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AR Engagement

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Howest.be

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ABSTRACT & KEY WORDS

EN:

This paper elaborates on my personal reason for choosing this research as well as why I chose chess for this paper, being wanting to gain more experience with AR while simultaneously improving my own chess skills.

The literature study will explain the basic aspects of how AR works and how chess is played, this is to make sure the paper is understood when mentioning terms.

During the development of the application and deciding on what method to gather data with, there were practical issues that had to be dealt with to make sure the progress of both could continue without any complications.

NL:

Dit artikel gaat dieper in op mijn persoonlijke reden om voor dit onderzoek te kiezen, en ook de reden waarom ik in dit geval voor schaken heb gekozen, omdat ik meer ervaring wou opdoen met AR en tegelijkertijd mijn eigen schaakvaardigheden wou verbeteren.

De literatuurstudie zal de basisaspecten uitleggen van hoe AR werkt en hoe schaken wordt gespeeld, dit is om ervoor te zorgen dat het artikel wordt begrepen als bepaalde termen vernoemd worden.

Tijdens het ontwikkelen van de applicatie en het beslissen over de manier waarop gegevens moesten worden verzameld, waren er praktische zaken die moesten worden opgelost om ervoor te zorgen dat de vooruitgang van beide zonder complicaties kon doorgaan.

PREFACE

When I first started the course, I wasn't too sure as to what I wanted to do. This gradually evolved into wanting to make an application that could serve to help people, whether it was physically or mentally.

Given the scope and time limit, this proved to be difficult to do on a big scale, so I had to size down quite a bit and landed on the research question listed in this paper: "How well does AR keep people engaged compared to real life?"

Initially I was quite upset for not being able to take things as far as I wanted to, but I was able to compromise and still research something that when explored more grandly, could be used to greatly improve experiences related to AR (Augmented Reality) or MR (Mixed Reality).

I've also wanted to always do an AR project where the result of it could be of use to others, this led to the decision of making it chess related.

Chess is a game that to me is a bit difficult when playing in real life and a bit boring when played online, this will be expanded upon in the introduction section of this paper.

I've always been a big fan of serious games, games that aren't for entertainment but more so for learning and/or rehabilitation and wanted to make something to contribute to that, hopefully this app and research could be a small portion related to that.

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INTRODUCTION

The research is conducted using an AR (Augmented Reality) application that holds a list of fixed chess puzzles and displays them on a chess board that you are able to place on any horizontal surface.

The reason AR was chosen as a research project is because it does get underestimated quite often.

People use it mainly for simple things such as filters on social media (Instagram, Snapchat, ...) and many people aren't even aware that it uses AR technology!

Even with the limited capabilities of AR right now there is a lot you can do with it that is both fun and practical, many organizations use it to make an interactive tour of certain locations such as campus grounds, cities, museums and more.

It can even serve as a good mental or physical workout depending on how it is used, combining real life positions within the aspects of the game, such as the application that was mentioned at the beginning of the introduction.

AR even has a lot of progress lined up for the future, currently expanding and becoming more of a mixed reality using special glasses, just think of those special hologram screens in movies, but in real life within those glasses. These can clearly make life easier and more comfortable and will surely be a great asset to humanity once development is finished.

Chess was the best game to use with the current circumstances, as it is a game that is both played as a hobby and competitive. It's a game that's been around for thousands of years and has been played and enjoyed by many people.

Playing chess in real life provides the problem with being stuck in one spot, giving not a great overview of the board. While playing online tackles that issues, it gives rise to a lack of immersion.

This gave rise to the idea to use AR as a solution and gives birth to the research question 'How well does AR keep people engaged compared to real life?'.

The research is to determine if AR can make things more fun or engaging for ordinary things such as board games, keeping the aspects of the game intact but not being bound by a physical playing board or being stuck on a 2D screen of a top down version of said board game.

For this research question, three hypotheses were set up:

- If they use the application, their overall interest and playing sessions will be longer compared to going to clubs or meetings.

This is under the assumption that people will prefer using their devices to learn things that they can also use physical props for. Even though AR will remove the need for those physical items, in exchange it means using their device to play the application instead of other things that might be of more importance.

- If they stay engaged longer with AR, their skill will improve quicker.

When people are able to learn in an environment that is convenient and fun, their brain will be able to pick up quicker on things and keep it locked into their memory for longer periods of time, meaning they will in turn learn things quicker and improve their skills just as fast.

- If they learn topics through AR, they will be prone to do more related activities out of interest outside learning environments.

Since the application can be opened anywhere as long as you have your device with you, it might trigger a desire to play it even outside of learning environments, just for the fun and enjoyment of it.

This can also in turn be brought back to the previous hypotheses where overall interest and skill will grow alongside their time spent.

LITERATURE STUDY / THEORETICAL FRAMEWORK

As mentioned above, this research made use of AR (Augmented Reality) technology in order to provide Chess related puzzles.

AR makes use of cameras that have sensors in them such as gyroscopes and accelerometers.

Gyroscopes give positional and rotational info to the device, so it knows how it's currently placed and rotated within the world space of the area.

The accelerometer keeps track of the current applied forces to the device, including gravitational.

Regular video games use a camera to display everything on the screen, from the environment to the HUD (Heads Up Display), AR does this too, but the camera is the physical device camera instead.

AR makes it possible for virtual / digital elements to be placed in a real-world environment, making the overall experience better by enhancing their interaction, perception and immersion.

A typical example, most younger people will recognize the application 'Pokémon GO' made by Niantic. This app makes use of GPS (Global Positioning System) navigation to know your location, show the rough layout of the map around you and spawn Pokémon as you walk around. When interacting with them, you have the option to use the AR camera to make it seem like they are there in real life through your camera sensors.

As for AR development, not much is different compared to regular games, Unity provides a template [3] containing everything you need to start developing the AR application.

This consists of a special AR camera [1], as well as an AR session object with settings that can easily be changed depending on your needs.[1][2] The AR Session object handles everything that happens in all AR instances by being able to enable or disable them and keeping track of data contained within the AR application.

