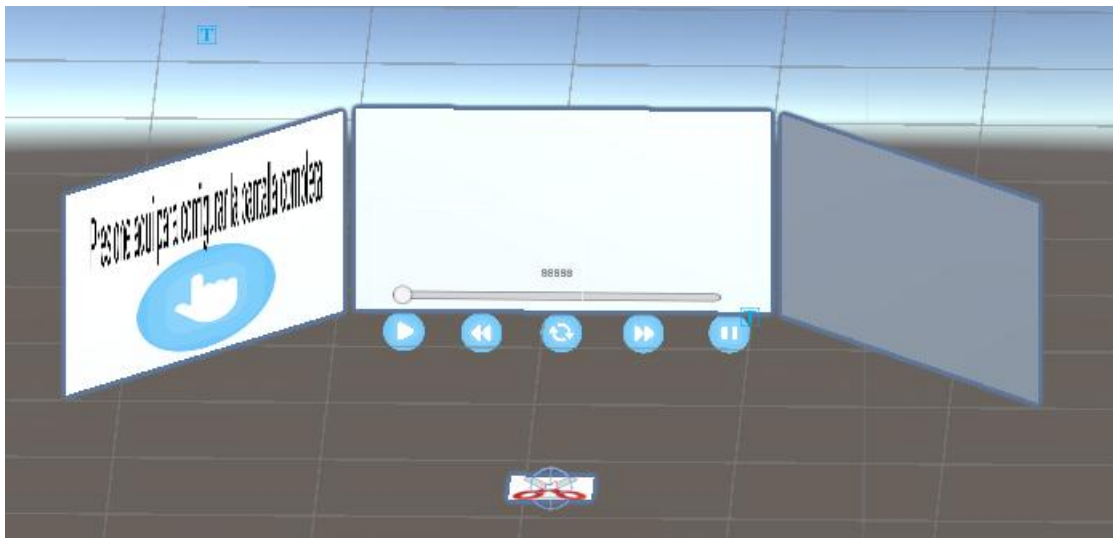


Figure 22 Video Plane design in Unity3D

The video implementation in application is shown in figure 23:

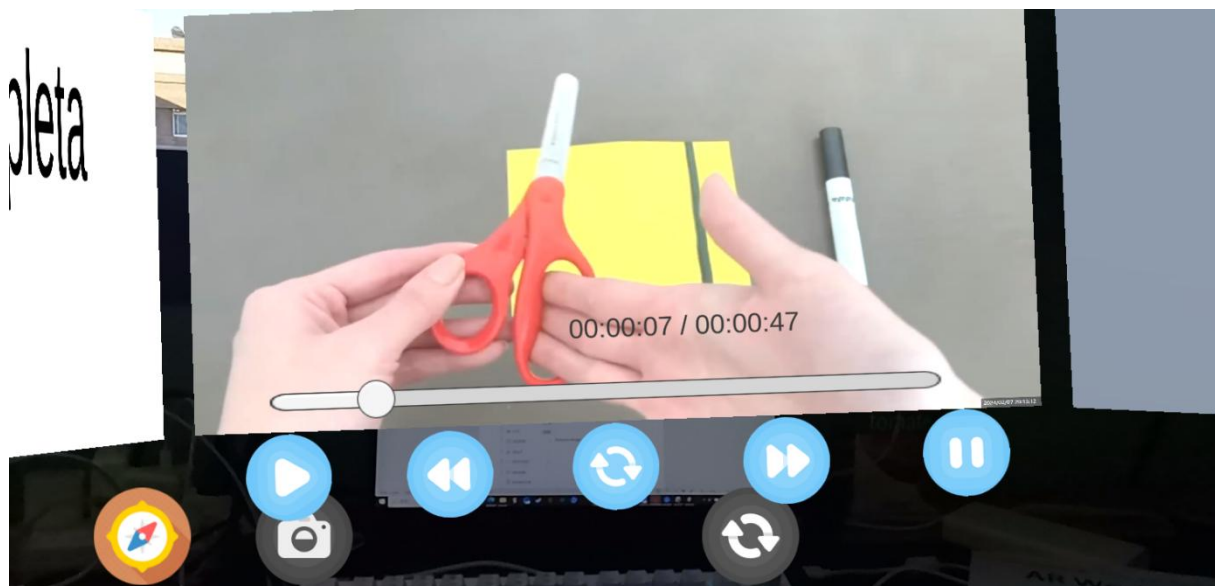


Figure 23 Video Plane

When scanned on particular image about video instructions three planes will appear and in figure 5 it is the video plane. It is a self-made video player control system based on Unity3D video player. There are five blue buttons and their functions are (from left to right): play, backward, replay, forward and pause with a text showing the timeline of this video. Here is the plane left to the video plane where can set the video to full screen mode with a trigger button and a text in Spanish which means “Press here to set full screen” as shown in figure 24:



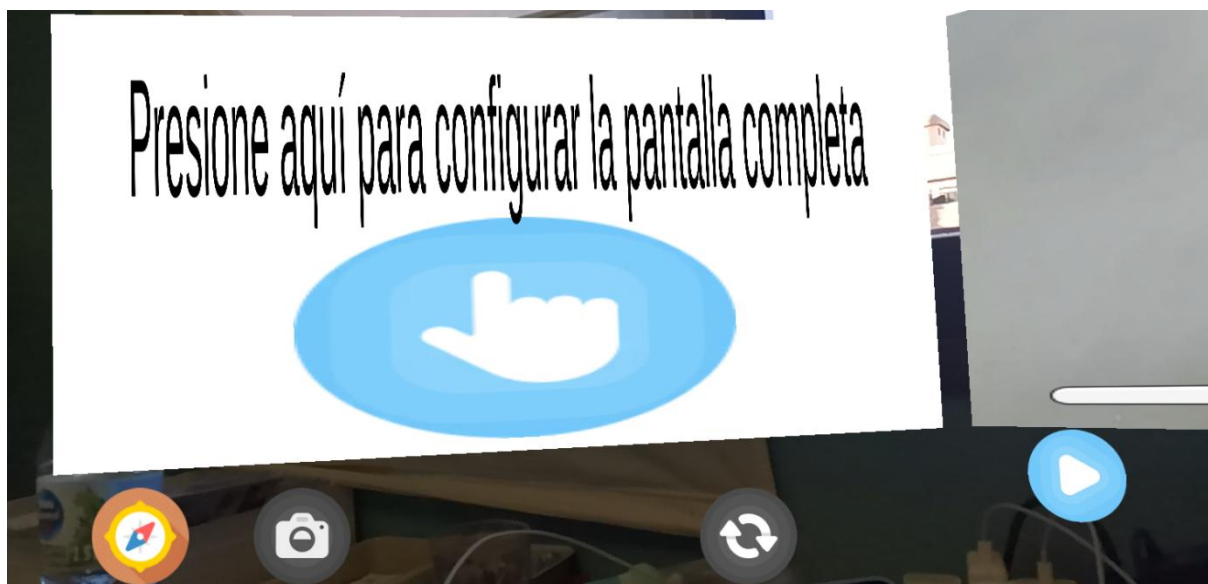


Figure 24 Full screen mode plane

And here is a blank plane right to the video plane that is for further functions as shown in figure 25:

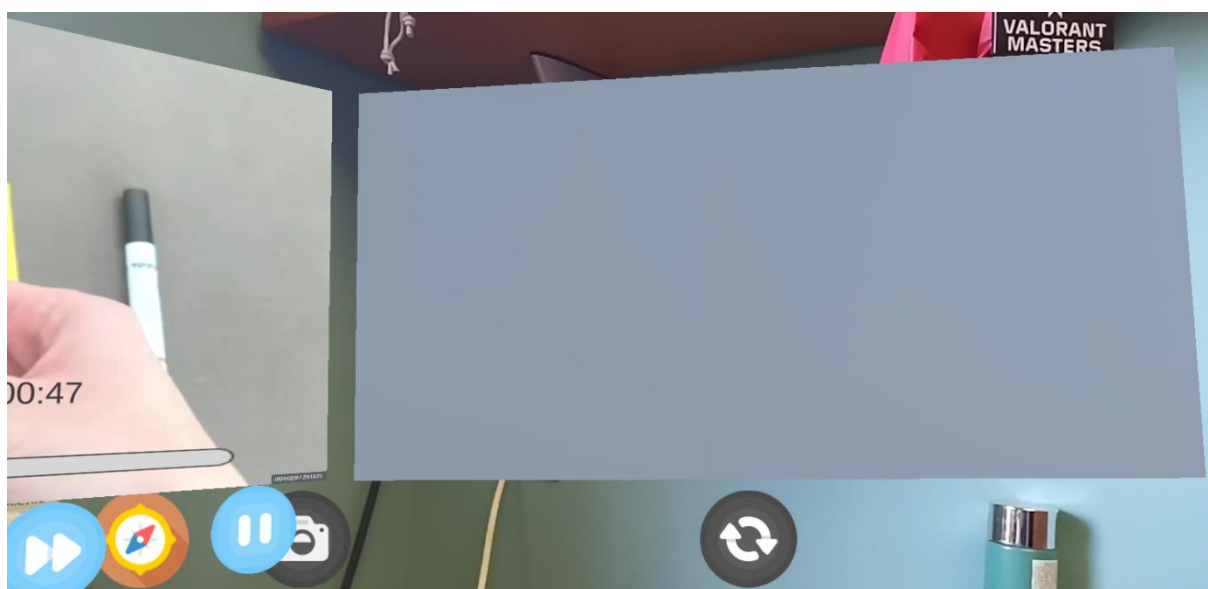


Figure 25 Blank plane

## ii) Animation function

To keep things interesting and providing more visual support for people functional diversity which is vital in teaching and helping them, after scanning on some particular images some animations related will appear as shown in figure 26 and figure 27:

