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Building and Understanding an AR Puzzle Game  
for Learning: A Step Towards Tailored Educational  
Gaming

- Demonstration



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# Building and Understanding an AR Puzzle Game for Learning: A Step Towards Tailored Educational Gaming -Demonstration

## **Abstract**

The primary objective of the thesis was to develop an Augmented Reality game to conduct detailed research on learning patterns for children in the educational field. The puzzle game was developed using Unity as a game engine. Different learning patterns and their use in the creation of Augmented reality has been discussed in the thesis.

The result of the thesis was an AR puzzle game which uses the game mechanic for the user to develop their puzzle-solving skills. Despite achieving partial success, as the game currently lacks a learning algorithm to modify itself based on user behavior, this research provides the initial steppingstones towards further development.

Future research will focus on individualizing learning strategies and embedding these learning patterns into the gaming ecosystem.

Keywords:

Augmented reality, psychological analysis, cognitive learning, Unity, IDE



# Contents

<b>1 Introduction</b>	<b>6</b>
<b>2 Traditional approach on the learning pattern framework</b>	<b>8</b>
<b>3 Modern approach on the learning pattern framework</b>	<b>9</b>
3.1 Introduction to meta cognitive and cognitive learning patterns	9
3.2 Benefits of modern Learning patterns	10
<b>4 Comparison between traditional and modern learning pattern</b>	<b>11</b>
<b>5 AR puzzle game</b>	<b>12</b>
5.1 Development	14
5.2 Learning and Game Design approach used in the puzzle game.	18
5.3 Game programming patterns	19
5.4 Gameplay	19
<b>6 Result</b>	<b>21</b>
<b>7 Scalability of the game</b>	<b>22</b>
<b>8 Conclusion and future work</b>	<b>23</b>
<b>References</b>	<b>25</b>

## List of abbreviations

2D	Two-dimensional
3D	Three-dimensional
API	Application Programming Interface
AR	Augmented Reality
IDE	Integrated Development Environment

# 1 Introduction

In the modern era of multimedia platforms, social networking, and the availability of portable devices, the potential for the increment of game content to be used anywhere in the real world is on the rise. Augmented reality (AR) games are the modern-day innovative digital games that enable the real players to interact simultaneously with both the digital world and the real world. Augmented reality can be achieved via various technological innovations such as general hardware components, displays, sensors, software either on their own or in conjunction with each other. AR technology provides an alternative approach on learning and experiment. Since, AR provides the fusion between real life and virtual environment, based on the experiment done with a group of randomly selected 122 students, the students selected in the AR group performed better than the traditional group based on the knowledge improvement. Moreover, statistically students showed more positive perceptions, knowledge improvement and cognitive load [1].

Learning pattern which was conceptualized in the 1970s is a theory related to the whole of learning activities that can be interrelated between cognitive, affective, and regulative learning activities. Different students have different learning styles and have their own special ways to learn and process the information. However, students all share some learning patterns, preferences and approached.

Child psychology is the study of the subconscious and conscious development which tends to map into the learning pattern that includes how children think, learn, interact with the surrounding/environment around them.

The study on cognitive learning method and the use of AR in modern-day education exhibits the strengths and the areas for continued development in the field of educational games for children and adult learning. Educational research has identified the AR to have a significant impact on affective and cognitive learning. However, only few works have been conducted to support the claim.

The primary goal of the thesis is to develop a game that can be used to conduct the detailed research on the Learning pattern and the impact of different learning patterns on the modern-day learning practices. Different chapters of the thesis explain various subject relation to the creation of the augmented reality game. While the second chapter introduces the traditional approach to learning patterns, the third chapter introduces the modern approach. The fourth chapter compares the traditional and modern approach on the learning pattern framework. The fifth chapter details the implementation of the AR game developed as a part of this thesis. Along with different technical aspects of the game, outcome of the game, limitation, and ways to overcome the limitation of AR with the technology available today has been discussed in the sixth chapter. Finally, the seventh chapter presents the conclusion of the thesis.