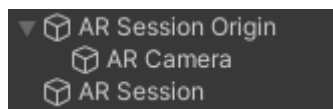


Figure 1 AR SESSION (ORIGIN) UNITY OBJECT

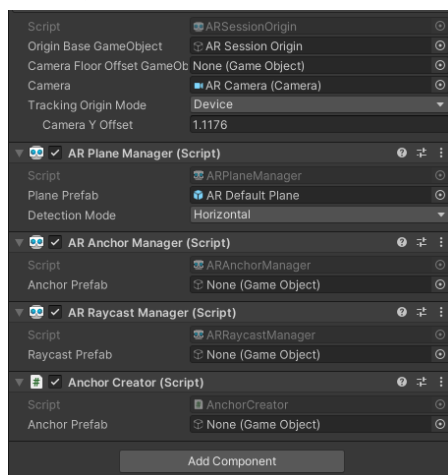


Figure 2 AR SESSION SETTINGS

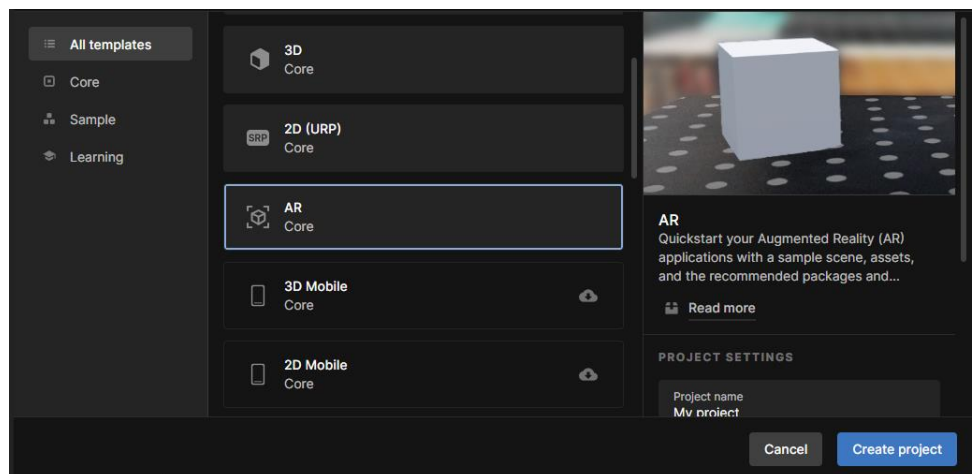


Figure 3 UNITY ARCORE TEMPLATE

For the chosen application, the decision was made to go for chess, a centuries old game, made around the 6th century AD and since then has been enjoyed by many people throughout the years.

It's a board game where 32 pieces are placed on an 8x8 grid, the goal is to lock down and attack the enemy King, this is called a checkmate.

Each piece has a different way of moving across the board [4][5][6][7], using the knowledge of how the pieces move, the ability to set up plans to capture the enemies and being able to predict the enemy's movements are all key in order to win your game.

Pawns are able to only move forward by 1 space, 2 if they haven't made their first move yet. They can only go one space diagonally if an enemy piece is captured.

The king can only move one space into any direction, as long as that move doesn't result into a check(mate) or if the square is blocked by an allied piece.

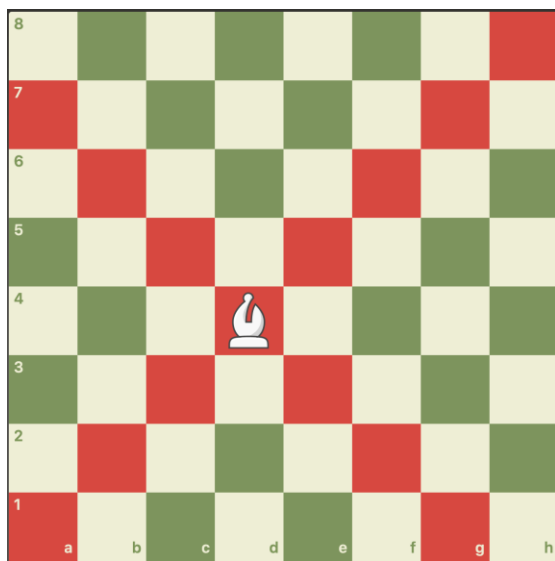


Figure 4 MOVEMENT OF A BISHOP PIECE. (Chess Pieces Names, Moves & Values - Chess.Com, n.d.)

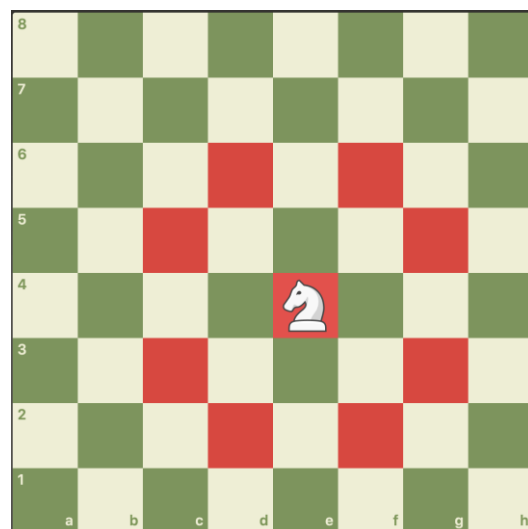


Figure 5 MOVEMENT OF A KNIGHT PIECE. (Chess Pieces Names, Moves & Values - Chess.Com, n.d.)

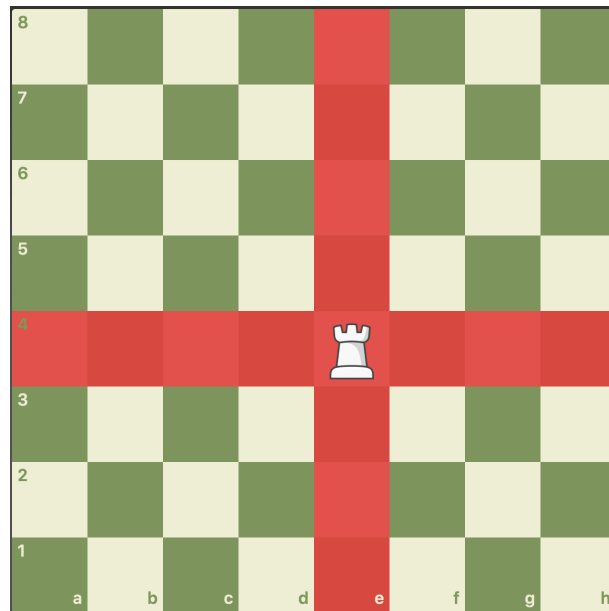


Figure 6 MOVEMENT OF A ROOK PIECE. (Chess Pieces Names, Moves & Values - Chess.Com, n.d.)

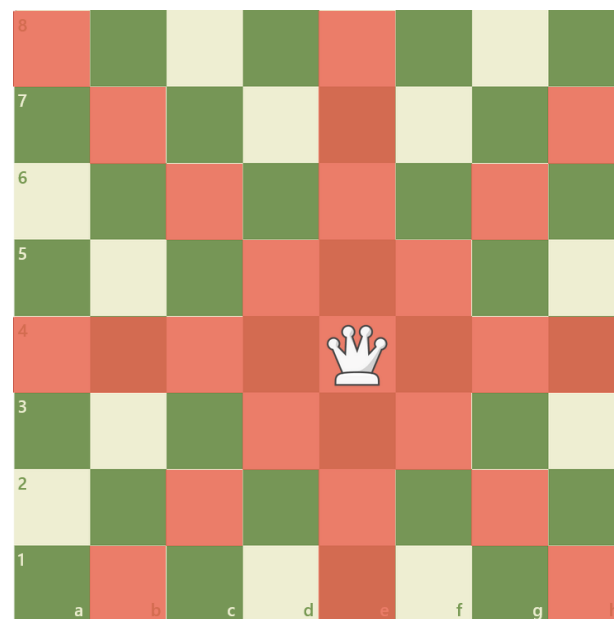


Figure 7 MOVEMENT OF A QUEEN PIECE. (Chess Pieces Names, Moves & Values - Chess.Com, n.d.)

