Final Project (TUI) – Puzzle Game

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Introduction

The main goal of the assignment is to create a tool that will be connected to a tangible user interface. In addition, it is necessary to document the entire process, which will include both the functional description and the realization of the prototype of the tool being developed.

Based on the given task, we decided to create a game for children. The game is called Puzzle Game.

Games for children are always interesting and informative. This game is no exception. The goal of the game is for kids to learn and memorize different colours and shapes. Learning colors and shapes is an integral part of a child's development. It's an important process to help children understand and interact with the world around them. Taking these elements on early in life makes it easier to learn while teaching a child the skills they need to succeed.

The goal of this game is to teach young children colours and shapes in a fun and entertaining way. Children are given a board in front of them with holes that represent shapes such as a heart, star, square and triangle. Each shape also has its own color of red, yellow, orange and green. At the same time, they are also given shapes with the same color, which they have to place in the correct place on the board. During the game, they are accompanied by a display on which they can see when the game is over, i.e. the puzzle has been solved.

This document describes the entire development of the game, which is divided into four parts.

In the first part, Description of the scenario, we will describe the scenario for our invented game and also identify the user group, and their needs for using our game. Also her manipulation.

In the second part, The prototype development, we will describe in detail the entire construction of the given game. It consists of the necessary components, the subsequent writing of the code, and finally the assembly of the component from the outside. The outer part represents the cover so that the user can easily handle it and at the same time it serves as a visual side.

The the third part, The evaluation, covers the evaluation process. It is a process that serves to identify the shortcomings of the prototype, and subsequently, the shortcomings can be improved. This will improve the given project. We will focus on the usability and quality of our game. We will implement it with the help of an interview with an expert and a user. Their opinion is very important for the next steps.

In the last part, Discusion, we will deal with the possible future direction of our game. Based on the evaluation process, let's think about the development of technical knowledge in mentally retarded children.

Description of the scenario

Most of us visualise a picture that has been divided into small pieces when we hear the phrase puzzle. Children or adults must put the stray pieces together to form a shape. A puzzle is one that has been made by slicing a board with a picture into tiny pieces of distinctive shapes that only go together in one way.[1]

The most instructive play activities for kids are typically the easiest ones. Puzzles can be one of them. [1]

The puzzle is also appropriate for toddlers between the ages of 18 months and 2 years, although they should begin with simpler toddler puzzles so they have the time and opportunity to develop their skills at their own rate.[1]

The typical first toys that 2-year-olds play with include simple pegs, shape sorters, shapes, and straightforward 2-4 piece puzzles.[1]

Children should begin doing them consistently while they are young, and as they become older, they should be able to assemble puzzles with smaller parts that are more difficult.[1][2]

There is no set timeline for when a youngster should be able to build them or what kinds he should learn to make first because every child develops along his or her own route.[3]

Kids develop skills through making mistakes on their own.[3]

For toddlers, there are many different kinds of puzzles.[1]

- *Shape sorters* - Typically, it is made of wood or plastic. These shape sorters are excellent for teaching children to identify and match the shapes they need to build puzzles.
- *Puzzles with pegs* - For infants to manipulate with their small fingers, wooden peg puzzles have a knob or peg attached to each piece. The contour of the wooden portion is the outline of the artwork, and the pieces are flatter, two-dimensional. The ability of toddlers to differentiate forms between various items is still evolving, whether they are presented with standard shapes or images of animals.

Children's capacity to learn to read, write, and count is directly impacted by them. They are among the best toys for education and ought to be used frequently. [2]

Puzzles develop skills such as:[3][4]

1. *Fine motor skills* - Control of tiny muscles like the fingers, toes, and eyes is referred to as having fine motor skills. To hold a pencil and learn how to write, kids need to have solid fine motor skills.
2. *Hand-eye coordination* - The capacity to move with the hands while being guided by the eyes is known as hand-eye coordination. Children use their hands and eyesight together to complete activities. The brain is trained to synchronise eye and hand motions through puzzle-solving.

