

Design and Development of Pocket Cube Solver: A Mobile app for Teach Restore Pocket Cube

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Abstract: Rubik's Cube, a well-known puzzle toy, is composed of 21 cubes. Although the structure is simple, it can have many kinds of changes, so it is also called Magic Cube. Pocket Cube is a 2 x 2 Rubik's Cube with only four cubes per face and eight cubes. Although it is simpler than a Rubik's Cube, there are also many variations. Most people think Pocket Cube is very simple and can be restored without learning, so few people pay attention to Pocket Cube, and there is relevant literature. Therefore, this study aims to design and develop mobile applications to guide users in learning how to restore Pocket Cube and achieve the function of promoting Pocket Cube. In modern society, everyone has a mobile phone and carries it with them. Using a mobile phone can make good use of their spare time to do things they like, such as playing games and studying to learn how to restore Pocket Cube. Using Pocket Cube Solver can make reasonable use of time while learning to restore Pocket Cube. The development method chosen is prototyping. It is the best development approach in cases where requirements are unclear. The purpose of this study is to evaluate the usability and practicality of the app. The results show that Pocket Cube Solver is valuable and easy to use. Respondents were also satisfied with the app's functionality. This article helps to understand the system requirements and interface of the mobile application.

Keywords: *Rubik's Cube, Pocket cube, mobile app, Prototyping*

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1. Introduction

Rubik's Cube, also known as Magic Cube, from this alias can be seen the magic of the Rubik's Cube let people think it is magic. Professor Ern Rubik of Hungary's Budapest School of Architecture invented Rubik's Cube in 1974, and it is now owned by over a billion people [1,2]. It was initially designed to help students understand the composition and structure of the Cube, which was inspired by the gravel of the Danube River. The Rubik's Cube, along with China's Huarong Road and the independent Diamond Chest, is one of the world's three most incredible puzzle games. It would be considered a

wise decision for a smart game design because prior studies [3,4] have suggested that a Rubik's Cube game would aid in developing human beings' spatial symmetrical capability.

Pocket Cube is a kind of Rubik's Cube. Usually, we talk about a Rubik's Cube as 3 x 3. Pocket Cube is a 2 x 2 Rubik's Cube. Rubik's Cube has 21 cubes, while Pocket Cube has only eight cubes, and the number of changes is relatively small. Although the Pocket Cube has only eight blocks, there are 3,674,160 states after it is scrambled.

As time went by, Rubik's Cube competitions were held worldwide, and the Rubik's Cube evolved from a prop used to educate students into a popular educational toy worldwide. These contests include Pocket Cube-related contests, such as

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Pocket Cube Quick Restoring Contest and Blind Restoring Contest.

Despite this, Pocket Cube is still not well known, and many people think it's too easy to play around with and restore. It is not. Although it is very simple, it cannot be restored randomly by playing with it. Even if a player can restore it once or twice by luck, they cannot guarantee that they can restore it every time because Pocket Cube has unique formulas and situations.

In this case, if a player wants to restore Pocket Cube every time, they need to learn how to restore it. Nowadays, everyone has a smartphone and carries it with them. There are many fragments of time in people's lives, and the emergence of mobile apps can make good use of these fragments of time. This study aims to design and develop a mobile app for learning restoring Pocket Cube. As a result, Pocket cube solver, a mobile app prototype for studying main pocket cubes, was developed and evaluated. This study helps to understand this application's system requirements and development process.

2. Background

This section is the background of Pocket Cube. Although the Pocket Cube only has eight cubes, its eight corner blocks are $8! / 24 = 1680$ position arrangements. Moreover, each arrangement has 1107 colour directions (colour direction is conserved during twisting, and most of the theoretical hue in 3 to the eighth power is impossible to appear); that is, after the disruption of the second order Rubik's Cube, there are total $(8! \cdot 3^7) / 24 = 7! \cdot 3^6 = 3674160$ states. Therefore, the maximum recovery distance of Pocket Cube (that is, how many steps are needed to restore at most) is 11 complete rotations or 14 regular rotations, and this result can be calculated by using the exhaustive algorithm of a computer.