RESEARCH

In order to confirm or debunk the hypothesis, a basic application was developed where a chess board can be placed, and puzzles are displayed for the player to solve.

The puzzles will be made to fit the course of the lesson that day to see if they properly understood the material that was being taught.

The test subjects will be students from the provincial chess club located in Gent, a phone and/or tablet will be provided and handed over to half of the people in the group. After class ends, a survey will be given to everyone to which they answer questions related to the class and how they experienced it.

These questions will be about the amount of fun they had, how much they think they'll keep using it and so on, with those answers, visual graphs shall illustrate the data.

Once the numbers have been analyzed, they will be used to confirm or debunk the hypotheses that have been stated above.

1. APPLICATION DEVELOPMENT

1.1. ENGINE CHOICE

This was the biggest decision for the application development, what engine should be chosen?

The two biggest engines that were left standing due to their relevance, overall good performance and workflow are Unity and Unreal Engine.

The Unity Engine [8] works with the C# programming language, which is a high-level language, and makes use of putting script on objects of components in order to add logic to their objects, HUD and overall game.

Unity uses a composition/component-based approach to their game objects.

The Unreal Engine [9] works with the C++ programming language, which is a low-level language, classes are made with the functionality programmed in it and then objects inherit from it in order to execute their logic.

Unreal mostly uses inheritance for its objects.

Both engines allow programmers to set up variable inputs and sliders for non-programmers in the editor tab. This way they can adjust values to test and iterate over different scenarios to balance things out. Though Unity offers more freedom and flexibility in the form of things such as Scriptable objects.

The biggest difference that always comes up between the two engines is the graphical quality each of them can handle. While Unity is easier to understand and master, it won't be able to produce high and/or realistic graphics like the Unreal Engine can. But in case you need a small or quick application made, Unity does triumph over the Unreal Engine in that regard.



Figure 8 UNITY LOGO. ("Unity (engine)," 2023)



Figure 9 UNREAL LOGO.

Since the application didn't need realistic graphics and was a relatively small project, the decision was made to use Unity as that would allow for fast development and quickly export the application to other devices.

Unity also provides an AR application template where everything is set up for you with an AR camera and AR session that handles all the AR logic for you, all that was left was to make the logic of the application.

1.2. CONTENT

The content that is contained within the application is a basic starting screen [10] that shows the 'title' of the applications along with the topic of the puzzles as well as a basic start button. This was to avoid the participants to be immediately thrown into the application without knowing what it contains or what they have to do. The topic of the application can easily be changed to fit the course material from the current or previous class.

There is a second scene containing a select set of puzzles, these puzzles will also vary depending on what material is being learned per class. This can range from learning how to pin down a piece to seeing the moves that can lead to a checkmate.

The data for the puzzles are made using Scriptable object in Unity, this way it was easy to determine the piece's coordinates, what type of piece it is and even from what team.

With another scene that was set up [11], UI buttons were used to easily click on a certain piece and place them on the board to then save the board state as a Scriptable object to then load in on the chess board.



Figure 10 APPLICATION TITLE SCREEN

The puzzles were provided by the certified chess trainer, providing a link to a book containing the used puzzles as preparation for the class that was going to be held next. The class in question being about being able to spot and capitalize on checkmates.



Figure 11 PUZZLE SETUP SCENE

1.3. DEVELOPMENT

The development was quickly met with a lot of difficulties, since Unity is generally used for Android [12] development while only 2 IOS [13] devices were in possession, some searching and digging was needed on how to solve this problem.

After searching for a way to make it work, there were 2 possible solutions, either pay to be able to do IOS development, or get an Android device, the latter was chosen for since this allowed for other Android development in the future.



Figure 12 ANDROID LOGO. ("Android (Operating System),"



Figure 13 APPLE LOGO ("Apple Inc.," 2023)

Once the target platform had been decided and dealt with, next up was making the actual logic of the game.

This includes:

- The movement logic of the pieces.
- The logic to detect a checkmate (and force end the game).
- The ability to do Castling. [16]
- The ability to promote a pawn. [17]
- Spawning in the board to play on any horizontal surface. [14][15]

The first four points were also rather difficult to decide on what to do, there were a lot of open sources found on the internet that utilize chess logic, movement and more, but they weren't compatible with the project in one way or another. An attempt was even made to install an external package into Unity that also contained all the logic needed to move on to the next step, this turned out to be incompatible as well.



Figure 14 PLANE DETECTION



Figure 15 SPAWNED BOARD

There were also a lot of issues with the device at that moment as it was not compatible with Google ARCore. We tried making it work by circumventing some of the restrictions but decided that getting another device that is supported would be for the best.

In the end a three-part YouTube tutorial was used as reference that covered the development to make a chess game to play a game. Pressing on a piece would show all possible moves for that piece for the team it's on, pressing it again will deselect the piece.

The tutorials covered everything that was needed from the list above, except for the board spawning. [14][15]

The chess board spawning was the simplest part, detect any flat surface [14] and when a screen touch was registered, a ray was cast from the position on the screen and the direction of the camera to determine if it 'touched' the plane, if it did then the board was spawned in[15] with a set board state using the data in the scriptable object.



Figure 16 CASTLING

After some iteration and a first round of testing, there were a lot of issues considering the player experience. This was namely due to the fact that planes kept getting detected and covering the board, this made it impossible for players to give in an input and continue playing. Since the application was also played on one device, it was awkward to play a game of chess where you have to keep handing over the device in order for the opponent to make their move.

The issue regarding the planes has been resolved, stopping to detect them once the board has been spawned and hiding ones currently visible.

To tackle the issue regarding the 'two players playing on one device' issue, changing the application to contain puzzles related to the course material would be better as the player can take their time figuring out the answer and keep playing rather than having to hand it over to the person in front of or next to them.

This didn't mean the application had to be remade in its entirety, the class that this application is tested in was about spotting and capitalizing on checkmates.

Some of the logic would have to change regarding what would happen if the game detected a checkmate.

At first, it was just a simple log that said 'Checkmate' and made both players unable to make a move.

So now that a handful of puzzles have been made, some changes were made and when a checkmate is detected, the game will show the text 'correct move', in the case of a set up move for checkmate in 2 moves, it won't show anything. The player is able to press a button to move on to the next puzzle, or if they made a wrong move to redo the puzzle with the button in the middle bottom of the screen.

If the player makes the wrong move, not a correct (checkmate) move, it will show the text 'wrong move' to indicate that they didn't solve the puzzle.

Going to the next or previous puzzle will remove the text and reset the positions of pieces.

The specific content of the puzzles were about finding a checkmate in 2 moves.

This means that with the right sequence of moves, a checkmate will always happen in those 2 moves.

Since the puzzles were made to be played by only one player, a work around had to be found for the 'opponent' move. So a very simple and small AI (Artificial Intelligence) was set up.

The puzzles contain a list of correct moves [18] since the puzzles are about a checkmate in 2 moves, this means there were 3 correct moves, the first and the last for the player, the one in between for the AI. These are also kept in the same scriptable object where the board layout is stored.