3. *Visual perception* - Learning to read, write, and perform math requires the ability to perceive visual information. The capacity of the brain to comprehend and interpret what the eyes see is referred to. One of the finest ways to improve visual vision is to solve puzzles. The subjects of colours, shapes, patterns, depth perception, etc. will be taught to children.
4. *Development of language and concepts* - Riddles provide a chance to expand vocabulary and enhance linguistic abilities. The pieces' forms and pictures depict objects and ideas. If the parent takes advantage of the chance to increase their child's vocabulary, these will be increased even further.
5. *Problem-solving* - All puzzles are issues that must be resolved. Each one is difficult and need careful planning to complete.
6. *Success and self-confidence* - Because a solved problem is a highly obvious indication of success, solving puzzles is a terrific method to experience success. For youngsters to experience what it's like to work hard to succeed, it's also a demanding exercise.
7. *Perseverance* - Children who abandon a puzzle unfinished do not feel satisfied. As kids are frequently driven to finish the puzzle in order to experience the fulfilment of having accomplished something, this is a recipe for cultivating persistence.
8. *Release the tension* - In addition to fostering a variety of physical, social, and cognitive abilities, puzzles can serve as an outlet for emotions. Working on quiet projects is a fantastic way to relax and unwind while learning.

We decided to create a puzzle for small children that are connected to technology. It is intended for children from the first age. This Puzzle develops their motor and visual skills and introduces them to technologies. Nowadays, technologies are a part of everything, and children need to be shown in a playful way that they are also helpful for learning, not just for fun.

The game consists of a board and puzzle parts. The board shows 4 shapes, a star, a heart, a triangle and a square, and there is also an LCD on it, which is used to display correctness.

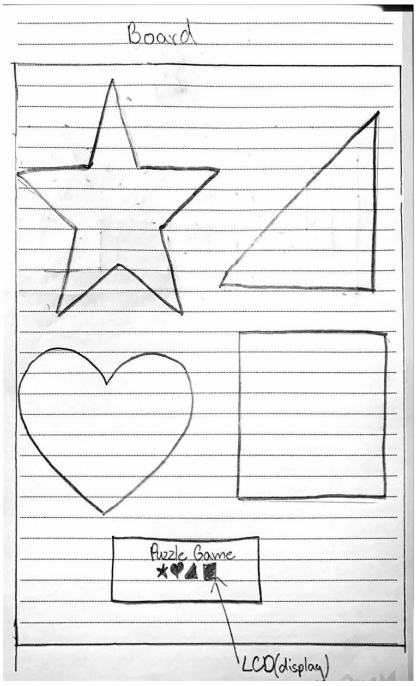

Figure 1- Board of the game

Puzzle pieces are also in four shapes, star, heart, triangle and square. Each shape also has its colour, yellow, red, green and orange.

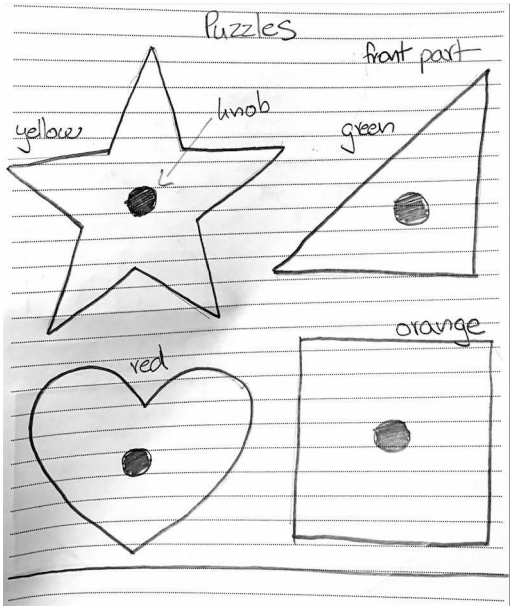

Figure 2 - Puzzle parts: front side

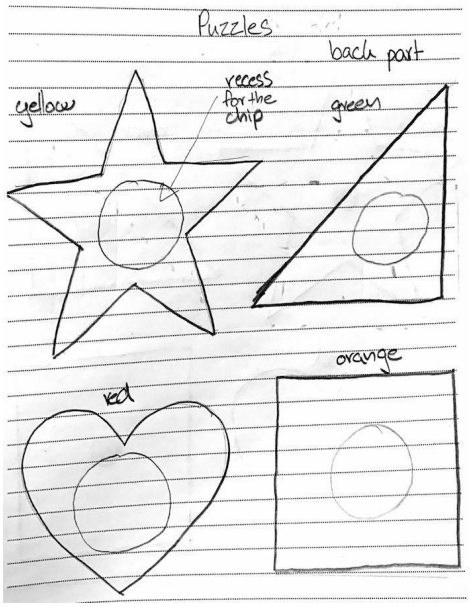

Figure 3- Puzzle parts: back side

The principle of the game is to place individual pieces on the board. The end of the game is when all the pieces are in the right place.

On the display, we can observe whether the inserted part is in the right place. If it is not, or there is no puzzle in place, the display shows X. If the puzzle is placed in the right place, it will be ✔ displayed. When all X's change to ✔, we will reach the solution of the task and the display will show 'Puzzle Solved!'.