## **2 Traditional approach on the learning pattern framework**

The traditional learning patterns prioritized memorization through memorized learning and depended heavily on repetitive assignments. Critical thinking, problem-solving, metacognitive, and social skills, however, received little focus. As the teacher predominated classroom conversation, there were few possibilities for active engagement and discussion among the students. Additionally, by today's standards, the methods used to manage conduct back then can be seen as severe.

This approach typically follows a structured and teacher-centered approach where the teacher is the central figure in the classroom for delivering content, explaining concepts and leading classroom activities. In contrast, students just play a passive role in this system and are taught with the same pace and curriculum. Traditional learning approaches heavily rely on assessments with little to none focus on deeper understanding or critical thinking skills [2].

Although Traditional Learning patterns have flaws, this is practiced in most part of the undeveloped or developing countries due to the lack of necessary infrastructures and technology.



### 3 Modern approach on the learning pattern framework

Research on learning and concept of learning were discussed in the late 1970s and early 1980s. The early research held on 1970s was focused on the cognitive strategies and motivation which became known as the student approach to learning tradition. However, the second pillar of research conducted in 1980s which focus on the metacognitive later developed into a tradition commonly known as Self-Regulated Learning shares the light on children's metacognitive knowledge, beliefs, and their self-regulated leaning strategies [3]. In cognitive learning, the knowledge is to be acquired is declared.

#### 3.1 Introduction to meta cognitive and cognitive learning patterns

Metacognitive learning pattern is the pattern to understand one's awareness of the ability and brain's thoughts and thought process to use prior knowledge to plan a strategy for approaching a learning task, solve the problem, reflect on, evaluate, and modify the approach for the future based on the previous evaluation. Cognitive learning is the immersive style of learning that focuses on the mental process in a constructive and long-lasting way to maximize the brain potential for thinking, understanding based on internal and external factors. For instance, when a child comes across a new item, they tend to find an existing schema which can be an object or a process in their head into which they can incorporate the new information or construction a new schema. [4]

Robert Gagne, a renowned educational psychologist developed a system of cognitive learning which consists of the three step such as:

- Preparation of learning where the main task is to gain students attention, provide information on what to learn and suggest recalling the previous information.

- Acquisition and performance where the task is to gain student's attention to the fact that is about to be provided to them. For instance, the students are Quizzed for the retrieval of information and students are reinforced with feedback or grade.
- Transfer of learning where the learned informed is transferred to different areas of learning life. [4]

Since, the social and behavioural aspect of the human is adjusted and adapted as we learn overtime and every process is impactful likewise, cognitive theory has also been adjusted and adapted over similar factors and can be main categorized into social cognitive theory and cognitive behavioural theory.

### 3.2 Benefits of modern Learning patterns

The modern Learning pattern focuses on the development of the student in relation to the environment and understanding of their own ability to gain, store and improved [4]. The most common benefits of the cognitive learning are:

- It helps student to get familiar with the environment and allow them to explore the material and develop and deep understating of the subject and its use application in real life.
- Effective learning helps to develop the core problem solving skill and apply it to every aspect of life.
- Through immersive learning, students can develop deeper understanding of topics and gain a better understanding of their subjects which help them build up the confidence [5].
- The immersive experience with the real-life environment helps to build the lifelong love for learning.
- Provides the visual spatial reasoning and flexible thinking.

## **4 Comparison between traditional and modern learning pattern**

To cultivate the mind of the students for an ever-changing world, modern learning patterns focuses on the skills such as critical thinking, creativity, collaboration, and adaptation. In contrast, the traditional approach fails to focus on the individual student's creative thinking skills.

Traditional approach mostly focuses on the textbook provided to the student whereas modern approach leverages a variety of resources beyond textbooks such as online materials, multimedia, simulations, and interactive tools. In contrary to traditional approach, collaboration and team works are encouraged in the modern approach which encourages student to build more social skills.