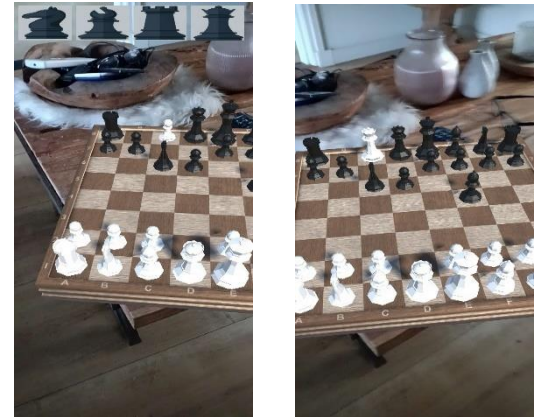


Figure 17 PAWN PROMOTION



Figure 18 CORRECT MOVES

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When the player makes a move, it will change the turn to black and force a piece on a certain position to move in a set direction. This means that no matter what move the player takes, the same opponent piece will always move the same way. This in general isn't an issue since the checkmate in 2 moves will also always be the same sequence of moves performed. In some cases the king can move to multiple spots but the end move of the player still remains the same as it will also result in a checkmate. [19]

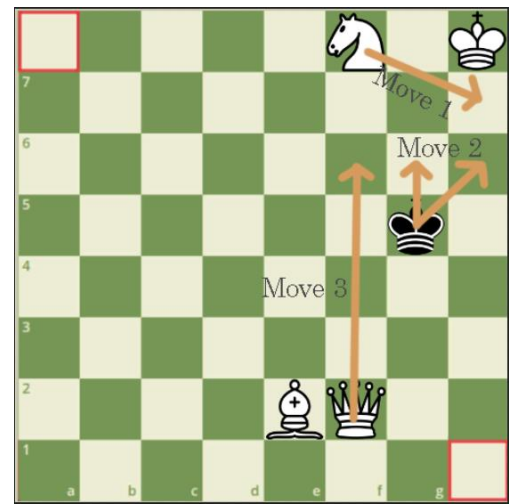


Figure 19 MATE IN 2, ENEMY KING MOVEMENT DOESNT CHANGE CHECKMATE OUTCOME

With the logic of the application completed after multiple iterations [20], everything had to be put together nicely to make it as clear as possible what it was about and how to handle it. For this multiple UI text and buttons were used to help guide the player to start playing the application.

This starts with the start screen mentioned earlier, showing what application is about 'AR chess puzzles', the topic of the current application '(check)mate in 2 moves' and a start button.

Once the start button has been pressed, the camera will search for the same horizontal planes and pressing on them still spawns the same board containing the puzzles.

The player is presented with text on top of the screen that tells them to scan around and tap the plane to make this more clear.

The moment the board is spawned in, the main UI canvas is shown, this provides the player with the text showing what puzzle they're currently on and the possibility to switch to the next or previous puzzle and a redo button that resets the puzzles if they got a wrong move.



Figure 20 FINAL APPLICATION ITERATION

2. DATA GATHERING

2.1 SURVEY

The decision was made to use a survey as a means to gather user feedback on the application and its uses. The survey is used as the only way of data gathering since the hypotheses are linked to user experience.

2.1.1. QUESTIONS

The survey is Google forms-based [21] questionnaire containing a total of 20 (7 for the first survey, 13 for the second) questions. All data gathered through this questionnaire are treated according to the GDPR, meaning the data on the Google forms drive is secured and is copied to a secured environment and then promptly removed from Google drive. The questions are organized in the following categories:



Figure 21 GOOGLE FORMS LOGO. ("Google Forms," 2024)

Category 1: Generic data. Age, gender, name & surname. These questions are not mandatory to be answered.

Category 2: User experience.

Category 3: Perceived impact on further usage and influence on chess development trajectory.

Here is the link to the first survey conducted: <https://forms.gle/hLRaKQNwtuJBGHj96>

Here is the link to the second survey conducted: <https://forms.gle/fgYMpJ4Nq9zL5Bkg9>

The questionnaire uses category-based answers such as gender and age, open questions such as name & surname. It will also contain questions with a linear scale as answering method with 9 gradations to give respondents the ability to answer neutrally (5).

2.1.2. ANSWERS

As mentioned above, all answers are treated according to the GDPR regulations and can as such only be consulted upon express request to the author.

Data gathering is formatted into bar charts, due to the limited pool of respondents, statistical analysis is not advised or even possible. Generally speaking, a sample size of 25 is required in order to do reliable statistical analysis. With a sample size of 10-12, the impact of outliers is potentially too large.

As such we will only use descriptive statistical figures.

2.2. RESPONDENTS

All respondents have given their consent to participate and have their responding data processed within the framework of this research paper. It is possible to respond anonymously, yet data such age, category and gender are mandatory.

All respondents are currently chess students in the Edgar Colle chess academy located in the Caïssa in Gent. The chess club organizing the academy is called KGRSL (Koninklijke Gentse Schaakclub Ruy Lopez) and is the largest and one of the oldest chess clubs of the country.

From the first survey, it's clear that the respondents are of varying age groups [22] . Surprisingly people of 49 and above are the majority (50%). There is about an even amount of both men and women in the current sample composition.

Leeftijd

6 antwoorden

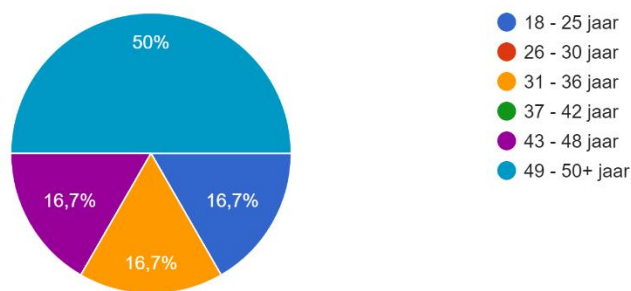


Figure 22 AGE PIE-GRAPH DATA. (Google Formulieren, n.d.)

2.3. DATA

2.3.1. SURVEY 1

After the first UI-oriented user test, we gathered the following data:

We had a total of 6 respondents for this survey.

The UI of the application was well received (66%) [23]. Nobody saw it as a real chess board, but half (50%) actually did see it as a mixture between a real chessboard and playing chess online like on chess.com or lichess.org. [24]

Wat vond je van de User Interface (UI)? Dit gaat over de knoppen die je kon induwen, hoe duidelijk het was wat je moest doen ten allen tijden terwijl je de applicatie speelde.

6 antwoorden

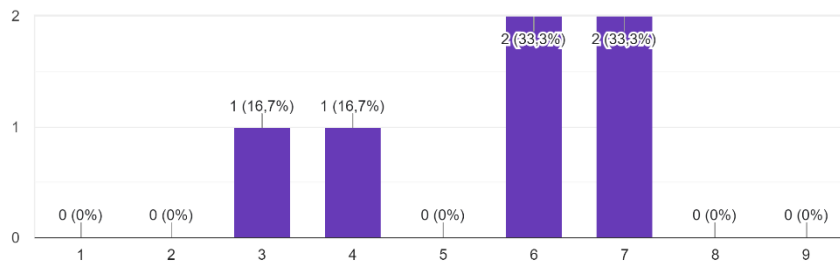


Figure 23 UI USER EXPERIENCE BAR-GRAPH DATA. (Google Formulieren, n.d.)