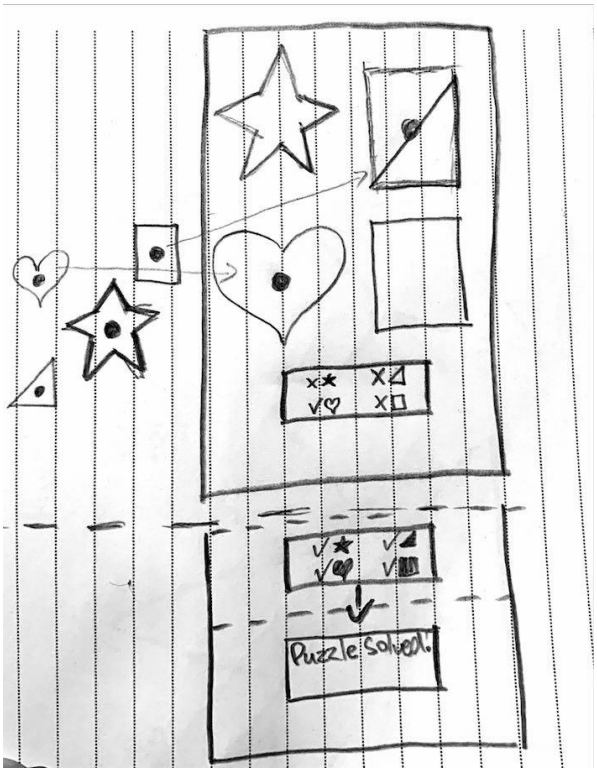

Figure 4 - the principle of the game

The prototype development

In this part of the task, we will describe in detail the realization of our first prototype, the Puzzle Game. In the previous assignment, we have a proposal that we will try to translate into reality.

We decided to use Arduino[1] for implementation. Arduino is an open-source electronic prototyping platform enabling users to create interactive electronic objects.

For the implementation we will need:

1. 1x Arduino Uno board
2. 4x RFID reader with tags
3. 1x LCD display
4. 1x Breadboard
5. Jumper wires (many)

Arduino Uno is the name of a small single-board computer based on ATmega microcontrollers from Atmel.

RFID reader is a contactless automatic identification technology is radiofrequency identification. The fundamental idea behind it is the automatic identification of recognised objects through the use of radio frequency signal transmission properties, spatial coupling or radar reflection.

A liquid crystal display (LCD) is a thin and flat display device whose image consists of coloured or monochrome dots lined up in front of a light source.

The breadboard is a reusable tool for designing prototypes of electrical circuits and for experimenting with circuits without soldering components.

Jumper wires are electrical wires or groups of wires in a cable with a connector or pin at each end that is commonly used to connect components.

After presenting all the components, we go to connect them. First, we have to make a wiring design. With the help of Tinkercad[2], in which we draw the design. In the application, Tinkercad is missing the part for the RFID reader, it looks like their end is only connected to the breadboard, but actually, the end source is the RFID reader.

Connecting an LCD to an Arduino uses a lot of pins. For this reason, we used I2C addresses for LCD, which only needs 4 pins, GND (ground pin), VCC (power pin), SDA (data pin), and SCL (clock pin). Power to the module needs 5V.

Table 1 shows which pins the individual ends of the LCD are on. In figure 6 we see in what order it is necessary to connect the jumper wires to RFID readers. On Figure 5 we can see the created design and on the next Figure 7, we can see its implementation. We didn't have enough jumper wires, so the colours may differ from the design. But it was reasonable to choose the same colours in the design for the sake of transparency, but in reality, it is not necessary because it is only a colour and the jumper wire performs the same function.