Professor Rubik applied the earliest patent of Pocket Cube on March 29, 1983, which is called R structure Pocket Cube. Chen Sen-li from Eastsheen Company in Taiwan applied for another type of Pocket Cube on October 27, 1998, called Eastsheen structure Pocket Cube.

Playing Rubik's Cube has many benefits. It can exercise observation, patience, memory, spatial judgment, reaction speed, and so more. Some teachers use it to teach math, physics, and so on. Imagine how many pieces a player can disassemble without breaking the Cube? 8 corner blocks, 12 edge blocks, one centre block, and 21 cubes in total. So, the total variation of Rubik's Cube is 4.3×10^{19} . What is the concept of this number? Assuming that the average human life span is 100 years, everyone twists the Rubik's Cube three times per second, all the time, it would take 4.6 billion people to rotate 4542 years to figure out every state. As a kind of Rubik's Cube, Pocket Cube naturally also has such variability, but because the Cube is less than a dozen pieces, the state is much less, only 3674160 kinds. According to scientists, the Rubik's Cube can be restored in as few as 20 steps, known as the number of God. Pocket Cube, on the other hand, the number of Gods is 11. So, if a player knows

the method is not blind rotation, they can recover in as few as 11 steps [5].

3. Methodology

For this study, the design and development of Pocket Cube Solver, a prototype model, is adopted for development [6]. A prototype is a software development model in which a prototype is built, tested, and reworked until it meets project requirements and becomes an acceptable prototype. It also lays the foundation for the final product of the software. It is best used when the project requirements and details are unclear. In addition, this is a way to communicate, share ideas, and try and fix bugs between developers and users.

The prototyping model has the following six SDLC phases as follows:

Step 1: Requirements gathered from supervisor and analyzed it

Step 2: Quick design

Step 3: Build a Pocket cube solver Prototype

Step 4: Initial user evaluation

Step 5: Refining Pocket cube solver prototype

(These phases do not end until all requirements specified by the user have been met.

The final application will be developed based on the final prototype approved by the user).

Step 6: Implement Product and Maintain

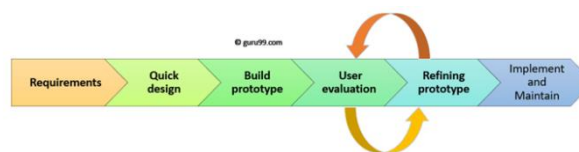


Figure 1: SDLC of Prototyping

For this research, prototyping is appropriate for this project. It also comes with the following benefits.

- Users can make comments early on the product. This can improve user satisfaction.
- Missing functionality and errors in the project are easily detected.
- Prototypes can be reused in future, more complex projects.
- Prototype models emphasize flexible design practices.
- Users have a better understanding of how the product works.
- User feedback can be received quickly because rapid user feedback can better understand users' needs.

4. Design and Development

This section mainly introduces requirements gathering and analysis for Pocket Cube Solver. There are two main methods: 1) Communicating with the supervisor to

understand the requirements. 2) Conduct information sorting and analysis by consulting relevant information online and looking for similar apps.

After analyzing the collected information, as shown in Table 1, as shown in Table 1, the app should be able to display pages, such as the situation page, and allow users to choose appropriate solutions based on the situation they encounter. Furthermore, the reaction time should not be too long; otherwise, it will affect the user experience, and the response time from one page to another should not exceed three seconds. The use case diagram shown in Figure 2 details the dynamic behaviour of the application.