Hoe ervaren je de applicatie?

6 antwoorden



Figure 24 APPLICATION EXPERIENCE PIE-GRAPH DATA (Google Formulieren, n.d.)

The selection and movement of the pieces was well received (83.3%) using the device's touch screen [25], however people were saying that they lack a way to scale the size of the board to fit on their screen. Some people attempted to scale the board size up or down by using their index finger and thumb.

Since the most common feedback was about the board size being too big and not able to fit on one screen, the board has been scaled down to half its size from what it was before. This proved to be effective in having a better and clearer overview of the pieces placed on top of it.

Hoe goed was de ervaring met het selecteren en bewegen van de stukken?

6 antwoorden

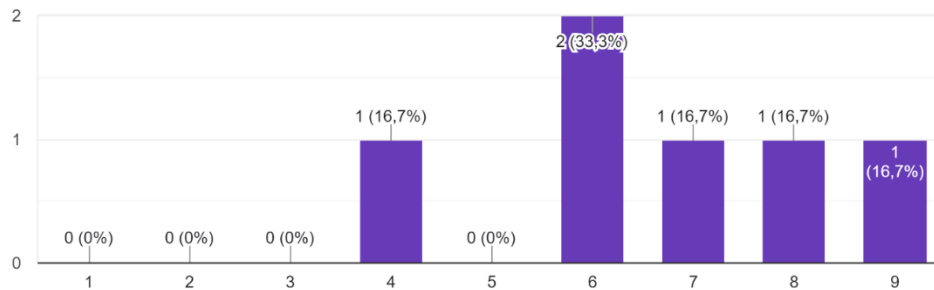


Figure 25 SELECTION AND MOVEMENT OF PIECES SATISFACTION BAR-GRAPH DATA. (Google Formulieren, n.d.)

2.3.2 SURVEY 2

This survey went more into depth about the engagement, enjoyment and availability of the application and whether or not the respondents would still consider playing it in certain circumstances.

The survey was able to reach more respondents and in turn lead to more accurate data.

In the data regarding the respondents their age, the percentage of respondents younger than 18 and their guardians have also consented to having their data processed and used for analyzing and showcasing for the sake of the research paper.

It immediately became clear that the group is of even more varying ages seen in the graph (30,8%) [26], the most being between the ages of 18 – 25 years old and the majority (76,9%) being male in gender. [27]

Respondents were able to participate on their own accord, meaning the general interest in trying out the AR application was higher among men than women.

Leeftijd in jaar / Age in years

13 antwoorden

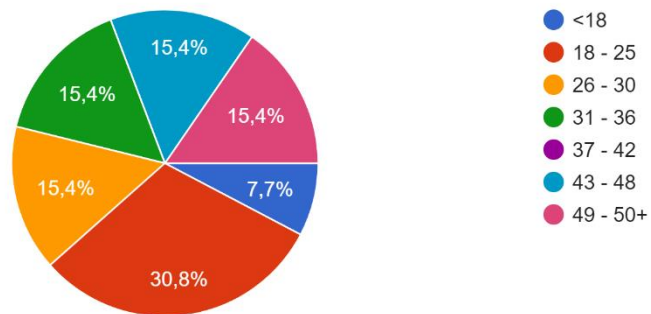


Figure 26 AGE PIE-GRAPH DATA SURVEY 2 (Google Formulieren, n.d.)

Geslacht / Gender

13 antwoorden

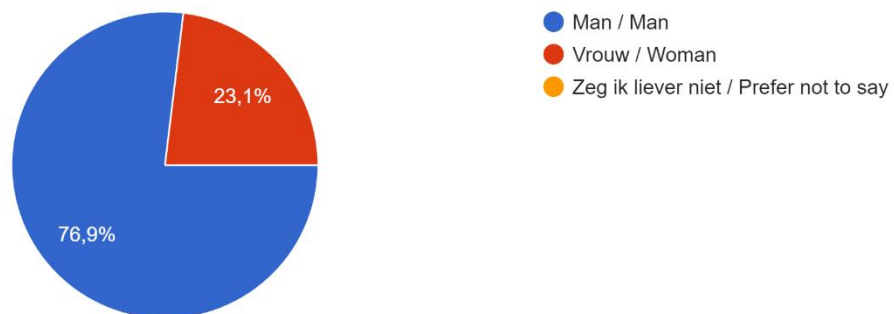


Figure 27 GENDER PIE-GRAPH DATA (Google Formulieren n.d.)

Using the AR application is generally very well received as only one respondent gave a slightly negative answer as can be seen in the graph below. [28] It also is clear that the vast majority (69,3%) of respondents, 9 out of 13, give a score of 7 or above.

Denk je dat schaken leren via de applicatie het leuker maakt? / Do you think learning chess through the application made it more fun ?

13 antwoorden

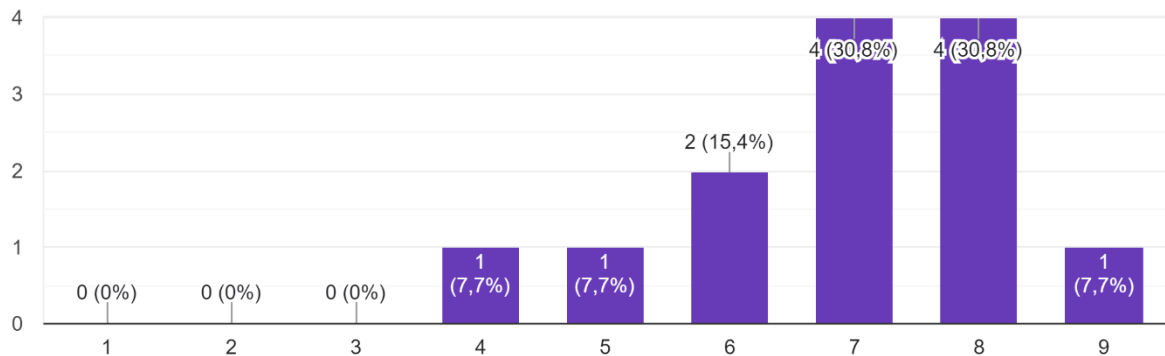


Figure 28 APPLICATION ENJOYMENT BAR-GRAPH DATA (Google Formulieren n.d.)

The realism of the application felt true enough for half (50%) of the respondents. This means that using AR to combine both the real and virtual world is a good approach and definite possibility for applications such as chess trainers and the like. The majority of the respondents found that the application was a good combination of both worlds. [29] The respondents had the option to freely comment which led to valuable feedback as can be seen in the graph below. All respondents are Dutch/English speaking citizens, so we can share their responses as is.

Hoe ervaarde je de applicatie? / How did you experience the application?