[1] https://www.arduino.cc

[2] https://www.tinkercad.com

LCD	ARDUINO UNO
GND	GND
VCC	5V
SDA	A4
SCL	A5

Table 1 - Connecting the LCD to Arduino

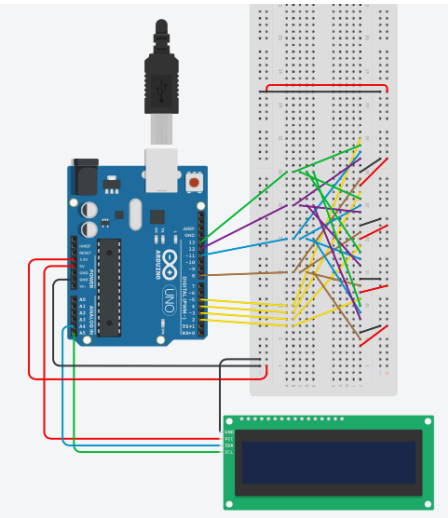

Figure 5 - Wiring design

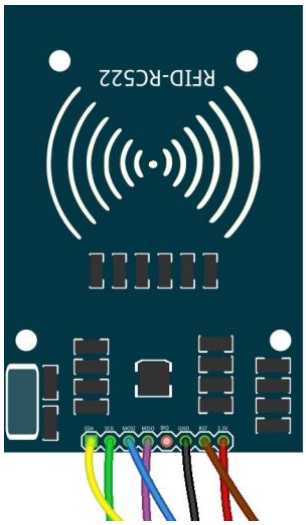

Figure 6 - Wiring of the RFID readers

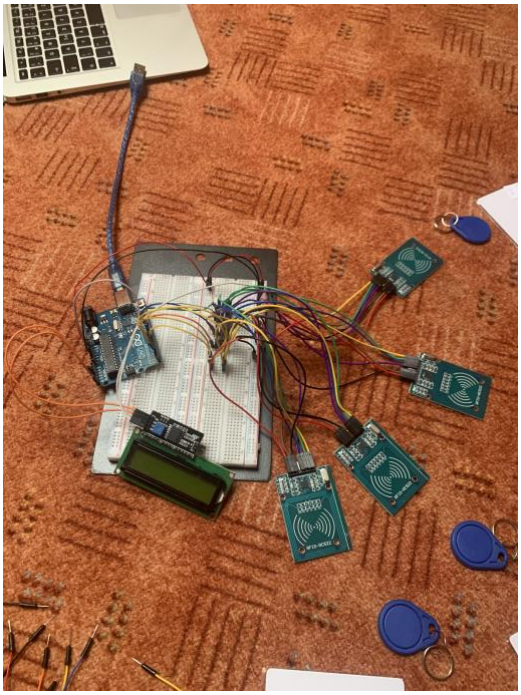

Figure 7- Wiring of the components

After connecting the individual components, we can go to the functional side of the game and write the code. We will need the Arduino IDE[3] environment for

[3] https://www.arduino.cc/en/software

implementation. Arduino IDE is an application that will allow us to easily work with the Arduino board. The Arduino IDE includes, among other things, a text editor and several buttons that serve to translate and then upload the code to the Arduino.

We installed the given environment on our computer and created the code. To be able to use the LCD, we have to import from the library, LiquidCrystal_I2C by Frank de Brabander. Next, we have to determine the address. The I2C address LCD depends on the manufacturer. Using the code[4] bellow we got the address of the device.

```
#include <Wire.h>
void setup() {
  Serial.begin (9600);

  // Leonardo: wait for serial port to connect
  while (!Serial)
    {
    }

  Serial.println ();
  Serial.println ("I2C scanner. Scanning ...");
  byte count = 0;

  Wire.begin();
  for (byte i = 8; i < 120; i++)
  {
    Wire.beginTransmission (i);
    if (Wire.endTransmission () == 0)
      {
      Serial.print ("Found address: ");
      Serial.print (i, DEC);
      Serial.print (" (0x");
      Serial.print (i, HEX);
      Serial.println (")");
      count++;
      delay (1);  // maybe unneeded?
      } // end of good response
  } // end of for loop
  Serial.println ("Done.");
  Serial.print ("Found ");
  Serial.print (count, DEC);
  Serial.println (" device(s).");
```

[4] https://lastminuteengineers.com/i2c-lcd-arduino-tutorial/

```
}  // end of setup

void loop() {}
```

After finding out the address, we use it.

```
LiquidCrystal_I2C lcd(0x27, 16, 2);
```

Another library we use is MFRC522 by Miguel Balboa. It includes a document that we studied and used the necessary data for our project. We mainly drew from the ReadUIDMultiReader.ino[5] example.

The code for our Puzzle Game can be found in Appendix – 3. Source of Code.

We connected the connected component using a USB cable to the computer through which we uploaded our code and tested whether the individual components react.

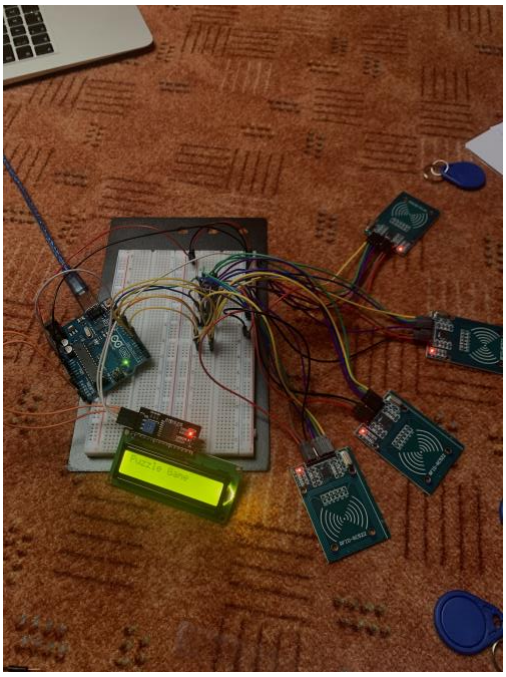

Figure 8 - Uploaded code to Arduino

When everything works as it should, we can move on to the next phase, which is to create the outer part, that is, to hide the given technology. We decided to use wood as a material.