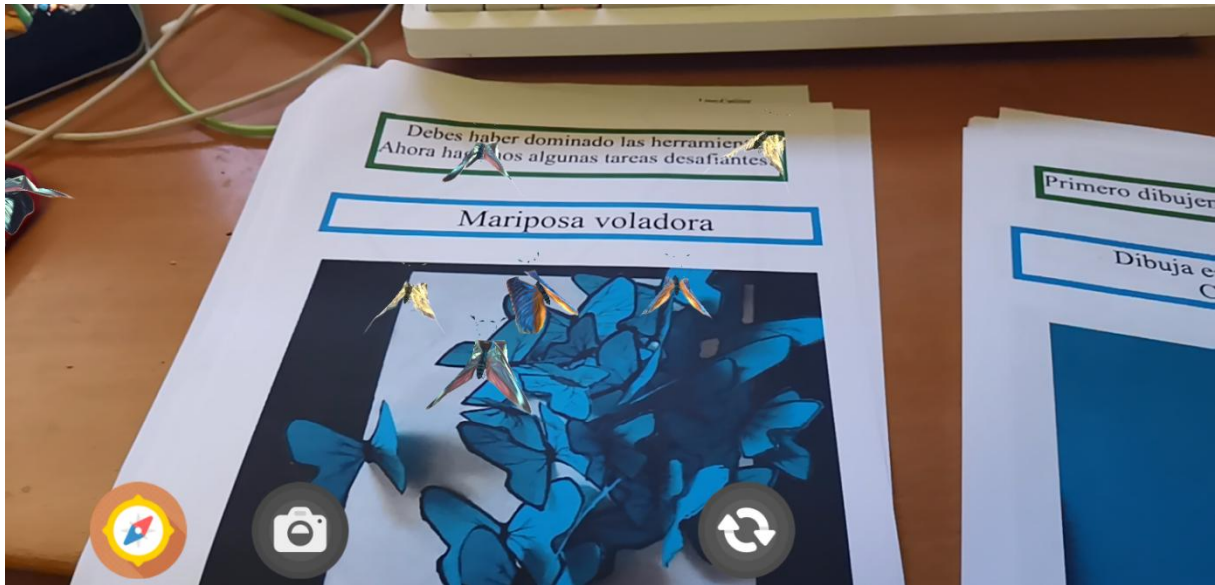


Figure 26 Flying butterflies



Figure 27 Flying sparrows

Models in animations are bought from Unity assets store which is a platform for indie developers to get and sell assets for Unity3D application development.

The models in Unity3D editor is shown in figure 28 and figure 29:



Figure 28 Sparrow in Unity3D

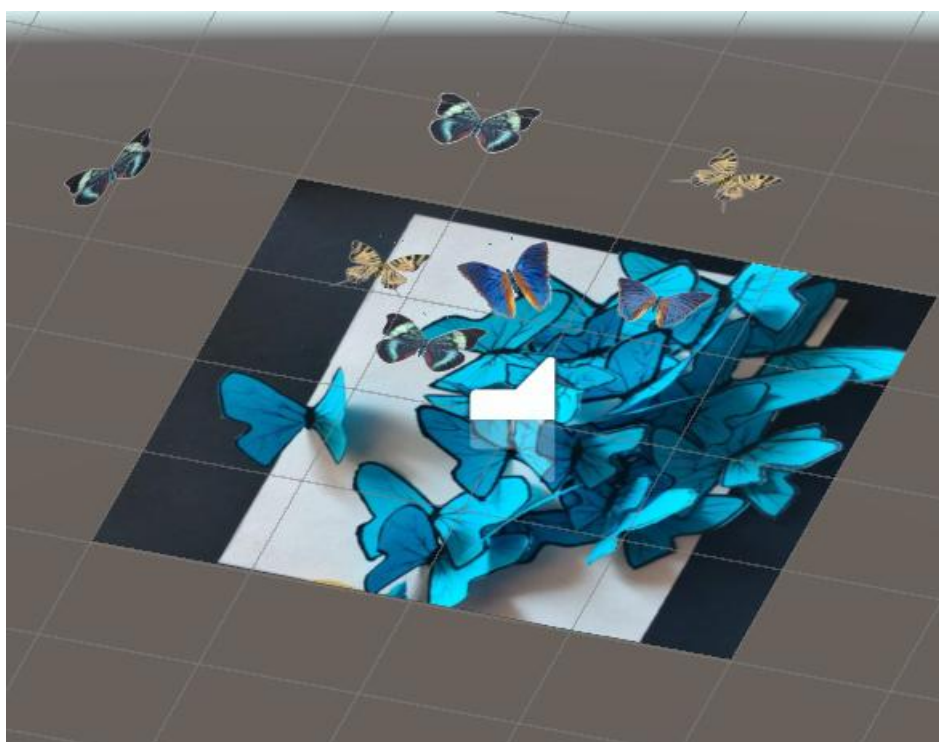


Figure 29 Butterfly in Unity3D

### iii) Voice speech support

Voice support is also very important in helping people with functional diversity because a majority of them have issue with reading and writing words. So that every time a scan-able image is scanned, a voice speech in Spanish will be automatically played. The content of voice speech is the same as the instructions in the page where the image is scanned. The custom voice speech is made by an open source text to speech website “[www.text-to-speech.cn](http://www.text-to-speech.cn)”.

Then introduce implementations in UI design :

- i) Main page UI

The main page UI is shown in figure 30:



**Figure 30 Main page UI**

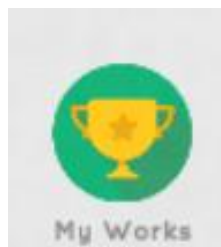
There is a title of this application “AR WORKSHOP” and a ribbon that shows the developers name “Made by Yunfu”.

The button in figure 31 is the start button:



**Figure 31 Start button**

The button in figure 32 is the review button:



**Figure 32 Review button**

The button in figure 33 is the exit button:



**Figure 33 Exit button**

ii)Game UI

The game UI when video full screen mode is not active is shown in figure 34:

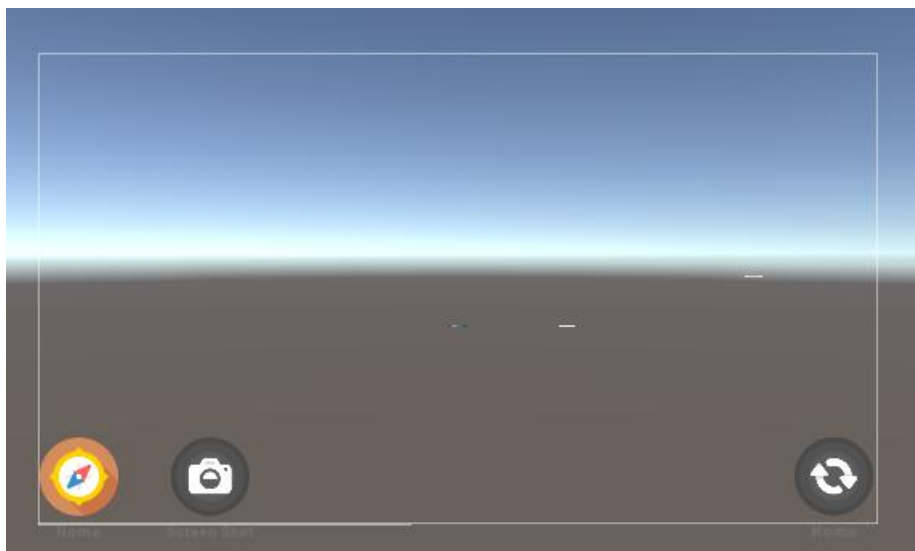


Figure 34 Game UI (full screen not active)

The functions of buttons from left to right are: back to main page, take a screenshot, reset the scene.

The game UI when video full screen mode is active is shown in figure 35:

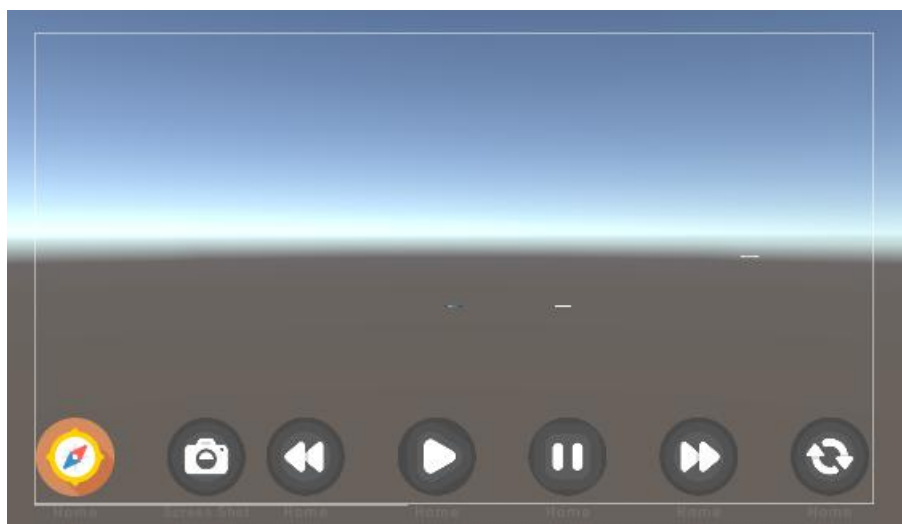


Figure 35 Game UI(full screen active)

The video control buttons group is the same in the video plane in figure 22 and figure 23.

ii)Review system UI

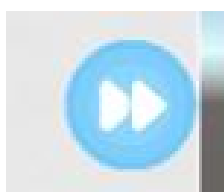
The review system UI is shown in figure 36:



**Figure 36 Review system UI**

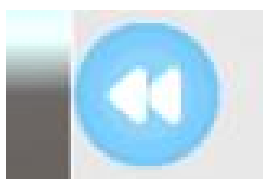
The title above in Spanish means “Review your work” in English.