Table 1: List of Requirements

ID	Name	priority
1	Display solution	
1-1	The app will display the solution page	High
1-2	The app will allow users to select which step they want to display	Medium
1-2-1	If select some special step app will give extra steps and allow the user to choose the suitable one	Medium
1-3	The app will display the step which the user selected.	High
1-4	Response Time	
1-4-1	The application's response to the user should not be more than three seconds.	High

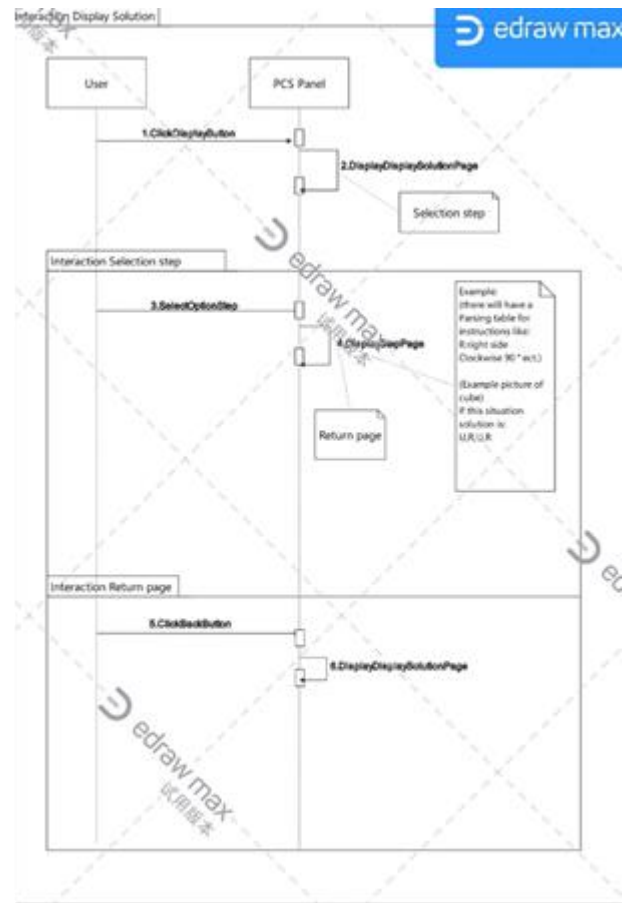


Figure 3: Sequence/Activity Diagram

The Sequence/Activity Diagram as shown in Figure 3 depicts a user using Pocket Cube Solver. First, the user clicks the display button, and the Pocket Cube Solver displays the screen selected by the user. The user then selects the steps, and the Pocket Cube Solver displays the selected step page. Finally, click the back button, and Pocket Cube Solver will return to the previous interface. Figure 4 shows the classes involved in this research.