## 5 AR puzzle game

For the user to start playing AR puzzle game, the user needs to detect the surface where the UI can be placed (Figure 1). Upon detection, the player can tap and place the game UI in the real-life environment (Figure 2).



Figure 1. Plane detection.

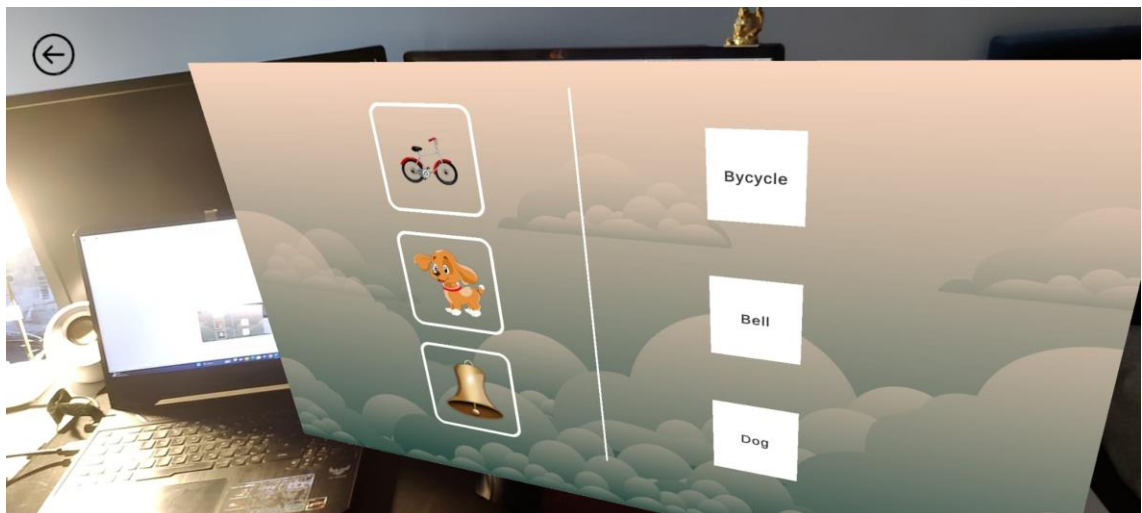


Figure 2. Tap and placing of the UI in real environment.

The AR puzzle game uses the modern learning pattern in conjunction with the AR technology which has multiple game mode. The first game mode consists of the visual representation on the left side of the screen and the text on the right side of the screen ( Figure 3). The player must drag and drop the text to the correct visual option. Upon completion of the round, the player will be presented with Descriptive option instead of a visual option on the left side of the screen and the same text on the right side of the screen (Figure 4).