The button for switching to next picture is shown in figure 37:



**Figure 37 next picture button**

The button for switching to previous picture is shown in figure 38:



**Figure 38 previous picture button**

The button to switch back to the main page is shown in figure 39:



**Figure 39 Back button in review UI**

The area that showing pictures is the white area in the middle of the UI plane.



## Chapter 4: Results and Discussion

The most important result in this project is its feedback from people with functional diversity users in the occupational center and their supervisors. And as for their capability, only few people can write and read and few people have the ability to use smart phones there is a rather low number of test times and testers. The results including: interview pictures with faces and questionnaires with names are authorized by the supervisors and the occupational center to use in this report and in order to protect the privacy of people with functional diversity please do not reuse any of the pictures in this report besides the research of people with functional diversity.

### 4.1 Project results

The results of this project is its user feedback and outcomes. User feedback is in the form of questionnaires and the outcome is a book and an downloadable android application.

#### 4.1.1 User feedback

Due to the time schedule with the occupational center the project has two precious tests.

i) First test with supervisors in occupational center

The picture of first test with supervisor(person in the yellow shirt) is shown in figure 40:



Figure 40 First test on-site picture

Here is the questionnaire for the first test in English version shown in figure 41:

# Augmented Reality and People with Functional Diversity

## AR workshop First test users questionnaire

Date:

Name:

1. Do you like the content of this book?

(Rate from 1 to 10)

2. Do you like the way of using this app?

(Rate from 1 to 10)

3. Do you think this will be helpful?

(Rate from 1 to 10)

4. Do you want a Spanish version of book or app?

(Yes or No)

5. Do you think it is too easy for you or too hard to use?

(Rate from 1 to 10)

6. Do you think the content is too easy for you or too hard for you?

(Rate from 1 to 10)

7. What are your expectations of this app?

8. What workshop themes do you want?

9. How do you want this app to help?

10. What do you like to see more on this app about AR?

11. What data do you want to know? (This question is for center staff only)

### Figure 41 First test questionnaire English version

Here is the questionnaire filled by the supervisor in Spanish version shown in figure 42:



# Augmented Reality and People with Functional Diversity

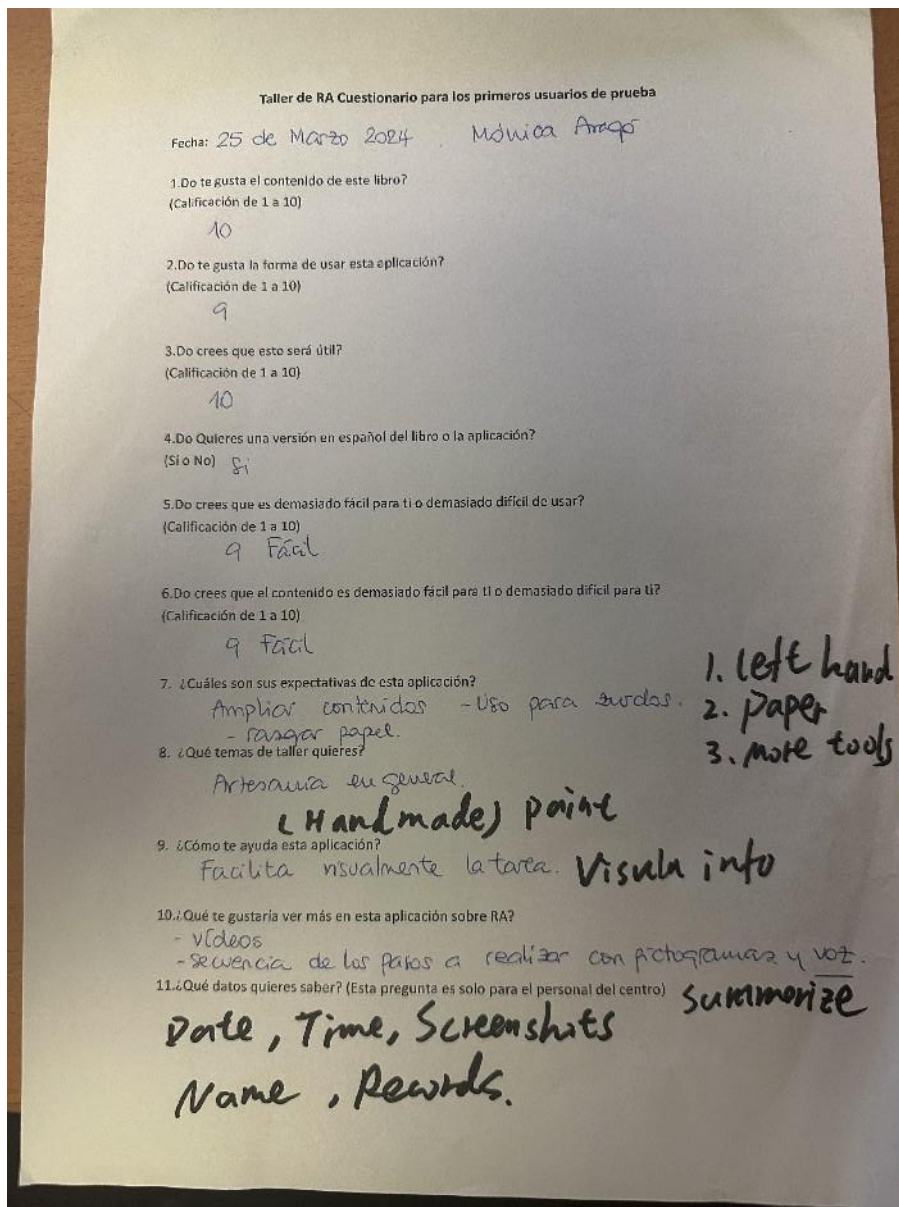


Figure 42 First test questionnaire

The questions in Spanish version is the same as the English version the only difference is language.

Here is the picture of the feedback collection for the first test shown in figure 43:



**Figure 43 First test feedback collection**

ii) Second test with people with functional diversity in occupational center  
The picture of second test feedback collection are shown in figure 44:



**Figure 44 Second test feedback collection 1**

Here is the pictures of testing shown in figure 45, figure 46 and figure 47:



Figure 45 Second test on-site picture 1

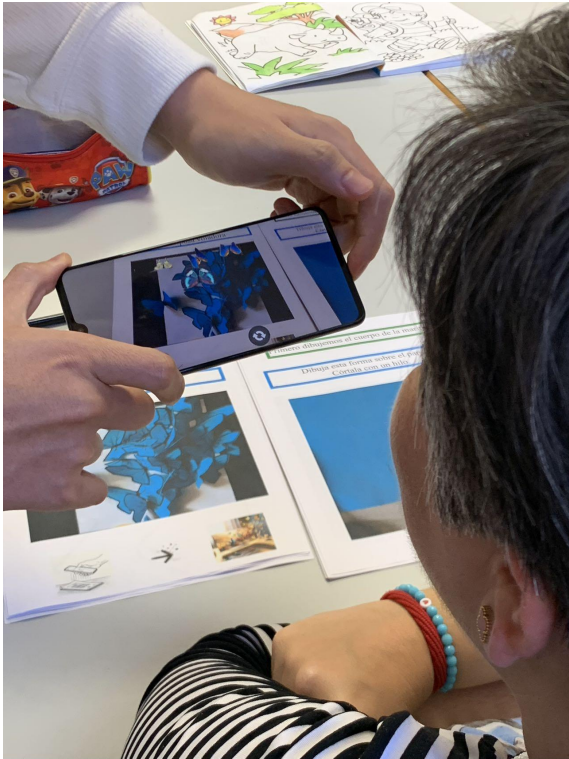


Figure 46 Second test on-site picture 2



**Figure 47 Second test on-site picture 3**

In figure 43 the supervisor is writing for the person with functional diversity (person in the pink shirt) because the disability in reading and writing words.