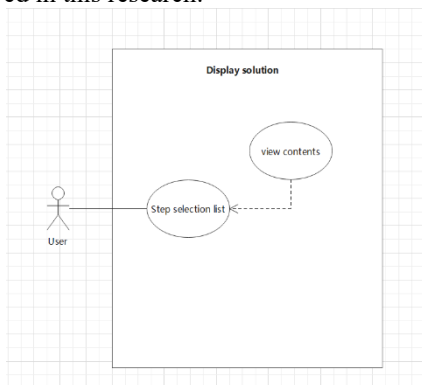


Figure 2: The use case diagram

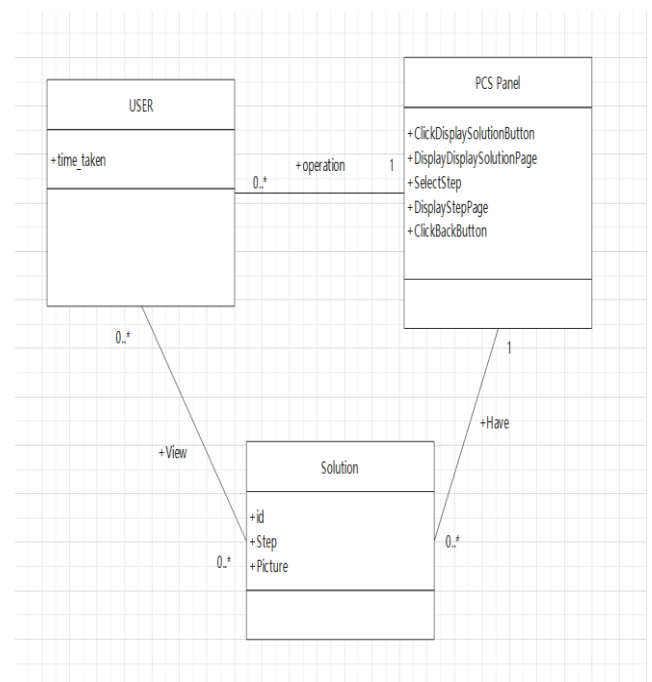


Figure 4: Class Diagram

5. The Pocket Cube Solver Prototype Development

A prototype of a mobile app for teaching how to restore pocket cubes named Pocket Cube Solver was developed. It represents the requirements explained in the previous subsection. Software prototyping is a standard way of demonstrating the software requirements so that further comments and suggestions could be obtained from the users based on their experience in interacting with the prototype [7].

The Android Studio [8] was used as the main integrated development environment (IDE) tool. The following figures (Figure 5, Figure 6, and Figure 7) show the most important pages of the prototype.

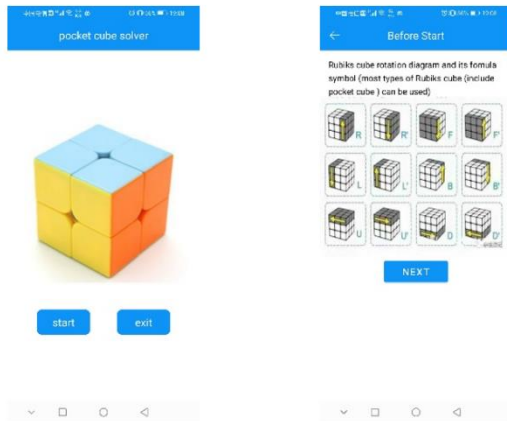


Figure 5: Main page and Start page

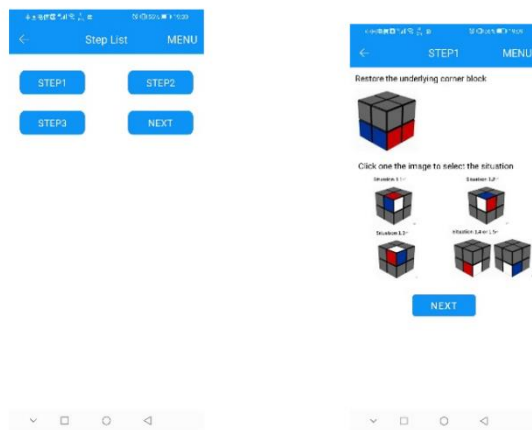


Figure 6: List page and Step 1 page



Figure 7: Step 2 page and Step 3 page

6. Evaluation of Pocket Cube

The evaluation of this research is classified into two categories as follows. The evaluation was conducted in a questionnaire survey with 30 samples from Rubik's Cube Communication Group and the author's relatives and friends. Among them, the male-to-female ratio is 7:3.70% male and 30% female as shown in figure 8.

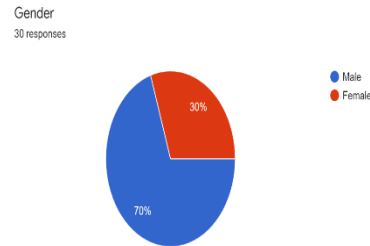


Figure 8:

Gender

Age distribution: 13.3% 16 to 20 years old, 33.3% 21 to 25 years old, 20% 26 to 35 years old, 10% 36 to 45 years old, and 23.3% over 46 years old, as shown in Figure 9.

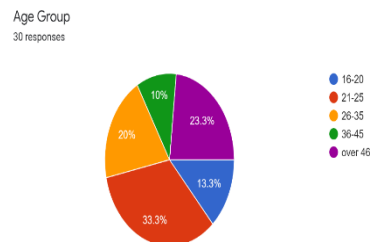


Figure 9: Age Group

Among the respondents, 23.3 % often play with Rubik's Cube, 20 % have never played with it, 36.7 % occasionally play with it, and 20 % have only heard of it, as shown in Figure 10.