12 antwoorden

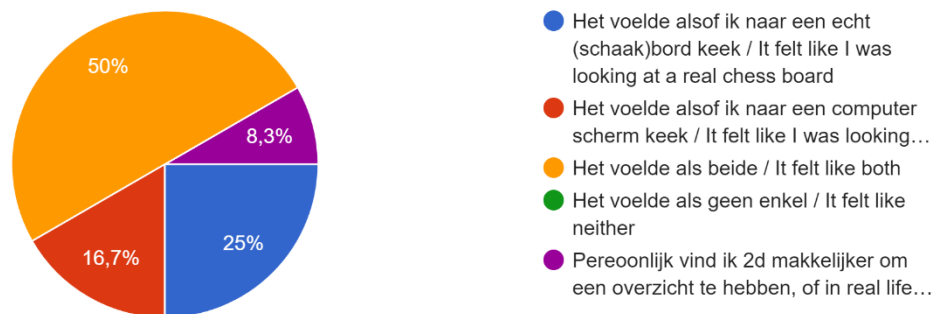


Figure 29 APPLICATION EXPERIENCE PIE-GRAPH (Google Formulieren n.d.)

Although a small portion of the respondents (15,8%) answered below neutral, the majority (84,2%) still answered that they're now more prone to do more things related to chess for reasons that aren't for learning or improving in skill and instead more for casual and fun reasons. [30]

It was clarified to the respondents that the goal of this question related to all manners of using this application, thus not limited to classes.

Denk je dat je schaak gerelateerde dingen zal doen apart voor het leren van de sport? / Do you think that you'll do more chess related things for reasons that aren't for learning?

13 antwoorden

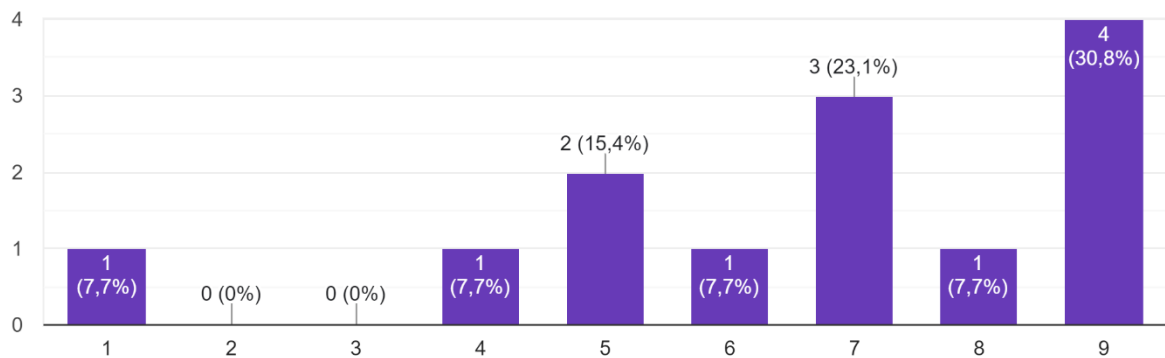


Figure 30 DOING MORE CHESS RELATED THINGS SURVEY DATA

A lot of people mentioned that the application and the ability to look at the pieces in 3D in a 360 degree view was able to help them understand the material of the class better (38,5% for yes, 30,8% for maybe). [31] The majority of the people who answered negatively were teachers rather than students so in turn they wouldn't understand it better since they already attained a high level of proficiency in chess.

The answers also indicate that a lot of the respondents (93,6%) think of an AR application with certain topics can be a good if not better alternative to learn chess as the majority of the answer are neutral (5) or above. [32]

Heb je de les beter of sneller begrepen door middel van het gebruiken van de applicatie? / Have you understood the material better by using the application?

13 antwoorden

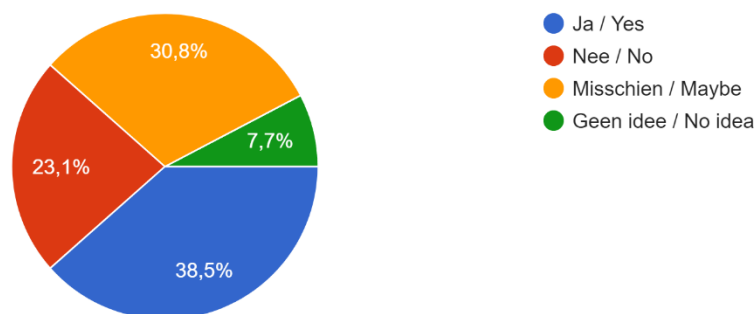


Figure 31 MATERIAL UNDERSTANDING SURVEY DATA

Denk je dat dingen leren via applicaties zoals dit een beter alternatief is in vergelijking met andere manieren? / Do you think learning through the application is better in comparison to other ways?

13 antwoorden

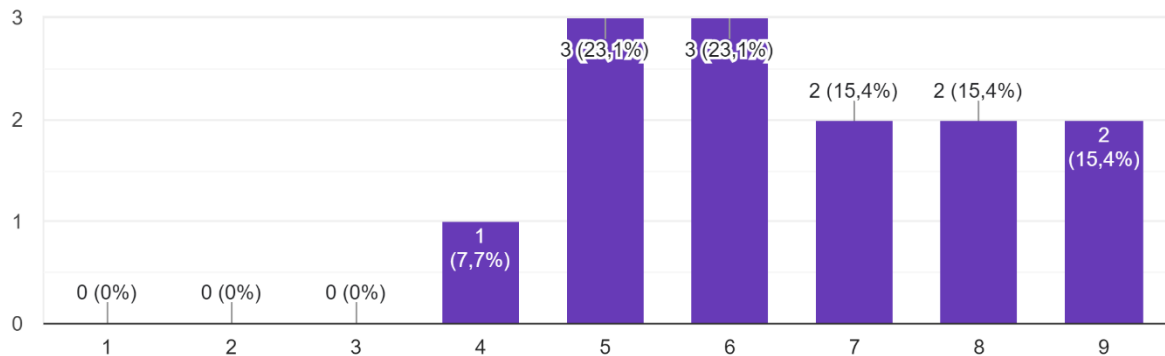


Figure 32 ALTERNATIVE LEARNING WAY SURVEY DATA

When polled about their willingness to use the application if they were required to install and use it on their own, the majority (53.8%) responded positively. [33] This means that AR has definitely a future in this field.

Zou je de AR applicatie nog spelen als je het zelf moest installeren met een stappenplan? / Would you still play the AR application if you had to install it yourself with the help of a guide?

13 antwoorden

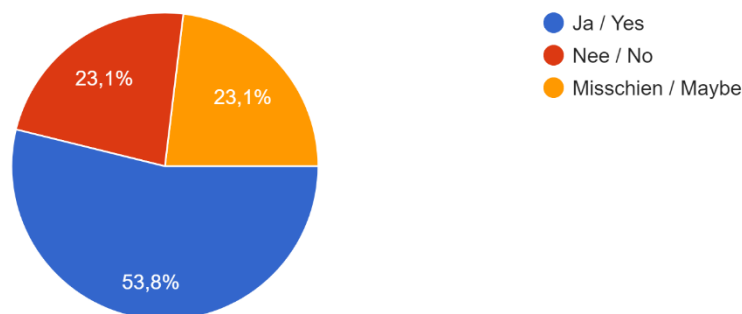


Figure 33 APPLICATION INSTALLED THROUGH GUIDE SURVEY DATA

The fact that respondents would not mind if the application required them to be outside (53,8%) similar to 'Pokémon GO' is seen as a benefit. We included this question so the respondents could share their own user scenario for the application. [34]

Als de applicatie buiten moest gespeeld worden, zou je het dan nog installeren en spelen? / If the application had to be played outside, would you still install and play it?