The questionnaires for the Second test is shown in figure 48:



## AR Workshop Second Test Questionnaire

Name:

Date:

1. Do you like the content of this book?

(Rate from 1 to 10)

2. Do you like using this app?

(Rate from 1 to 10)

3. Do you think this will be helpful?

(Rate from 1 to 10)

4. Do you think the content is too easy for you or too hard for you?

(Rate from 1 to 10)

5. What are your expectations of this app?

6. What part of this app do you think should have some improvement?

7. Do you prefer the video tutorial (butterfly & sparrow) or the text tutorial (Landscape) or both or both not?

8. What do you like to see more on this app about AR?

9. Do you prefer the "Use your imagination" part or more detailed tutorial?

10. How do you like the instructions on the book?

**Figure 48 Second test questionnaire**

The questionnaire for the second test collected are shown in figure 49:

# Augmented Reality and People with Functional Diversity

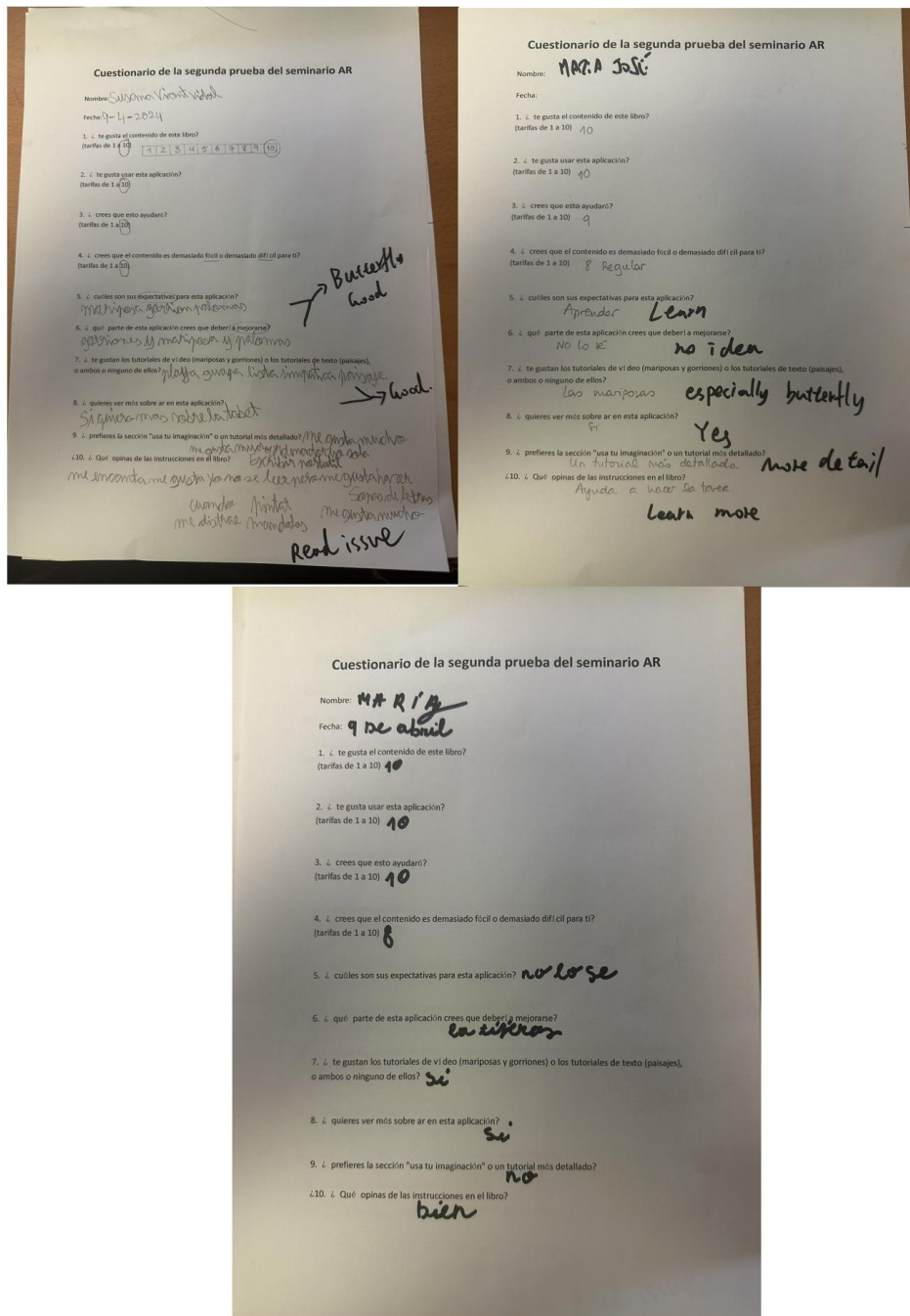


Figure 49 Second test questionnaires collected

The 4 testers are selected by supervisors in the occupational center out of over 40 people with functional diversity. They have the ability to speak their words and use mobile phones.

## 4.1.2 Outcomes

### i) Practical outcomes

The practical outcomes of this project are an open source printable e-book and an android application that can be downloaded in Google Play Store which is a platform for android application.

### ii) Successful design and implementation

After interviews and questionnaires in testing supervisors and people with functional diversity

in the occupational center. All of the testers are very satisfied with the content of the book and the using experience of the application. That means the design and implementation is a success and accomplished its goal which is being helpful to their labour integration and imagination.

## 4.2 Discussion of results

To discuss the result, questionnaire feedback is the key. Questions in questionnaire has objective questions and subjective questions. So that the analysis of objective questions could show whether the content of the project is satisfying and the analysis of subjective questions could show whether the project is in a right direction and reveal problems unseen.

### 4.2.1 Analysis of results

#### i) First test analysis

The first test is for supervisors to provide right directions for this project.

The result of object questions is shown in figure 50:

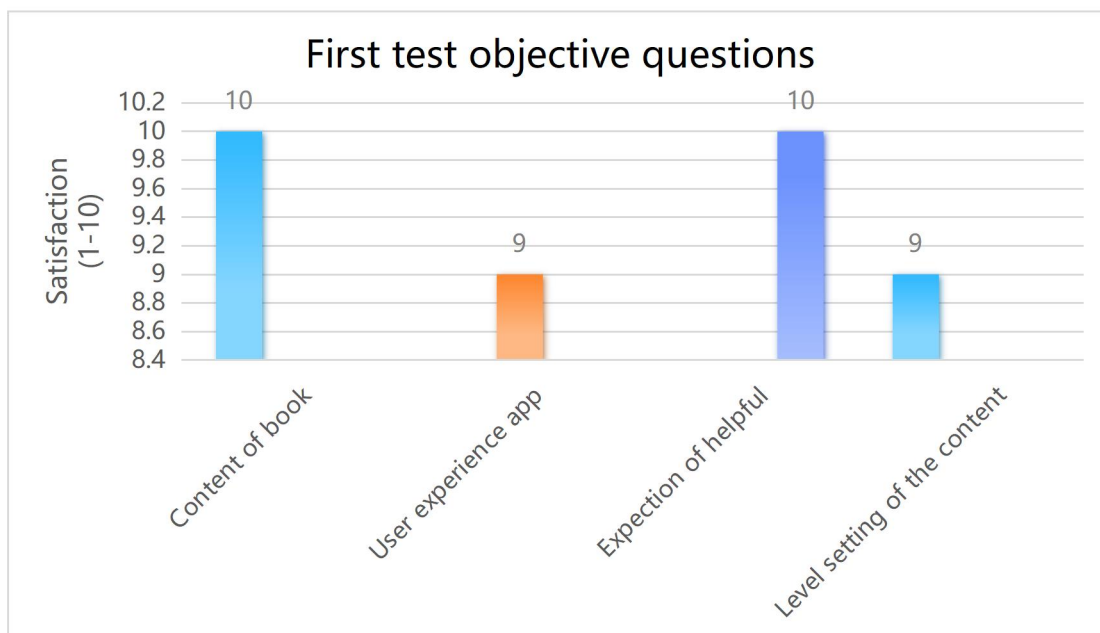


Figure 50 First test objective questions results

For subjective questions, the supervisor give some valuable suggestions:

#### a. Expectations about the application:

Provide instructions for left-hander, more tools instructions and paper-torn instructions.

#### b. Workshop theme expected to see:

Painting workshop

#### c. Expectation from the book and app:

More videos instructions, more visual support such as a sequence of instructive image to summary the content of current learning material and more sound support such as a voice speech about the content in the current page. And they require a Spanish version of the book.

#### d. Data need to be collected

## Augmented Reality and People with Functional Diversity

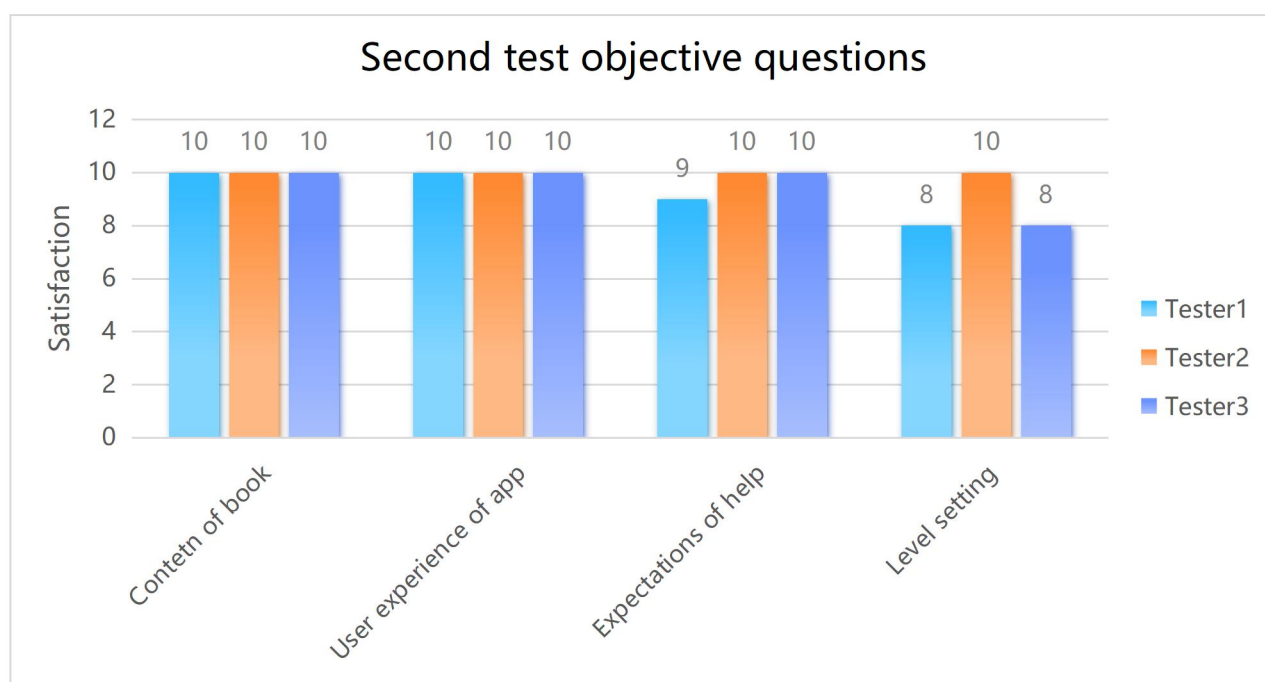
Screenshots including: date, time and name

From figure 50 the degree satisfaction about book and app is very high and the supervisor strongly believe the project will be helpful in their workshop learning. After serious consideration and thorough discussion with my supervisors, the application adds a screenshot function and the book adds a painting theme and more video instructions and a paper-torn tutorial. More sound and visual supports are added to the book and the app. The language of the text and voice speech are set to Spanish.