Otherwise, our prototype consists of wooden parts that we nailed together.

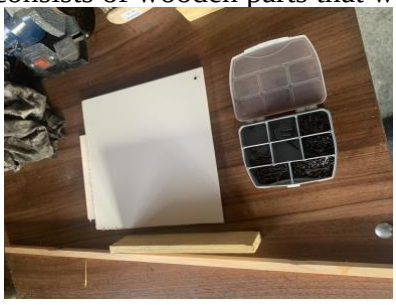

Figure 9 - Wooden parts

5 https://github.com/miguelbalboa/rfid/blob/master/examples/ReadUidMultiReader/ReadUidMultiReader.ino

The upper part is laser cut. First, we drew individual shapes on the computer that were cut out. We once again cut out the individual shapes, into which we also cut out small circles. We then glued and painted the cut parts. We stuck a holder on one part and inserted a tag from the bottom part where the hole is located.

Finally, we connect the component with the wooden structure. To be able to do this, we have to disconnect the jumper wires, mount the RFID readers to the wooden board and then connect them again.

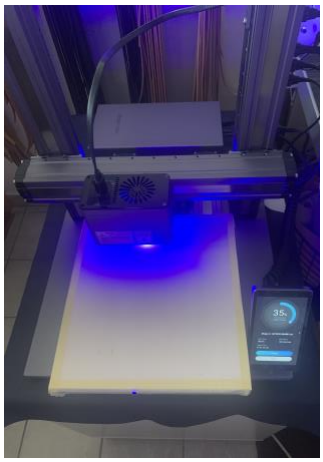

Figure 10 - Laser cutting (board)

Figure 11 - Laser cutting (parts)

Figure 12 - Puzzle parts

Figure 13- Puzzle parts with tags

Figure 14 - Board

Figure 15 - Wooden structure

Figure 16 - Reconnecting

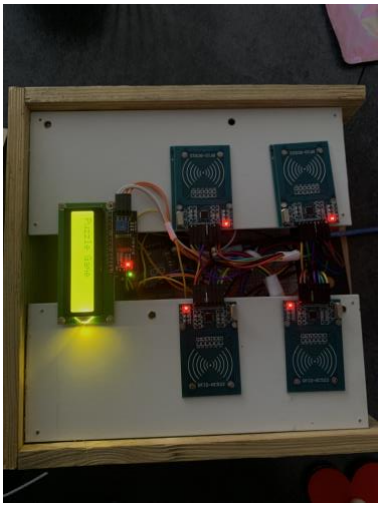

Figure 17- Checking

Next, to find out if everything works, we connect to the computer again and upload our code, if everything works, our prototype is ready. In Appendix – 4. Source of video you will find a whole video of the realized prototype.

The evaluation

The gaming experience has emerged as a key differentiator, and game companies have to contend with fierce competition. Thus, players can easily switch to another game if their current experience is not satisfactory.

The evaluation process as formative evaluation is a method of assessment that is specifically used to find issues. They are typically discovered early in the game production process and are used in each iteration of the process to improve and enhance the games before they are ready for release. [5]

In our work, we developed the very first prototype, which still has a long way to go to the perfect product. But due to its continuation and finding the best product that will be of interest, we decided to do an evaluation process right from the beginning. During the evaluation phase, we try to focus on the usability and quality of the game. From the point of view of quality, we are interested in whether it can remain as a wooden toy or whether it should be made of a different material. And from the point of view of usability, we are interested in whether the idea of combining technology and a puzzle game, finding the right shapes, is useful for the development of children.

Real users and experts participate in the evaluation phase of the game creation technique. In our case, the expert is a teacher who has sufficient knowledge about the child's education and needs. And the user will be a parent, considering that the toy is intended for young children, and therefore we will focus mainly on the parents' opinion. As a method, we chose to interview both the expert/teacher and the user/parent. The evaluation analysis in the form of open questions directly with the exporter/teacher and user/parent. We have created eight questions for everyone, which are related to the usability and quality of the given toy.