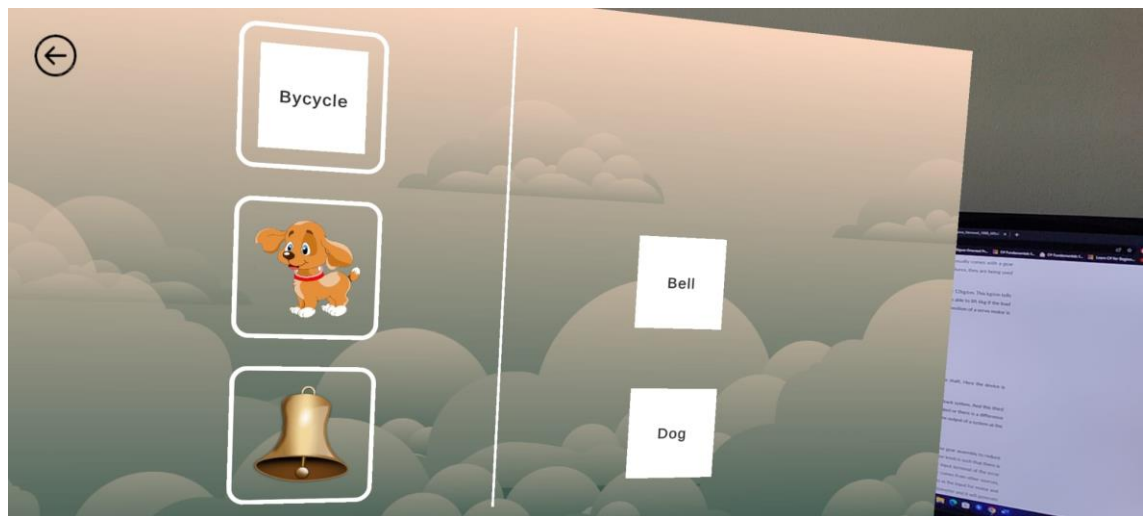


Figure 3. First round of the game mode.

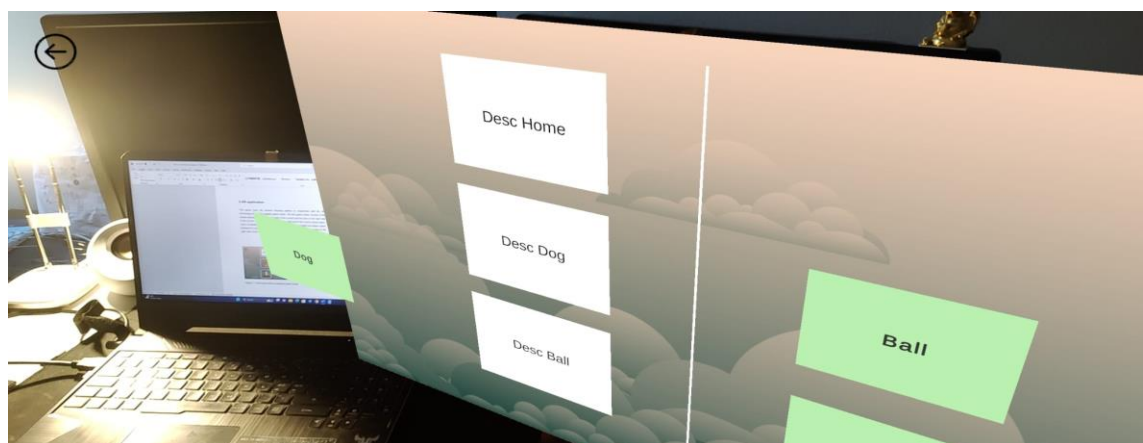


Figure 4. second round of the of game mode.

As seen in Figure 4, the UI elements can be dragged anywhere in the real-life environment which enables the students to have more fun and be more engaged.

## 5.1 Development

Adobe XD was used to create a design and prototype of the game and Unity as a Game engine to design and to code the game. Jet brains IDE was used to code the game in C sharp programming language.

Unity is a beginner friendly Cross-platform game engine developed by Unity technologies which is used to create 2D and 3D interactive simulation that includes VR and AR. It has various functionalities which includes Cross-platform, Visual editor, Scripting and Programming, Asset Pipeline, Animation and many more which helps the developer to increase the efficiency of the workflow. (Figure 5)



Figure 5. Advantages of unity Game Engine. Source:

<https://www.hireunitydeveloper.com/wp-content/uploads/2018/03/Hire-unity-developer-unity-3d-game-development.jpg>

The UI development of the game is done in Unity with use of sprites and assets. The UI, drag and drop functionality and the amounts of cards shown in the Game mode needs to be controlled via Scriptable Objects. (Figure 6)