### ii) Second test analysis

The Second test is for people with functional diversity to test the project could work as expected and achieve preset goals. And considering the privacy of people with functional diversity the name, age and gender of testers will not shown in the report directly.

The result of object questions is shown in figure 51:



**Figure 51 Second test objective questions**

For subjective questions the testers have give important suggestions:

#### a. Expectations about the book and app:

More animations like flying butterfly and paper sparrow, more learning instructions

#### b. Improvement:

Instructions should have more details, more thorough visual support because of reading disability. They expected to see the app could scan on real world object besides image targets.

From figure 51 the people with functional diversity in the occupational center are very satisfied about the content of the book and the user experience of the app. They strongly believe the project will help them learning workshop and the level setting is properly set.

### iii) Overall analysis

In conclusion, the design and implementation of both the book and the app is a great success and both supervisors and people with functional diversity are satisfied. And the project goals are accomplished. However, there are things need to be improved. They requite more visual



## Augmented Reality and People with Functional Diversity

aids and more learning contents. And the app should add a function to scan the real world object to provide more information in workshop learning.

### 4.2.2 Problems

During the test there are problems that arouse by testers and problems related to design flaws of application programming and book design.

i)Problems from testers

- a.Visual aids are not thorough enough
- b.The quantity of learning theme is not enough
- c.The quantity of animations is not enough
- d.The app cannot scan real word object instead of images to show information needed

ii)Problems in design

- a.Page design of the book is rough
- b.In some situations screenshots cannot be found in review system
- c.In some situations the position of video plane is not the same as programmed
- d.In some situations the animation is still on going when the video is set to full screen

These problems reveal there are still further work to do.

## **Chapter 5: Conclusion and Further Work**

### **5.1 Conclusion**

The goals of this project have been accomplished according to the test results. A book and an application have been developed and ready to be used. People with functional diversity are very satisfied about this project and they think this will enrich their knowledge in workshop.

### **5.2 Reflection**

During developing testing this project, there are a lot of encounters and discussion with people with functional diversity. And this provides an opportunity to see things in their point view which is unimaginable if there is no practical encounter. Here are some suggestions and research directions for further study on people with functional diversity:

- i) People with functional diversity is a concept from society point of view, and in this case the key is their social inclusion. So do not consider healing their physical or mental conditions when working with them. Instead, try to make tools or works for the public also available for people with function diversity. Their social inclusion increase with their labour integration.
- ii) People with functional diversity need thorough and clear visual support and sound support
- iii) The time for attention is a must-consider in workings related to people with functional diversity
- iv) Unity3D is a great platform to develop AR applications
- v) If the project considers object detection using AR, the costs of time and resources should be well considered.

### **5.3 Further work**

Though the initial goals are well accomplished, there are still some problems need to be solved. So here are further works to do for this project.

- i) Provide more themes and learning instructions details in the book
- ii) Hot fix for application programming flaws
- iii) More thorough visual support both in the app and the book
- iv) Object detection function for the app
- v) More animations programming for the app
- vi) Keep updating in the google play store

## References

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## **Acknowledgement**

First, I'd like to give a huge credit to BUPT, QMUL and especially UPV for offering me such an exciting life experience in Spain and every knowledge I need for this project. And also to my amazing supervisors from QMUL and UPV, thanks for picking me in this project and providing me with vital instructions both in project and life, that means a world to me. And to those of you who is working for people with functional diversity, thank you for making our world a better place of everyone in this planet. It will be a huge honor if my project could help or guide you and your work in any kind of way.

Then it is you, the one who is reading my paper. Thank you for being a part of my finale in bachelor study. For my fellow students, I wish this report will be useful and for my supervisors I hope I didn't let you down.

And most of all I'd like to express my deepest love to my parents, they give me full support on everything in this journey. Wish this could make you proud.

Here are some words for you and future me:

Be brave and sure be kind to the world!!

Most importantly: Hope my back, neck and head stopping hurting :-)

## Appendices

### Disclaimer

This report is submitted as part requirement for the undergraduate degree programme at Queen Mary University of London, and Beijing University of Posts and Telecommunications. It is the product of my own labour except where indicated in the text. The report may be freely copied and distributed provided the source is acknowledged.

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Full Name (Pin Yin):Ao Yunfu

Full Name (Chinese):奥云夫

Signature:

Handwritten signature in Chinese characters: 奥云夫. The signature is written in black ink and consists of three characters: '奥' (Ao), '云' (Yun), and '夫' (Fu).

Date:April 10, 2024

## Project specification

Part I:

<b>Project ID</b>	<b>Augmented Reality and People with Functional Diversity</b>		
<b>Academic Supervisor</b>	Dr. Yan SUN (QM) <a href="mailto:yan.sun@qmul.ac.uk">yan.sun@qmul.ac.uk</a>		
<b>External Supervisor/Institute</b>	Dr. Carlos Hernández Franco (UPV)		
<b>Description</b>	<p>Information technologies constitute a valuable tool of daily use for society. In the case of people with functional diversity, these technologies can boost individual autonomy, thus increasing self-esteem and facilitating greater social inclusion.</p> <p>The design, implementation and testing of an app that helps people with functional diversity is proposed in this project. Based on the augmented reality, this app will be able to making the environment much more understandable to the person with functional diversity.</p> <p>The app should be able to identify certain common objects, providing an explanation through text and/or audio of their main characteristics.</p> <p>It should run on a mobile phone based on Android environment.</p>		
<b>Keywords</b>	Functional diversity, Augmented reality (AR), App, Android, Autonomy, Self-esteem, Social inclusion		
<b>Requirements</b>	The student must have knowledge in the development and programming of apps for the Android environment		
<b>application area</b>	Software development	<b>Project Type</b>	Implementation
<b>Project Nature</b>	Software	<b>Target students</b>	Telecom and IoT programme
<b>Four Main tasks</b>	<ol style="list-style-type: none"> <li>1. State of the art on apps using AR to helping people with functional diversity</li> <li>2. Design, implementation and testing of the app.</li> <li>3. Proposals for improvements according to the results of the test.</li> <li>4. Development of a User Guide. App available for download from a web server.</li> </ol>		
<b>Expected output for exams</b>	<ol style="list-style-type: none"> <li>1. People with functional diversity have an App that enriches their knowledge in real time about the environment where they are.</li> <li>2. Facilitate social interrelationships and self-esteem of people with functional diversity.</li> <li>3. Have a downloadable version of the App from a web server or another online platform.</li> </ol>		

Part2:

北京邮电大学 本科毕业设计（论文）任务书

Project Specification Form

Part 2 - Student

学院 School	International School	专业 Programme	Telecommunications Engineering with Management		
姓 Family name	AO	名 First Name	YUNFU		
BUPT 学号 BUPT number	2020213219	QM 学号 QM number	200976792	班级 Class	2020215107
论文题目 Project Title	Augmented Reality and People with Functional Diversity				
论文概述 Project outline  Write about 500-800 words  Please refer to Project Student Handbook section 3.2	<p>This project is to build a mobile phone application based on android environment using augmented reality. And this project is cooperated with <i>Universidad Politécnica de Valencia</i>(Polytechnic University of Valencia, UPV) and <i>La Torre</i> which is an occupational center for people with functional diversity. These two organizations provide software development environment, experiments objects and research background data.</p> <p>In this project, the design, implementation and testing of the app is proposed to help people with functional diversity. People with functional diversity are people who uses alternatives that differ from what the majority of the population uses to carry out certain tasks for example, a person with a hearing impairment uses sign language to communicate, instead of words and hearing like the rest of the hearing population. People with functional diversity, either because of environmental barriers or because of their reduced mobility, have fewer opportunities to participate in different daily activities or risk situations outdoors thus they have a trouble of self-esteem and social interrelationships. Information technologies constitute a valuable tool of daily use for society. In the case of people with functional diversity, augmented reality(AR) technology can boost individual autonomy, thus increasing self-esteem and facilitating greater social inclusion. AR technology is a relatively new technological content that promotes the integration of real world and virtual world. It simulates the content that was difficult to experience in the real world on the basis of computer science technology. It overlays virtual content on the real world through smart phones or any other displayable equipment to achieve a sensory experience that transcends reality which virtual content and physical content has a coexistence. AR technology can not only effectively reflect the content of the real world, but also promote the display of virtual information content, which complements and overlaps with each other. This application is intended to make the environment much more understandable to the people with functional diversity and it should be able to identify certain common objects, providing an explanation through text and/or audio of their main characteristics with a downloadable version from a web server or another online platform.</p> <p>AR is the core technology employed in this project. AR is deployed and programmed in Unity3D using ARcore SDK in this project under Windows 10 system. It will be implemented on android mobile phones. It has six steps in this case:</p> <ol style="list-style-type: none"> <li>1) Collect real-time video through the phone camera and identify symbols;</li> <li>2) After identifying a target symbol, use it as a reference to determine the</li> </ol>				