13 antwoorden

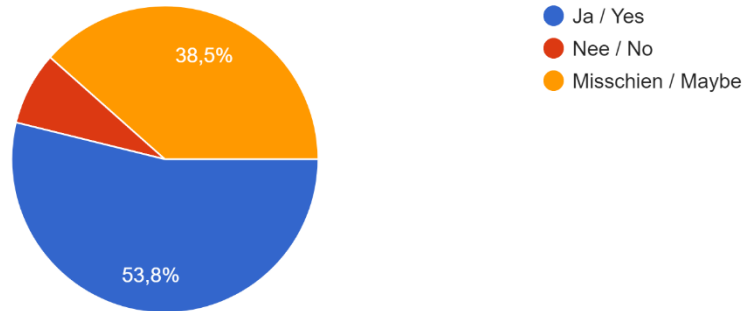


Figure 34 OUTSIDE APPLICATION SURVEY DATA

The majority (77%) would also install and play an AR application, or at least consider it, even if the AR application is not related to chess in any way. This shows that the interest in AR overall is bigger than initially anticipated. [35]

Als de applicatie over iets anders zou gaan dan schaken, zou je het dan nog installeren en spelen? / If the application was about something other than chess, would you still install and play it ?

13 antwoorden

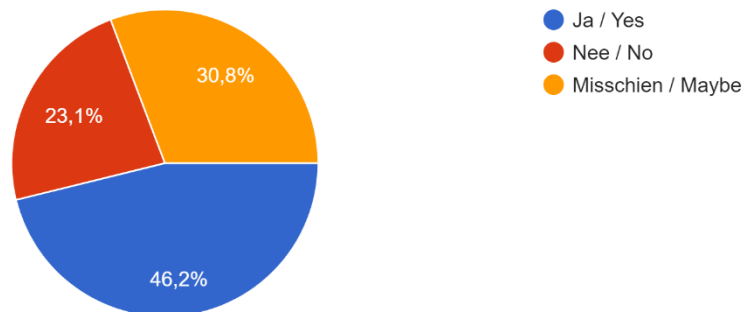


Figure 35 APPLICATION OTHER THAN CHESS SURVEY DATA

The most important question of the survey is about their active engagement with the application. Each respondent has had enough time to spend on the application as they wish before answering the survey.

The majority (58,3%) answered that they felt more engaged doing the puzzles through AR than a physical board or web applications. This has also been clarified at the time of them taking the survey that it was in comparison of AR with real/pure virtual chess puzzles. [36]

Of the participants that answered yes on the question above, they were prompted to give a number to evaluate their increased engagement with the application and the statistics show that average engagement is very high. (100%) [37]

Zou je zeggen dat je je meer betrokken voelde in het oplossen van puzzels met de applicatie?

/ Would you say you were more engaged when solving the puzzles through the application?

12 antwoorden

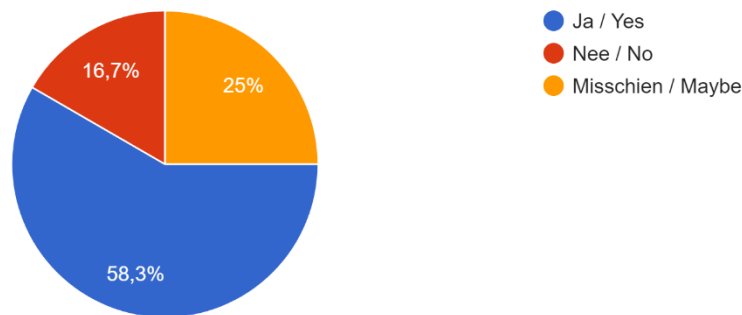


Figure 36 APPLICATION ENGAGEMENT SURVEY DATA

In het geval van ja op de vraag erboven, hoe veel extra zou je zeggen dat je je betrokken voelde? / In

case you answered yes on the previous question, how much more would you say you were engaged?

9 antwoorden

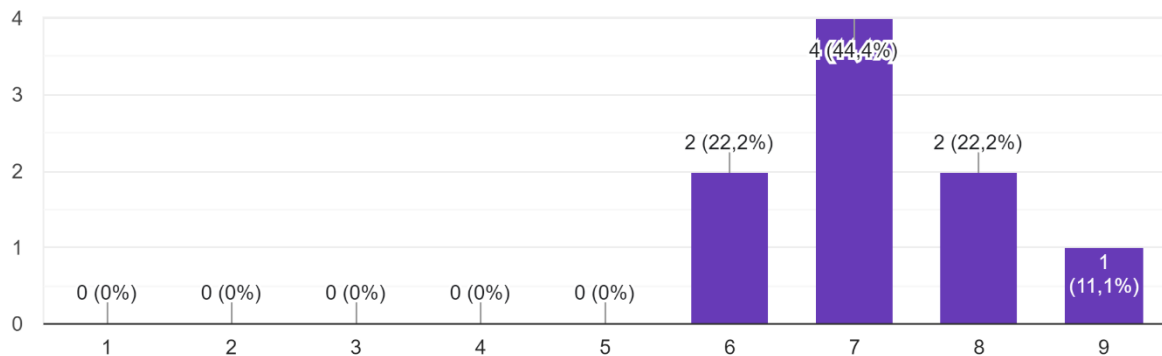


Figure 37 EXTRA ENGAGEMENT GAUGE SURVEY DATA

DISCUSSION

It is interesting to see how people from different age groups perceive, interact and understand AR as a whole. As it is very apparent that AR itself isn't as well known or understood in the eyes of a certain age.

Despite them not knowing fully what AR entails, once they've been given a proper explanation, they were able to figure things out on their own and make their way through the process of the application.

From the results on one of the questions of the survey, being able to combine both the best elements of real life and online chess was definitely something that can be obtained and/or enhanced if proper polishing and tweaking could be done.

Despite the respondents of being varying age groups, their overall enjoyment of using the AR application has a high average rating as well as their increased feeling of engagement with the material presented within the AR world.

This study shows that age does not interfere with the experience of using AR technology to learn something new while having a good time doing so. It shows with chess that most find it quite enjoyable, although a lot of the feedback went into the aspects of the game itself such as the models not being clearly differentiable or the board not being able to be scaled up or down properly.

CONCLUSION

According to the tests we've conducted, the following hypotheses have either been confirmed or debunked.

- If they use the application, their overall interest and playing sessions will be longer compared to going to clubs or meetings.

→ This hypothesis has been confirmed by the survey results from the questionnaire. The majority of respondents felt an increase in engagement and played the application for longer than was initially needed. Many also stated that there was a combination of the feeling of looking at a screen and 'real' chessboard at the same time. [\[29\]](#) [\[36\]](#) [\[37\]](#)

- If they stay engaged longer with AR, their skill will improve quicker.