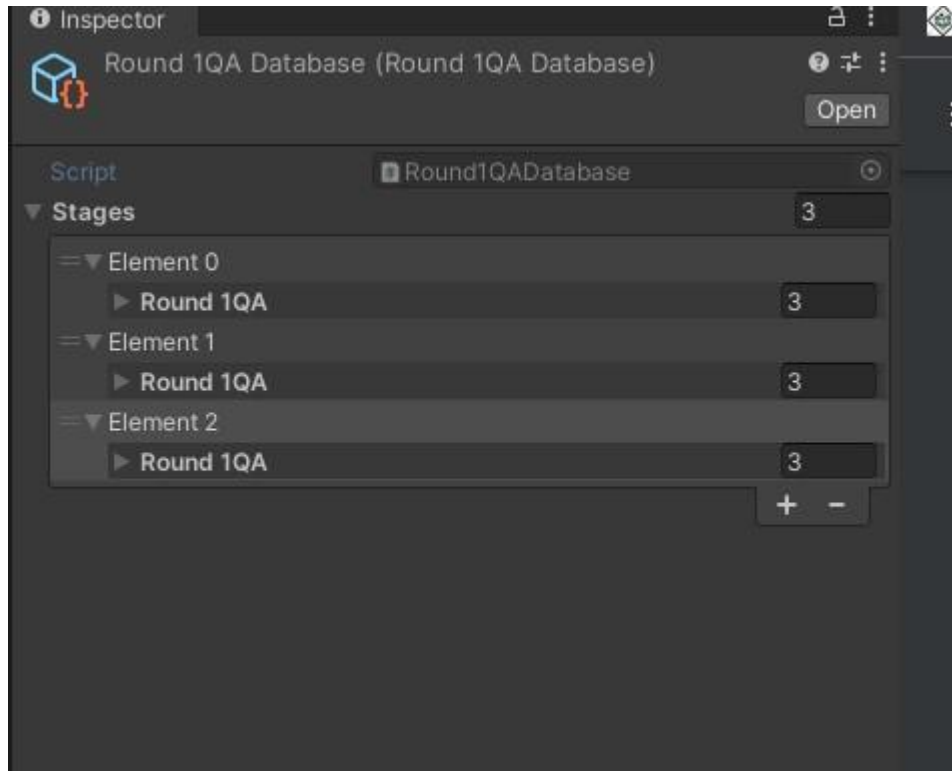


Figure 6. Scriptable object UI.

The figure 6 shows the importance of scriptable objects in the scalability and maintainability of the game. The number of questions and rounds can be controlled throughout the game by just changing the value here.

The figures 7 and 8 show code that controls every aspect of question and answers of the vocabulary game mode. The code controls the visual representation of the game along with the text part of the game.

```

1  using System;
2  using System.Collections.Generic;
3  using UnityEngine;
4  using UnityEngine.Serialization;
5
6  [CreateAssetMenu(fileName = "Round1QADatabase", menuName = "ScriptableObject/Round1QADatabase")]
7  public class Round1QADatabase : ScriptableObject
8  {
9      public List<StageForRound1> stages;
10 }
11
12 [Serializable]
13 public class StageForRound1
14 {
15     public List<Round1QA> round1QA = new List<Round1QA>(capacity: 3);
16 }
17
18 [Serializable]
19 public class Round1QA
20 {
21     public Sprite question;
22     public string ans;
23 }

```

Figure 7. Code of the scriptable object.

```

1  using System;
2  using System.Collections;
3  using System.Collections.Generic;
4  using UnityEngine;
5  using UnityEngine.Serialization;
6
7  [CreateAssetMenu(fileName = "Round2QADatabase", menuName = "ScriptableObject/Round2QADatabase")]
8  public class Round2QADatabase : ScriptableObject
9  {
10     public List<StageForRound2> stages;
11 }
12
13 [Serializable]
14 public class StageForRound2
15 {
16     public List<Round2QA> round2Qas = new List<Round2QA>(capacity: 3);
17 }
18
19 [Serializable]
20 public class Round2QA
21 {
22     public string description;
23     public string ans;
24 }

```

Figure 8. Code to control the second part for the game mode.



The code controls the matching of the description of the object with corresponding correct answer which upon completion shows the feedback in form of stars which helps to enforce the sense of achievement and short and quick gameplay helps to improve the processing speed (Figure 9).