## Augmented Reality and People with Functional Diversity

	<p>position and direction of the animation to be generated in the AR environment and store these parameters in the phone;</p> <ol style="list-style-type: none"> <li>3) Digitize the collected video stream into images, and then identify the identification marker through a series of processes such as feature point detection, feature point descriptor generation, and feature point matching mentioned above;</li> <li>4) Match the identification symbols with the preset target image;</li> <li>5) The animation (virtual information) is rendered into the video stream.</li> <li>6) The program adjusts the animation based on the position of the marker (virtual information)</li> </ol> <p>Users are people with functional diversity who have a sound physical condition, it means they only suffers from mental problems such as attention deficit hyperactivity(ADHD), bipolar, depression, autism and anxiety disorder. So this application will be used whenever they are in trouble due to their special conditions and try to improve their ability in social activities and control their conditions. For users, the process of AR implementation is simply open this application on the phone and aim the camera at their target objects then the app will generate expected animations on the screen.</p> <p>This project is tested on the target users in <i>La Torre</i> and experiments should be done in different groups of people with functional diversity divided by their conditions. The users feedback is the core data for this project, it is collected by interviews and questionnaires after a specific usage duration. The feedback includes user experience, improvement of their condition and what actual problems have been solved. If the feedback shows the app increase self-esteem and facilitate greater social inclusion of the user, it means this application is working as expected and will be provide a downloaded version on the web and a official user guide.</p>
<p>道德规范 Ethics</p>	<p>Please confirm by checking the box:</p> <p><input checked="" type="checkbox"/> I confirm that I have discussed ethical issues with my supervisor.</p>



Augmented Reality and People with Functional Diversity

<p><b>Please discuss ethical issues with your supervisor using the ethics checklist in Project Handbook Appendix 1.</b></p>	<p>Summary of ethical issues: (write "None" if no ethical issues)</p> <p>This project includes disabled people and their personal information will be protected.</p>
<p><b>中期目标 Mid-term target.</b></p> <p><b>It must be tangible outcomes, E.g. software, hardware or simulation.</b></p> <p><b>It will be assessed at the mid-term oral.</b></p>	<p>The implementation has been done according to the design and the application has a early-access version with a usable prototype.</p>

### Work Plan (Gantt Chart)

Fill in the sub-tasks and insert a letter X in the cells to show the extent of each task

	Nov 1-15	Nov 16-30	Dec 1-15	Dec 16-31	Jan 1-15	Jan 16-31	Feb 1-15	Feb 16-28	Mar 1-15	Mar 16-31	Apr 1-15	Apr 16-30
<b>Task 1 State of the art on apps using AR to helping people with functional diversity</b>												
Investigate the need of the target user and collect knowledge of the target field.	X	X	X									
Learn AR technology implementation	X	X	X	X	X	X						
Learn Unity3D programming skills	X	X	X	X	X	X						
State the art on the app			X									
<b>Task 2 Design, implementation and testing of the app.</b>												
Design the application UI ,core functions and core interactive AR animations prototype. Identify elements for software development.			X	X								
Implement the design and product a usable prototype				X	X	X						
Alpha Test to see if the app working as expected							X					
Collect user feedback							X					
<b>Task 3 Proposals for improvements according to the results of the test.</b>												
Fix problems and adjust design.							X	X				
Beta Test to improve the user experience according to the feedback								X	X			
Collect user feedback								X	X			
Fix problems and adjust design then final the version of the app									X	X		
<b>Task 4 Development of a User Guide. App available for download from a web server.</b>												
Develop a user guide										X		
Make the app available for download from a web server											X	
Prepare for viva												X

## Early-term progress report

### 北京邮电大学 本科毕业设计（论文）初期进度报告

#### Project Early-term Progress Report

学院 School	International School	专业 Programme	Telecommunications Engineering with Management		
姓 Family name	Ao	名 First Name	Yunfu2		
BUPT 学号 BUPT number	2020213219	QM 学号 QM number	200976792	班级 Class	2020215107
论文题目 Project Title	Augmented Reality and People with Functional Diversity				
<p><b>1. Introduction</b></p> <p>In this project <i>Augmented Reality and People with Functional Diversity</i>, the design, implementation and testing is proposed to help people with functional diversity mainly gain greater social inclusion and self-esteem. Main task is to use Augmented Reality(AR) technology to develop an Android system mobile phone application to train people with functional diversity(PFD) with their labor integration. Nowadays information technology is well-developed and AR technology has a promising future. PFD are people who perform differently in daily life and labor work compared to the majority of people. And AR technology can have a coexistence of virtual world and real world, it overlays the virtual animations to the real world objects through cameras and screens. In this case, a proper AR technology application can boost individual autonomy,thus increasing self-esteem and facilitating greater social inclusion. In this literature review, we will talk about previous research about the relations between AR and PFD then give the definition and development about AR and PFD to make a conclusion about this project's direction.</p> <p><b>2. Previous Research</b></p> <p>People with functional diversity is a developing concept that appears in the last two decades as a result of a process of rethinking approaches to and under standings of disability. Promoting the labour integration of people with functional diversity is a key element to achieve their social inclusion<sup>[1]</sup>. There are lots of researches to help with PFD's labour integration but little of them are using information technology like AR technology most of the researches are using the tradition ways to transit based on the kind of disability, educational background and duration of the program are dimensions that could have an impact upon intervention<sup>[2]</sup>. And much research has focused upon the study of transition into adult life of people with disability, without having the desired effect to improve social and labor inclusion but as we mentioned that is the key to PFD related research. Researches about AR and functional diversity has mentioned that AR has the potential to support individuals with special needs and to enable their development of daily living skills<sup>[1]</sup>. AR has been used in few previous studies to enhance certain functional skills such as way-finding skills<sup>[3]</sup>, numeracy<sup>[4]</sup>, shopping<sup>[5]</sup>, behavior management<sup>[6]</sup>, literacy, and recreational skills<sup>[7]</sup>. These researches have shown that AR is fully able to train PFD with their living skills and labour work related skills with a thorough test among different types of disabilities(including intellectual disability, autism spectrum disorder, attention deficit hyperactivity disorder, Down syndrome, hearing disability, and visual disability). And it is potential for further investment.</p> <p><b>3. Definition and Scope of Functional Diversity</b></p> <p>People with functional diversity refers specifically to people who perform certain functions differently than the average population so they are different than the statistical norm due to some reason<sup>[9]</sup>.People who function in an unusual way, instead of the meaning according to which they</p>					



lack capabilities, so the context is very important in this concept. It results from the interaction between persons with disabilities and attitudinal and environmental barriers that prevent their full participation and effective in society on equal terms with others. It has a dimensional different from the concept "disability", they has a transversal category from the individual body dimension to the cultural dimension of the social group. Functional diversity is associating with human dignity, while disability aligns with the paradigm of exclusion, of the other. It is stated that "disability is not an objective characteristic applicable to the person, but an interpretive construction inscribed in a culture. In this sense, mentioning equal opportunities for all people is considered "because of their equality of humanity and not because of the equality of their abilities". It is important to study this concept and improve their social position. Because it is estimated that 15 % of the world's population<sup>[9]</sup>, that is, approximately 1000 million people have some type of intellectual, physical or sensory deficiency by 2017. Likewise, demographic aging has led to a higher prevalence of disability in activities of daily living and according to the statistics of the United Nations, 82% of people with disability who live in developing countries are below poverty threshold employment rate among people with disabilities was 25.9% in 2017<sup>[10]</sup>.

#### 4. Development of AR Technology

Augmented Reality (AR) technology has witnessed significant development, transforming the way we interact with the digital world. This evolution is marked by advancements in hardware, software, and applications, fostering a seamless integration of virtual elements into the real environment. AR's growth has been propelled by innovations in mobile devices, wearables, and spatial computing, enabling immersive user experiences.

One pivotal aspect of AR development is its application across diverse industries, such as healthcare, education, and gaming. For instance, AR-enhanced medical simulations provide realistic training for healthcare professionals, while educational applications offer interactive learning environments. The gaming industry has also embraced AR, creating captivating experiences that merge the virtual and physical realms.

Numerous studies contribute to our understanding of AR's progress. Research by Smith et al. (2019) explores the impact of AR in medical education, highlighting its effectiveness in skill acquisition<sup>[11]</sup>. Additionally, Wang and Dunston (2020) delve into the role of AR in enhancing spatial computing, offering insights into its implications for future technologies<sup>[12]</sup>. Another study by Smith and Jones (2021) investigates the integration of AR in gaming and its effects on user engagement<sup>[13]</sup>.

In conclusion, the development of AR technology is a dynamic and interdisciplinary field with far-reaching implications. As evidenced by the referenced studies, AR's influence extends beyond entertainment, shaping education, healthcare, and spatial computing. The continuous evolution of AR is poised to redefine our digital experiences in the years to come.