Question for expert/teacher

1. How long have you been working as a teacher?
2. Briefly describe yourself as a teacher (your position, what subjects you teach and what age group,….)

3. What is your first impression of the toy?
4. Do you think this game is useful for education?
5. Could you imagine using it as an educational aid?
6. What flaws do you see in the game?
7. What would you recommend for improvement?
8. Do you have any other suggestions?

Question for user/parent

1. Do you have children? If so, how old are they?
2. What is your first impression of the toy?
3. Can you clearly determine the rules of the given game?
4. Do you think your kids would enjoy this game?
5. Do you think this game is useful for education?
6. Would you buy the suggested game for your kids if you saw it in a store?
7. What would you change about the game?
8. Do you have any other suggestions?

The interview with the expert/teacher and the user/parent took place in person where they first looked at the toy and then tried it on. The interview was conducted in Slovak, during which we recorded and take notes on their answers and then translated them.

Answer of expert/teacher

1. I have been a teacher for over 30 years.
2. I work in a special elementary school where children with mental disabilities attend. I teach children from 1st to 9th grade, representing children from 6 to 15 years old. I teach social and natural science subjects, but all basic subjects are taught for younger grades from 1st to 4th grade.
3. At first glance, the toy is transparent. I like distinct colours and shapes that are different and represent basic shapes. The most I noticed most is that the toy is made of wood. This is a big plus for me. Toys made of wood are more suitable for children, children perceive them differently than plastic, which changes shape over time and breaks easily.
4. Yes, I see great potential in her. It develops children's fine motor skills, they also perceive colours and geometric shapes.
5. Yes, children with mental disabilities need more attention and take more time, these children also learn more slowly, therefore they also learn colours and shapes more slowly, and even older children around the age of 6-7 can play with the game. I would use it as a relaxing activity, during which the child would play, but learn at the same time. Next, on subjects such as mathematics, where individual geometric shapes would be realised through play, or perhaps arts, where colours would be taught.
6. However, I miss one thing and that is the sound effect. A child needs not only to perceive with his eyes but also to experience sound, a sound effect.
7. Since I would be able to present the given game to older children, I would add the names of the shapes and the names of the colours to the individual figures. I would be able to imagine enlarging and adding more forms, or adding bigger and smaller shapes so that they would learn to differentiate between bigger and smaller. Colours also bring more forms to the surface.
8. I would use the potential of the display, where I would add other options, such as asking questions like Find the red colour, find the square, etc. The toy could

also be used by older children who already know how to read, or the given objects would be displayed on the display when they are just learning to read. Otherwise, different games could be invented on one board using the display.

Answer of user/parent

1. I have two children aged 3 and 5.
2. The colours and shapes of the given game caught my attention first. Also, the game looks to be smooth and easy to control, which is suitable for small children. I was also interested in the display of the corresponding game. I assume that it shows the solution of the given game.
3. Yes, as soon as I saw the given game, the rules were suitable, you have to put the individual pieces (shapes) in the right place.
4. Yes, children in this age group like to discover and the given colours and shapes of the individual figures will catch their attention. Also, the display, which shines brightly and shows different shapes, can impress them.
5. I agree with that, as it develops their motor skills and they get to know basic colours as well as different shapes. It is very important to develop children in this area at an early age.
6. The toy would certainly interest me in the store, it is made of wood, which I personally prefer for children's toys. They are ecological and more practical. It represents a logical game during which the child learns, otherwise, I would definitely consider buying it. I also like the connection with technology, which is also important nowadays to get to know it.
7. I see the biggest disadvantage in the display that shows words. Small children don't know how to read, so I would prefer a sound or a light sign to see if the shape is in the right place. In this way, the correctness and incorrectness of the given game would be distinguished, which even a child would understand very easily.
8. The game has good potential, I like the idea, but I would definitely add more shapes and thus expand the range of colours. Since it is a game for small children, I would also welcome sound effects.

After summarizing the answers from the expert/teacher and user/parent, we can say that the toy has a future and there will be interest in it. We found that the material wood was a good choice, as they mentioned, it is ecological and children also feel better when they play with wooden toys.

From the answer, we found out that the toy is usable, but its biggest flaw is that the sound part is missing. Because the child must also be interested in sound or various light sensations.

They also mentioned increasing the area, which could add more shapes and colours. This fact was obvious to us, but negligible from the point of view of development, where the principle of the game can be determined even from a smaller number of shapes.

We were most interested in the answer of the expert/teacher who mentioned the usability of the display in favour of adding more games. We would be able to combine technology and a logical game for a larger age group. The game could also be useful for older children who already attend school.