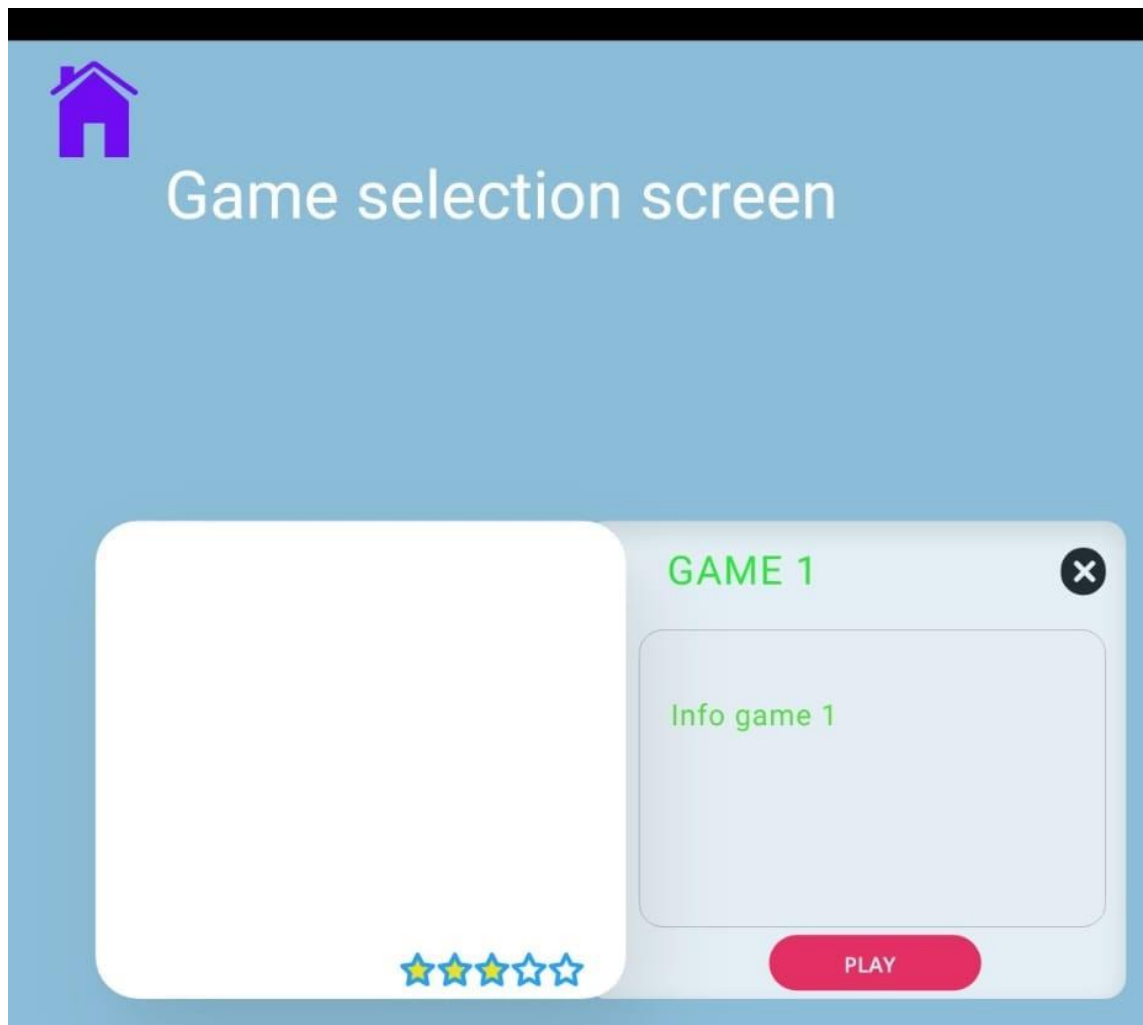


Figure 9. Reward system.

## 5.2 Learning and Game Design approach used in the puzzle game.

Cognitive Learning practice was used in the development of the game where the player can improve the processing speed, thinking strength, flexibility thinking capacity, working memory of the player with fun and interactive game play.

The AR content provides immersive experience aligned with learning objective by overlaying the character and object in the real-world environment and creating a scenario that requires cognitive skills to complete the task. The game has the gradual learning progression that helps the players to understand and apply the cognitive skills required.