#### 5. Conclusion

In conclusion, the intersection of Augmented Reality (AR) technology and addressing the needs of People with Functional Diversity (PFD) holds great promise for enhancing social inclusion and self-esteem. This project focuses on the design, implementation, and testing of an Android system mobile phone application utilizing AR technology to facilitate the labor integration of PFD. As information technology continues to advance, AR emerges as a powerful tool with the potential to create a coexistence of the virtual and real worlds, offering opportunities for innovative interventions.

The literature review emphasizes the evolving concept of functional diversity and the importance of promoting the labor integration of individuals with diverse functional abilities. While traditional approaches have been employed, the integration of AR technology in interventions for PFD presents a novel and potentially transformative avenue. Previous research indicates that AR has been successfully employed to enhance various functional skills, ranging from way-finding to literacy, across different types of disabilities.

The scope of functional diversity is defined not as a lack of capabilities but as a unique way of



performing certain functions. This concept is intrinsically linked to human dignity and challenges the traditional paradigm of exclusion associated with the term "disability." With an estimated 15% of the global population experiencing some form of intellectual, physical, or sensory deficiency, the need to address functional diversity and improve social positions becomes paramount.

The development of AR technology is highlighted as a dynamic and interdisciplinary field, with applications spanning healthcare, education, and gaming. The referenced studies demonstrate AR's effectiveness in medical education, spatial computing enhancement, and gaming engagement. This suggests that AR's impact extends beyond entertainment, influencing various aspects of our digital experiences and potentially transforming interventions for PFD.

In summary, this project aims to leverage AR technology to create a positive impact on the lives of PFD, promoting their autonomy, self-esteem, and social inclusion through innovative and personalized training experiences. As we move forward, continuous exploration of AR's capabilities and its integration into interventions for functional diversity can contribute to a more inclusive and empowered society.

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Augmented Reality and People with Functional Diversity

<p><b>是否符合进度? On schedule as per GANTT chart?</b></p> <p>YES</p>
<p><b>下一步 Next steps:</b></p> <p>Design the application UI ,core functions and core interactive AR animations prototype. Identify elements for software development and implement the design and product a usable prototype.</p>

## Mid-term progress report

### 北京邮电大学 本科毕业设计（论文）中期进度报告

#### Project Mid-term Progress Report

学院 School	International School	专业 Programme	Telecommunications Engineering with Management		
姓 Family name	Ao	名 First Name	Yunfu		
BUPT 学号 BUPT number	2020213219	QM 学号 QM number	200976792	班级 Class	2020215107
论文题目 Project Title	Augmented Reality and People with Functional Diversity				
是否完成任务书中所定的中期目标? <b>Targets met (as set in the Specification)?</b> YES					
<p>已完成工作 <b>Finished work:</b>  <b>The mid-term target of this project is :</b>                      The implementation has been done according to the design and the application has a early-access version with a usable prototype.</p> <p><b>1. Project background</b>                      This project is about developing an Augmented Reality(AR) mobile phone software application and the most important part of this project is its users who are People with Functional Diversity(PFD). It's a group of people who need more social inclusion for any public context. So what this project is trying to do is to explore a modern method to increase accessibility in some workshops context using AR. In a word, the vital part of the project are PFD and the core part of users is their context.</p> <p><b>2. Application design</b>                      This project's design is about an AR application and a special AR book to support application which is essential. In the case of that this project's users have mentally diversity instead of physical conditions so that the basic idea of this project is let a special <i>AR Workshop book</i> to guide the PFD in their workshop context to train their labour and creation ability for make handcraft to further use and express their feelings. This book is currently design to have 3 themes which are handcrafts, woodwork and mental health. And the handcrafts contains scissors and art knife training and the combination of them with tapes and glues to create DIY(Do It Yourself) handcrafts. Here is the application mechanics diagram below showed in figure 1 :</p>					
<pre>                     graph LR                         A[Scan on Image] --&gt; B[Video]                         A --&gt; C[Text]                         A --&gt; D((Supportive Animation))                         B --&gt; E[Workshop Instructions]                         C --&gt; F[Supportive Voice Speech]                         G[Learning Materials] --- B                         H[Instructions &amp; Explanation] --- C                     </pre>					

# Augmented Reality and People with Functional Diversity

Figure 1 Application mechanics diagram

So basically the users need to scan on specific image on the book to further support their work in some workshop themes. According to the context of using, the image will show videos and text to provide support and in case of reading disorders, the application will provide voice speech of text to support. In order to train and lead PFD for a better inclusion in a certain workshop the level setting is essential. Here is the basic level setting diagram in this application (take handcraft as an example) shown in figure 3:

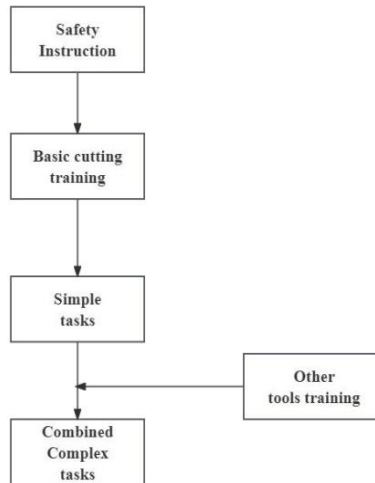


Figure 2 Level setting diagram

And here is a detailed scissors workshop mechanics diagrams show in figure 3:

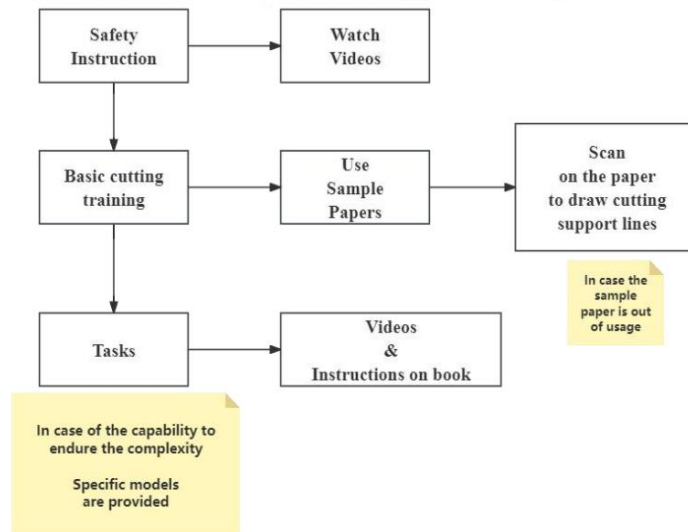


Figure 3 Scissors detailed diagram

The usage of this application for PFD is under surveillance of professional crews and their persons in charge. And in the case of their capability, it is important to develop surveillance system and here is the mechanics for the system shown in figure 4:



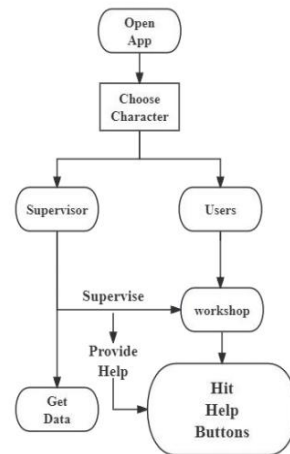


Figure 4 surveillance system diagram

**3. Early-access version prototype**

So far the scissors and knife training part and simple DIY part has been done and waiting for the encounter of users to test the early-access version. The prototype has two parts which are AR application and the AR book.

**3.1 AR book prototype**

Some pages is still under design so that they will be shown simply in words. And here is the prototype by the time of 22th, February shown in figure 5:

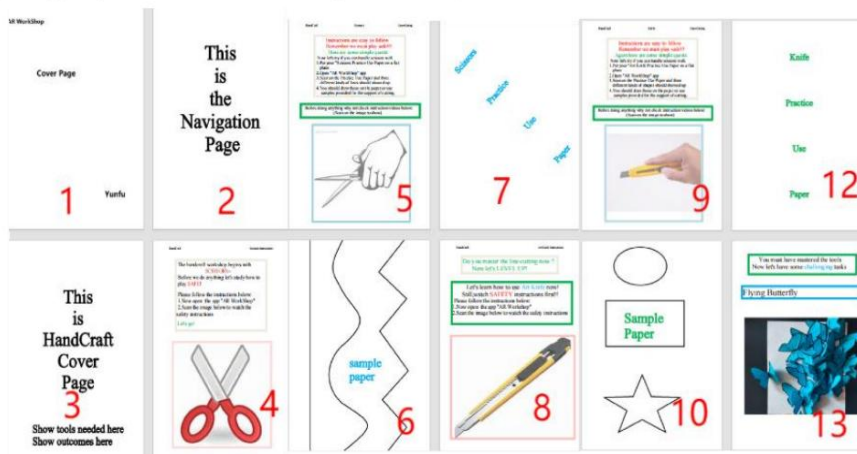


Figure 5 book prototype

This includes scissors and art knife training and a simple DIY task.