Discussion

In this part of the work, we will focus on one possible development of our game. From the previous chapter Evaluation, we were interested in her point of view and the possible further development of the logical game during the interview with the expert/teacher.

He is a teacher of mentally disabled children who are also able to learn subjects, they just need more time. Her idea was to add individual names of colours and shapes to the characters. This expands the game and it can also be used for children in preschool age or the first years of school. At the same time, we can use the corresponding display, with the help of which we can ask about individual colours or shapes.

In this work, we will focus on the question:
How to engage and teach children with mental retardation something new using technology and our puzzle game?

Mental disability is defined as an inborn deficit of mental abilities manifested by insufficient development of thinking, limited ability to learn and more difficult adaptation to normal living conditions. Cognitive, speech, motor and social skills are reduced. During the school period, they are manifested by problems in the ability to read, write, and count. The level of concentration of attention, short-term memory and abstract thinking is reduced. An insufficient level of motor skills is reflected in a lower skill in manual activities. The child's adaptability, independence and ability to establish contacts are weakened.[6]

The consequences of a child's mental disability can be mitigated by appropriate upbringing and education. For this process to be successful, it is necessary to know the degree of mental disability and the limitations that result from it and influence the choice of appropriate educational and educational procedures.[8]

In the education of children with developmental disorders and behavioural disorders, the use of technological possibilities has been talked about for a long time, but it is difficult to produce various games, applications and digital aids designed precisely with the special needs of these children in mind. In order for digital games to suit the majority of children with intellectual disabilities, they must meet various criteria. In the list intended for educators and parents of children with various forms of mental disabilities, it is stated that care must be taken to ensure that the game contains understandable instructions, that it is possible to turn off its sound, that the level of difficulty, the number of images on the screen or display can be set. If the game contains time limits, it is necessary that the option to turn them off is incorporated. Images and photos or animations used should be realistic. It is recommended to use both images and text in the content.[6]

The risk is the fun dimension of digital games. Finding a balance between fun and learning is not as easy as it might seem. A child can become so engrossed in a game that the fun effect outweighs the educational effect. This trap lurks above all in more complex games - adventure or simulation. This is precisely where the role of parents, educators and educators is important - to ensure that the child acquires new knowledge in addition to enjoying the game. Especially children with milder forms of disability tend to understand the pattern of solutions and minimize the effort of learning, enjoying only the distraction.[7]

For educators who are interested in working with students in teaching in new, motivating, attractive ways and forms of work, multimedia programs are a real useful helper. To make the teaching process more efficient, educators will increasingly use information and communication technologies and electronic teaching materials. If children are properly guided, and given a clear direction and goal, such education will benefit them. The experience of teaching through multimedia programs confirms to us that this form is very motivating for students. It helps students with mental disabilities to access subjects that would otherwise be very difficult to master.[8]

Conclusions

The assignment was to develop a kid-friendly digital game that will be linked to a tangible user interface. Puzzle Game is a game we've made specifically for kids. The board game called Puzzle Game is made to help children to learn and remember different colours and shapes. It is crucial for a child's growth since it enables him to comprehend and interact with his environment.

In the first section, Description of the scenario, Puzzle Game is a game for children that are connected to technology. It introduces kids to technology while helping them develop their motor and visual skills. When all the pieces are in their proper spots, the game is over and an LCD screen displays Puzzle Solved!

In the second section, The prototype development, we cover in detail the creation of our prototype Puzzle Game. We apply Arduino Uno, a compact single-board computer built on Atmel's ATmega microcontrollers. We'll need an Arduino Uno board, an LCD screen, an RFID reader and tags, a breadboard, and jumper wires. For implementation, we require the Arduino IDE environment. We used nails to join wooden pieces to create our prototype. You may find the documentation for the entire procedure in Appendix X, X.

The the third section, The evaluation, uses a kind of assessment called formative evaluation that is especially useful for identifying problems. We make an effort to concentrate on the game's usability and quality during the evaluation phase. In our situation, the expert is a teacher who is sufficiently knowledgeable about the educational needs and requirements of the child. And given that the item is made for small children, the user will be a parent. Eight questions about the quality and usability of the provided toy have been created for everyone. We discovered that there is interest in the item and that it has a future. Wood was a wise option as a material because it is environmentally friendly and children feel better playing with wooden toys. The child is interested in sound, thus the major issue is that it's lacking.