Different game mode focuses on development of different skills among different players with different capabilities.

The puzzle game consists of the card that has picture on one side and the description on the other side. The player must first match the picture with the option provided in the game. Upon completion of the round the card will Change only providing the description of the object and must match with the text provided in the option. After completion, the player is provided with the feedback to boost the confidence and provide the sense of accomplishment.

The Gameplay sessions are short and frequent which helps to reinforce new connections more effectively which help to improve the processing speed and thinking strength [6].

### 5.3 Game programming patterns

Game programming patterns or just programming patterns in general are structured and efficient solution for the frequent problem which occur in programming. This helps in improvement of the code reusability, maintainability, scalability. In Game development, state management pattern can be used to manage different state such as menus, game levels and overall game flow.

One of the game programming patterns used in the creating this game is singleton pattern and creating a scriptable object also helps to maintain a reusability and scalability of the code.

Scriptable objects are a special type of data container that helps in creating a reusable data object that can be accessed and modified at runtime [7].

### 5.4 Gameplay

The AR learning game aims to provide the gameplay that is suitable for the learning children to help them improve their cognitive abilities with simple and effective progression. [8] Gameplay is also trying to maintain the balance between art and science, learning design and game design and play and guided discovery.

### **Objective**

The main objective of the game is to improve their skills overtime and train their brain daily. By completing the problem in each game mode, the player will earn stars as a reward. The difficulty level varies depending on how many stars are

obtained. This is done to maintain their motivation and maintain their interest in learning, and it hides the boring part of the game with some incentive to make the connection between learning and fun [8]. The star or feedback system also aligns learning goals with the game goals which also tackles the main objective i.e., improvement of cognitive skills.

### **Game progression**

The children's learning game should grow in and should easy-to-follow with efficient manner. The gameplay changes based on the performance of the user. The higher the stars obtained, difficult the question will be and vice versa. On different game mode, the time also plays a vital role.

### **Target system**

The main core library used to make this game is AR Core. So, Device must be running Android 7.0 or newer and API Level 24 or higher.

## 6 Result

The puzzle game aims to aid students in understanding abstract ideas and gaining practical experience in risk-free virtual environments. The puzzle game can also be used as a library of immersive content, first hand demonstration of the specific matter and tool for the disabled children. The Immersive technology student to interact in real time with peers and instructors while taking part in remote learning activities in a passive manner [9]. The puzzle game will try to explore and implement the best learning method to inculcate the required skills among student/players.

## **7 Scalability of the game**

The core idea that is implement in the game has the immense potential to adapt and expand the game to accommodate a growing number of users, content, and education objectives. The underlying cloud-based services help to manage the multiplayer functionality which encourages the user base to interact with other people and make new friends. This can be the selling point of the game since current demographics struggle to connect with people in real life. This will have good impact on child psychology.

The exponential growth of AI in recent years can also be useful in assessing student behaviour and customizing the game style for each learner. This would shed more light on children's development with cognitive learning which includes thinking, learning, remembering, and understanding of information and concepts was encouraged since it is an effective way of nourishing the life-long love of learning and improvement.

## 8 Conclusion and future work

The main goal of this thesis was to research, evaluate and compare all the learning patterns and create an AR game based on research of learning patterns. Upon research and comparison between different approach of learning pattern, the modern approach of learning patterns has the better effect in child learning behaviour.

In this thesis, it was demonstrated that modern approach of learning pattern nourished the cognitive learning of the student which encourages the lifelong love of learning and improvement. The learning approach has undergone various transitional periods to cater the needs and demand of individuals and teachers. A few decades ago, it was difficult to imagine the possibility of a learning platform that might be more constructive, intuitive, and immersive, but because of the quick development of augmented reality technology, it is now a reality. From personal experience, rewarding students for their hard work motivates them to study. Such a strategy helps them overcome issues with attendance, punctuality, and motivation for the class. Along with the potential, AR games have limitations that include high processing power, battery drain, environmental issues, and distractions. Poor lighting, uneven surfaces, and insufficient room can hinder learning and negatively impact child psychology. Limited technological advancements may hinder access for students from developing countries and underdeveloped countries.