**3.2 AR application early-access version prototype**

The application development is using Unity and C# to implement AR technology and here is the designed prototype in Unity shown in figure 6 and figure 7:

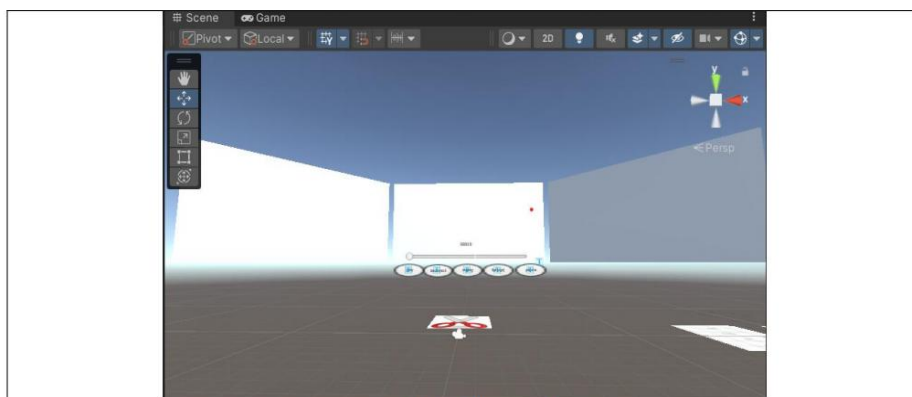


Figure 6 Video Player in Unity

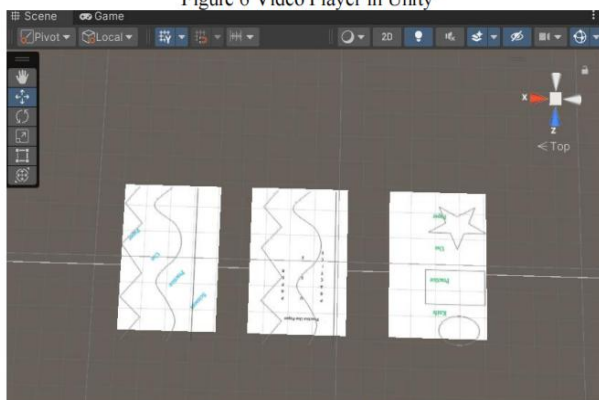


Figure 7 Cutting Support Line in Unity

And here are the application screenshots shown in figure 8 and figure 9:



Figure 8 Video Player in app

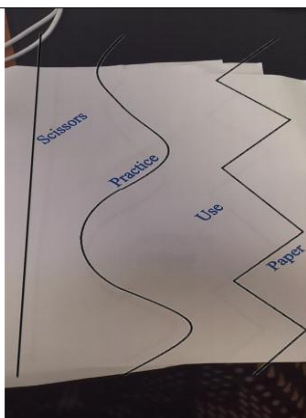


Figure 9 Cutting Support Line in app

**尚需完成的任务 Work to do:**

**AR book designs:**

1. Further design on other themes
2. Cover page design
3. Support models design

**AR application:**

1. UI design
2. Surveillance system design
3. Detail design of instructions
4. AR camera adjustment
5. User feedback collection

**存在问题 Problems:**

**AR book:**

1. Book texture and ways to build
2. Support models texture and ways to build

**AR application:**

1. Still need a lot of users feedback to improve interactive designs
2. Animations and models still needs to adjust for any context of usage

**拟采取的办法 Solutions:**

Try more textures in building book pages and models  
Detail the time schedule to meet the core users and prototype plans

**论文结构 Structure of the final report: (Chapter headings and section sub headings)**

*Abstract*  
*Keywords*

**Chapter 1: Introduction**

**1.1 Project Description**

- 1.1.1 Background of the project
- 1.1.2 Aim of the project

**1.2 Project Goals**

1.2.1 Outcome of the project
<b>Chapter 2: Background</b>
<b>2.1 People with functional diversity</b>
2.1.1 Definition
2.1.2 The need of people with functional diversity
<b>2.2 Augmented Reality</b>
2.2.1 Definition
2.2.2 Technological principles
2.2.3 Advantages and disadvantages
<b>Chapter 3: Design and Implementation</b>
<b>3.1 Software application design</b>
3.1.1 Development environment
3.1.2 Software system mechanics design
3.1.3 User-interactive design
3.1.4 Supported systems and devices of user
<b>3.2 Supportive book design</b>
3.2.1 Reading logic design
3.2.2 Appearance design
3.2.3 Software-book interactive mechanics design
<b>3.3 Project implementation</b>
3.3.1 Book implementation
3.3.2 Software implementation on the book
<b>Chapter 4: Results and Discussion</b>
<b>4.1 Project results</b>
4.1.1 User feedback
4.1.2 Outcomes
<b>4.2 Discussion of results</b>
4.2.1 Analysis of results
4.2.2 Problems
<b>Chapter 5: Conclusion and Further Work</b>
<b>5.1 Conclusion</b>
<b>5.2 Reflection</b>
<b>5.3 Further work</b>
<i>References</i>
<i>Acknowledgement</i>
<i>Appendices</i>
<i>Disclaimer</i>
<i>Project specification</i>
<i>Early-term progress report</i>
<i>Mid-term progress report</i>
<i>Supervision log</i>
<i>Additional Appendices (as needed)</i>
<i>Risk and environmental impact assessment</i>

## Supervision log

北京邮电大学 本科毕业设计（论文）教师指导记录表

### Project Supervision Log

学院 School	International School	专业 Programme	Telecommunications Engineering with Management		
姓 Family name	AO	名 First Name	YUNFU		
BUPT 学号 BUPT number	2020213219	QM 学号 QM number	200976792	班级 Class	2020215107
论文题目 Project Title	Augmented Reality and People With Functional Diversity				
Please record supervision log using the format below:					
Date: dd-mm-yyyy					
Supervision type: face-to-face meeting/online meeting/email/other (please specify)					
Summary:					
Date: 26-10-2023					
Supervision type: online meeting					
Summary: First meet up to discuss the whole process and project direction					
Date: 11-11-2023					
Supervision type: online meeting					
Summary: discussed the project specification					
Date: 1-12-2023					
Supervision type: online meeting					
Summary: discussed the project details when arrived Spain					
Date: 18-1-2024					
Supervision type: face-to-face meeting					
Summary: First meet-up in Spain to discuss the schedule and works in UPV					
Date: 25-1-2024					
Supervision type: face-to-face meeting					
Summary: discuss the project details about people with functional diversity and research direction					
Date: 5-2-2024					
Supervision type: face-to-face meeting					
Summary: project follow-up and discuss the project process schedule					
Date: 21-2-2024					
Supervision type: face-to-face meeting					
Summary: project process check and discuss the mid-term report					
Date: 27-2-2024					
Supervision type: face-to-face meeting					
Summary: mid-term process check and discuss the presentation and follow-up works					

## Augmented Reality and People with Functional Diversity

Date: 12-3-2024

Supervision type: face-to-face meeting

First meeting with the supervisor in the occupational center to get a basic idea of main users then adjust the direction of the application and the book.

Date: 25-3-2024

Supervision type: face-to-face meeting

First test of app with the supervisor of the occupational center to collect the first user feedback then adjust the content of the book and application

Date: 9-4-2024

Supervision type: face-to-face meeting

Second test of app with the people with functional diversity of the occupational center to collect user feedback from them then adjust the content of the book and application and fix bugs

Date: 22-4-2024

Supervision type: face-to-face meeting

Third test of app with the people with functional diversity of the occupational center to collect user feedback from them then provide more content they need and keep updating the application



## Risk and environmental impact assessment

This project is about workshop learning using a book and an application. And in this case people may get hurt during the workshop learning because of the tools and may cause material waste like paper and wood because of workshop content. However, with thorough safety instructions and the surveillance of the local supervisor it is rare for people to get hurt. So that the score of likelihood  $L=1$  according to the table 2 in student handbook.

*Table 2 Scores for level of likelihood*

Level <i>L</i>	Description	Meaning
0	Impossible	Cannot happen
1	Rare	May happen in exceptional circumstances
2	Unlikely	Could happen at some time
3	Moderate	Should happen at some time
4	Likely	Will happen often
5	Certain	Expected to happen

The consequences is negligible because few materials are used in the usage of this project and it can be carried out using recycled materials and the used materials can be recycled also. Besides, the tools used in the project are designed for children usage so that it has the lowest level of ability to harm people. So according to the table 3 in student handbook the score of consequences=0.

*Table 3 Scores for level of consequence*

Level <i>C</i>	Description	Meaning (This depends on the application, e.g. potential harm to people, animals, the environment, the project itself. The following table suggests possible consequences for the project itself. A separate risk assessment must be carried out for each possible risk.)
0	Negligible	No noticeable effect on the project.
1	Minor	Undesirable but something that can be handled without affecting the overall progress of the project.
2	Serious	Might cause slight disruption to project progress but will not prevent completion.
3	Very Serious	Will cause a significant disruption to project progress but completion still possible.
4	Major	Problem so severe that it is unlikely the project can be completed. Some aspects may be salvageable.
5	Catastrophic	Completion of project is impossible. Situation is unrecoverable.

And according to the table 4 when  $L=1$  and  $C=0$  the score of risk  $R=0$

Table 4 Assessed level of risk combining consequence and likelihood

		Likelihood level <i>L</i>					
		Impossible	Rare	Unlikely	Moderate	Likely	Certain
Consequence level <i>C</i>	Negligible	0	0	0	0	0	0
	Minor	0	1	2	3	4	5
	Serious	0	2	4	6	8	10
	Verv serious	0	3	6	9	12	15
	Major	0	4	8	12	16	20
	Catastrophic	0	5	10	15	20	25

And according to the table 5 in student handbook when the score of risk  $R=0$  there is no risk for this project and no required actions.

Table 5 Ratings of risk and urgency of required action

Score	Rating	Action
0	No Risk	No action required.
1 - 3	Low Risk	Take action if easy to implement.
4 - 6	Moderate Risk	Take action if cost effective.
8 - 12	Significant Risk	Take action urgently.
15 - 25	High Risk	Requires immediate action.