→ This hypothesis will need a bigger sample size in order to come to a conclusive answer. From the survey results, a lot of the participants answered that they understood the material better through the use of the application and a big portion of them weren't too sure about it. [\[31\]](#)

Although the data doesn't show a clear answer to this hypothesis, the people who undertook the class about the material and then later played it through the application do indicate they understood it better through the use of the application, therefore their skills technically improved quicker as they caught and absorbed info much better.

- If they learn topics through AR, they will be prone to do more related activities out of interest outside learning environments.

→ This hypothesis has been confirmed by the question on the survey. [\[30\]](#) A big majority answered in favor of doing more chess related activities that weren't for the sake of learning or improving.

FUTURE WORK

With additional resources allocated to this research, there could have been a more extensive focus on development, allowing for the inclusion of larger sample sizes and the exploration of diverse data collection methods for analysis.

With serious games becoming popular and more standard, AR could have a chance to provide a similar environment while keeping the interaction with real world consistent. This gives the best of both worlds, being able to learn and improve through the use of games, all while it being set in realistic and familiar surroundings.

When it comes to the next course of action, I'd first suggest normalizing AR being used as a game media, after that proper and thorough research can be done on how it affects the thought process and engagement of those who actively use it. The mix of realism and game can potentially make it easier for people to learn things quicker or retain info longer which could then translate to an overall increase in interest in learning new skills.

As for the application, a teacher who teaches a separate class mentioned that with some polishing this could be a presentable idea to chess.com. If the opportunity presents itself, I would like to remake the application on my own with my current understanding of how the logic is written and polish it in a nice and presentable way before considering the suggestion of the teacher.

If this is something that they'd be interested in, it could be a good step in my career as well as a great first milestone as a developer that is also passionate about playing chess.

CRITICAL REFLECTION

While working on and nearing the end of this research, I have learned that the scope for accurately gathering data for this project was too large considering the time constraints that were present. If I could have started the application development sooner, the data would have been more reliable and more spread out.

Personally, I was surprised to learn how AR development wasn't as difficult as I made it out to be, the issues that arose were related to the build platform, wrong settings and overall generic coding problems / bugs that pop up during development. As such the accessibility of AR is far higher than I had estimated it to be, which in turn opens up many more possibilities for development.

It is remarkable to see how few applications have risen using this technology, this could be because not every Android device is compatible or supports AR and IOS puts their services behind a paywall. This is no problem for companies, but for hobbyists or those who do it for research, it's less appealing.

Although it didn't happen this time around, one thing I've gotten a scare of and have learned is that if you're giving out a survey and need a certain question to be answered, put it as mandatory if you're using google forms. It's a setting that you can enable or disable.

REFERENCES

Android (operating system). (2024). In *Wikipedia*.

[https://en.wikipedia.org/w/index.php?title=Android_\(operating_system\)&oldid=1192934390](https://en.wikipedia.org/w/index.php?title=Android_(operating_system)&oldid=1192934390)

Apple Inc. (2023). In *Wikipedia*. https://nl.wikipedia.org/w/index.php?title=Apple_Inc.&oldid=66712299

AR Development.pdf. (n.d.). Retrieved October 24, 2023, from

<https://citeseerx.ist.psu.edu/document?repid=rep1&type=pdf&doi=0f9e15c2413e5f3964d36fff72cb033c07552d20>

Chess Pieces Names, Moves & Values—Chess.com. (n.d.). Retrieved January 3, 2024, from

<https://www.chess.com/terms/chess-pieces>

Dinesh Punni (Director). (2019, August 11). *AR Foundation & Unity 01: Setup for Android*.

<https://www.youtube.com/watch?v=0mpsiO2lCx0>

GameDevChef (Director). (2020a, December 2). *Chess Game in Unity Tutorial! Part 1: Architecture and Board Generation*. https://www.youtube.com/watch?v=cWgoOak_8sE

GameDevChef (Director). (2020b, December 9). *Chess Game in Unity Tutorial! Part 2: Piece Movement and Input System*. <https://www.youtube.com/watch?v=8W-MJlgAz8U>

GameDevChef (Director). (2020c, December 28). *Chess Game in Unity Tutorial! Part 3: Finishing the Project*.

<https://www.youtube.com/watch?v=9-6EcY1qLug>

Google Forms. (2024). In *Wikipedia*.

https://en.wikipedia.org/w/index.php?title=Google_Forms&oldid=1193719130

Google Formulieren: Online formuliermaker | Google Workspace. (n.d.). Retrieved January 7, 2024, from

<https://www.facebook.com/GoogleDocs/>

Is Unity Good for AR/VR? [Comparison With Unreal Engine] - Whizpool. (2023, September 7). Whizpool | Your Software Development Partner. <https://whizpool.com/mobile/is-unity-good-for-ar-vr/>

Leren schaken met de Stappenmethode—Geschiedenis. (n.d.). Retrieved October 21, 2023, from

<https://www.stappenmethode.nl/nl/geschiedenis.php>

McCarthy, P. (2023). *What is NuGetForUnity? [C#]*. <https://github.com/GlitchEnzo/NuGetForUnity> (Original work published 2015)

samyam (Director). (2022a, December 12). *How to Build & Run Unity to iOS for Testing*.

<https://www.youtube.com/watch?v=-Hr4-XNCf8Y>

samyam (Director). (2022b, December 28). *Plane Detection in AR Foundation—Unity Tutorial 2023*.

<https://www.youtube.com/watch?v=mDLmqhhY-6g>

Schaakhuis Caissa. (n.d.). Retrieved October 21, 2023, from <https://www.kgsrl.be/caissa/info.html>

Science, L. S. of E. and P. (2022, April 12). *Location-based mobile games like Pokémon Go may help alleviate depression*. London School of Economics and Political Science. <https://www.lse.ac.uk/News/Latest-news-from-LSE/2022/d-Apr-22/Location-based-mobile-games-like-Pokémon-Go-may-help-alleviate-depression.aspx>

Sviatoslav. (2023). *Gera Chess Library* [C#]. <https://github.com/Geras1mleo/Chess> (Original work published 2022)

Unity (engine). (2023). In *Wikipedia*. [https://nl.wikipedia.org/w/index.php?title=Unity_\(engine\)&oldid=65231289](https://nl.wikipedia.org/w/index.php?title=Unity_(engine)&oldid=65231289)

Unity Real-Time Development Platform | 3D, 2D, VR & AR Engine. (n.d.). Unity. Retrieved January 3, 2024, from <https://unity.com>

Unreal Engine. (2023). In *Wikipedia*. https://nl.wikipedia.org/w/index.php?title=Unreal_Engine&oldid=66507292

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APPENDICES

GitHub project: https://github.com/JonasBruylant/Chess_AR

Chess training in 5333+1 positions by Judith Polgar1994: <https://ausee.files.wordpress.com/2016/06/23.pdf>

UI-experience survey: : <https://forms.gle/hLRaKQNwtuJBGHj96>

User experience survey: <https://forms.gle/fgYMpJ4Nq9zL5Bkg9>