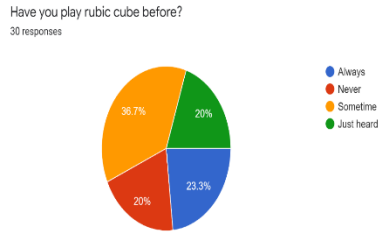


Figure 10: Have they ever tried Rubik's Cube?

Among the respondents, 43.3% have heard of Pocket Cube, 30% have not heard of it, and 26.7% think they have heard of it, as shown in Figure 11.

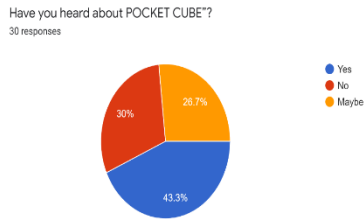


Figure 11: Have they heard of Pocket Cube?

Figure 12 shows whether the subjects found Rubik's Cube difficult. 20% of the subjects thought it was difficult, 46.7% thought it was not difficult, and 33.3% were unsure.

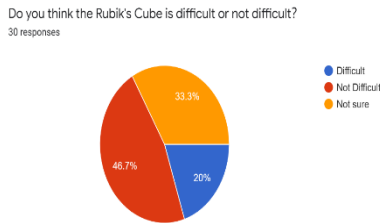


Figure 12: Difficulty of the Rubik's Cube

An analysis was conducted on the respondents' responses to the questionnaire. The section measures the respondents' perception of the Pocket cube solver's usefulness and ease of use. Table 2 and Table 3 show the details of the responses.

Table 2: Respondents' responses to Pocket Cube Solver functionality

Question	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
The steps explained are very detailed	0	0	0	0	30 (100%)

I'm satisfied with the way each case is analyzed in the Pocket cube solver	0	0	0	2 (6.7%)	28 (93.3%)
The combination of text and images is satisfactory	0	0	0	4 (13.3%)	26 (86.7%)
Text and images clearest	0	0	0	6 (20%)	24 (80%)
The interface style is good	0	0	0	3 (10%)	27 (90%)
The formula analysis is better than other apps of the same type	0	0	0	5 (16.7%)	25 (83.3%)
This app is fully functional	0	0	0	2 (6.7%)	28 (93.3%)
The picture selection is good	0	0	0	4 (13.3%)	26 (86.7%)

Table 3: Respondents' responses to Usefulness of Pocket Cube Solver

Question	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
Pocket Cube Solver is more useful than the manual that comes with Pocket Cube	0	0	0	0	30(100%)
To understand how to restore Pocket Cube. Using the Pocket Cube Solver is better than the manual	0	0	0	0	30(100%)
I'd rather use Pocket Cube Solver than come with a manual	0	0	0	0	30(100%)

In general, the subjects have a high evaluation of Pocket Cube Solver. Most of the features fit their needs well, and the way of teaching to restore pocket cubes is also good. In

addition, the combination of text and images is accepted by most people and highly evaluated. Finally, we only need to improve some details to improve the Pocket Cube Solver.

7. Limitation and Future Works

The scope of this research is only limited to Pocket Cube. A more well-known puzzle cube, Rubik's Cube, has more cubes, specifically 21. The algorithm can be applied to this famous Cube in the future but needs more work and time.

8. Conclusion

This article introduces a mobile application for learning how to restore Pocket Cube. It is a combination of pictures and images to guide the user can be rooted in their situations to carry out different solutions to each step. It provides a formula for each step, along with a table explaining the meaning of the symbols in the formula. After the questionnaire survey, most of the subjects were satisfied with this mobile application. Some of the minor questions raised by the subjects have been corrected in subsequent studies.

9. Acknowledgements

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