This thesis lays the groundwork for further improvements and new implementations that can build on it. Due to quick advancement in AI in recent years, a new more advanced game could be developed to understand the student cognitive learning strength and implement the game mode based on that. However, due to technological and time limitations , the math computation game and the essay game are left for the future work. In the case of the math computation game, the game can only be played in the specific period set by the player. The gameplay is scheduled at the specific time for specific duration where the player must solve mathematical problems based on the instructions provided

to them. A definite time break is given after each round whereas, in the essay Game session, the user is provided with the essay sample which will be curated for specific idea bubbles. The player must select all the related idea bubbles which summarize the essay. The essay sample is visible only three times in the 10 min period for thirty second period after the player has reviewed the essay in the beginning.

Further development of mentioned games would require the use of more complex technologies and design models than the one used in this thesis.



## References

- [1] Liu, Q., Yu, S., Xu, S., Wang, Q. and Chen, W., 2021. The effects of an augmented reality based magnetic experimental tool on students' knowledge improvement and cognitive load. [online] Wiley Online Library. Available at: <<https://onlinelibrary.wiley.com/doi/10.1111/jcal.12513>> [Accessed 8 July 2021].
- [2] Serroukh, S. and Serroukh, I. (2022) (PDF) traditional teaching method vs modern teaching ... - researchgate, Traditional teaching method Vs Modern teaching method Traditional teaching method Vs Modern teaching method the traditional way of teaching and learning. Available at: [https://www.researchgate.net/publication/362162911\\_Traditional\\_teaching\\_method\\_Vs\\_Modern\\_teaching\\_method\\_Traditional\\_teaching\\_method\\_Vs\\_Modern\\_teaching\\_method\\_The\\_traditional\\_way\\_of\\_teaching\\_and\\_learning](https://www.researchgate.net/publication/362162911_Traditional_teaching_method_Vs_Modern_teaching_method_Traditional_teaching_method_Vs_Modern_teaching_method_The_traditional_way_of_teaching_and_learning) (Accessed: 20 June 2023).
- [3] Ajisuksmo, C. R. P., & Vermunt, J. D. (1999). Learning styles and self-regulation of learning at university: an Indonesian study. *Asia Pacific Journal of Education*, 19(2), 45–59.
- [4] 2015. Cognitive Processes in Learning: Types, Definition & Examples. [online] Available at: <<https://study.com/academy/lesson/cognitive-processes-in-learning-types-definition-examples.html>> [Accessed 8 August 2021].
- [5] GradePower Learning, 2021. The Benefits of Cognitive Learning | GradePower Learning. [online] GradePower Learning. Available at: <<https://gradepowerlearning.com/benefits-of-cognitive-learning/>> [Accessed 21 September 2021].
- [6] BrainWare Learning Company. 2021. Cognitive Learning Examples. [online] Available at: <<https://mybrainware.com/cognitive-learning/cognitive-learning-examples/>> [Accessed 1 November 2021].
- [7] Unity Learn. (no date). Introduction to scriptable objects Available at: <https://learn.unity.com/tutorial/introduction-to-scriptable-objects#> (Accessed: 20 June 2023).
- [8] Hirumi, A., Appelman, B., Rieber, L. & Van Eck, R. (2010). Preparing Instructional Designers for Game-Based Learning: Part 2. *TechTrends* 54, 19–

27 (2010). <https://doi.org/10.1007/s11528-010-0416-1> (Accessed: 20 June 2023).

[9] Likens, S. and LEckert, D. (2021) "How Virtual Reality is Redefining Soft Skills Training,". Available at: <https://www.pwc.com/us/en/tech-effect/emerging-tech/virtual-reality-study.html> (Accessed: 20 June 2023).