The final section, Discusion, focuses on leveraging technology and our puzzle game to engage and educate youngsters with mental retardation. A mental impairment is characterised as an innate lack of mental talents shown by sluggish thought development, restricted learning capacity, and more challenging adaptability to normative living circumstances. For digital games to be appropriate for kids with intellectual disabilities, they must adhere to a number of standards. Make sure the game's instructions are clear by taking care to include them. Realistic pictures, images, and animations should be used. In the content of digital games, it is advised to use both text and visuals.

The increasing share of the use of information and communication technologies in schools is a reason for the teacher to examine their impact on the acquisition of new knowledge. Multimedia teaching aids find their place and are widely used in today's schools and in general, it can be said that they help the teacher in his work. They are an excellent aid supplementing standard forms of education for healthy children as well as children with disabilities.

References

[1] Yunanto, S. H., & Chandrawati, T. B. (2016). " Smart Puzzle" Game Helping Children Learn to Read. *SISFORMA*, *3*(1), 13-19.

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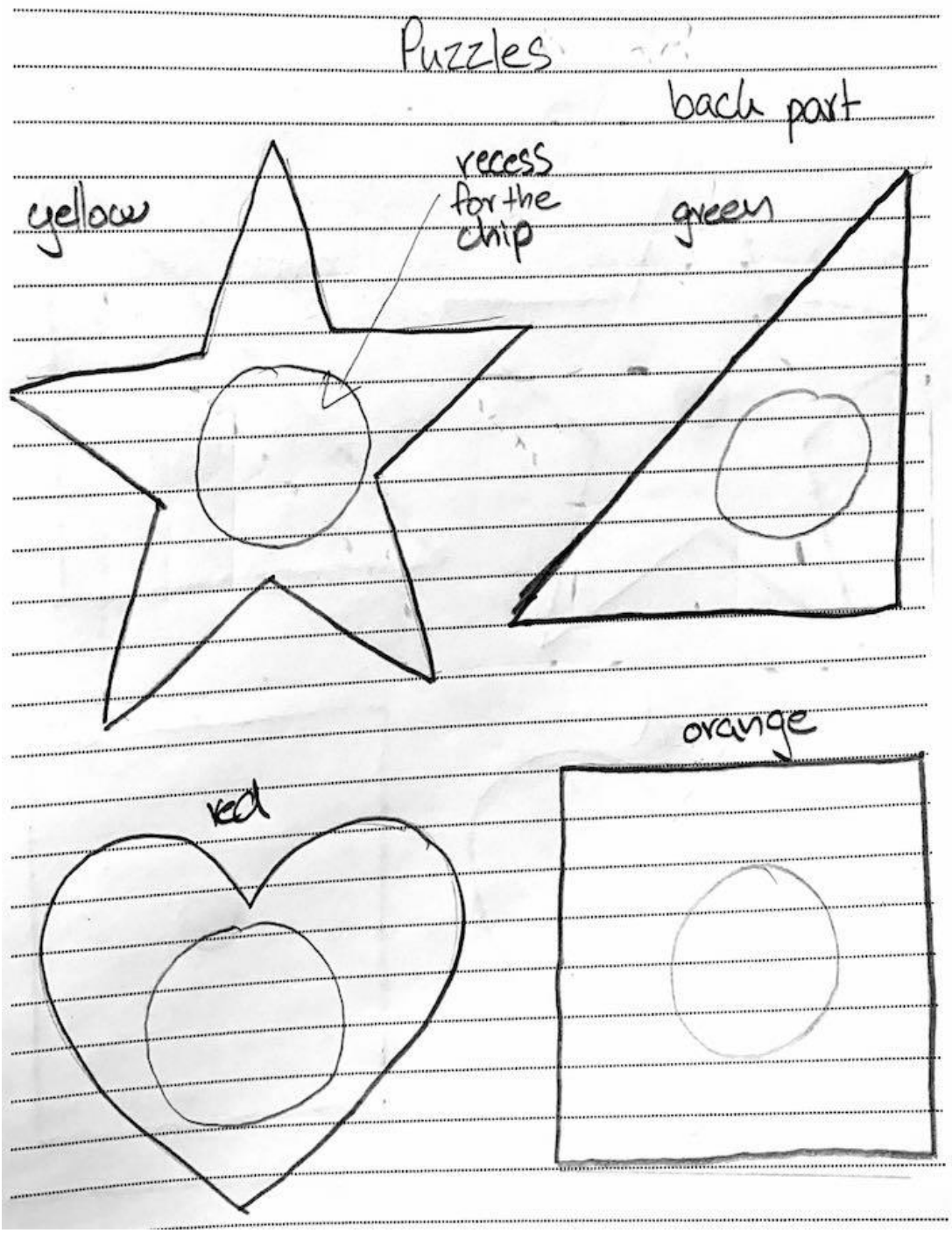
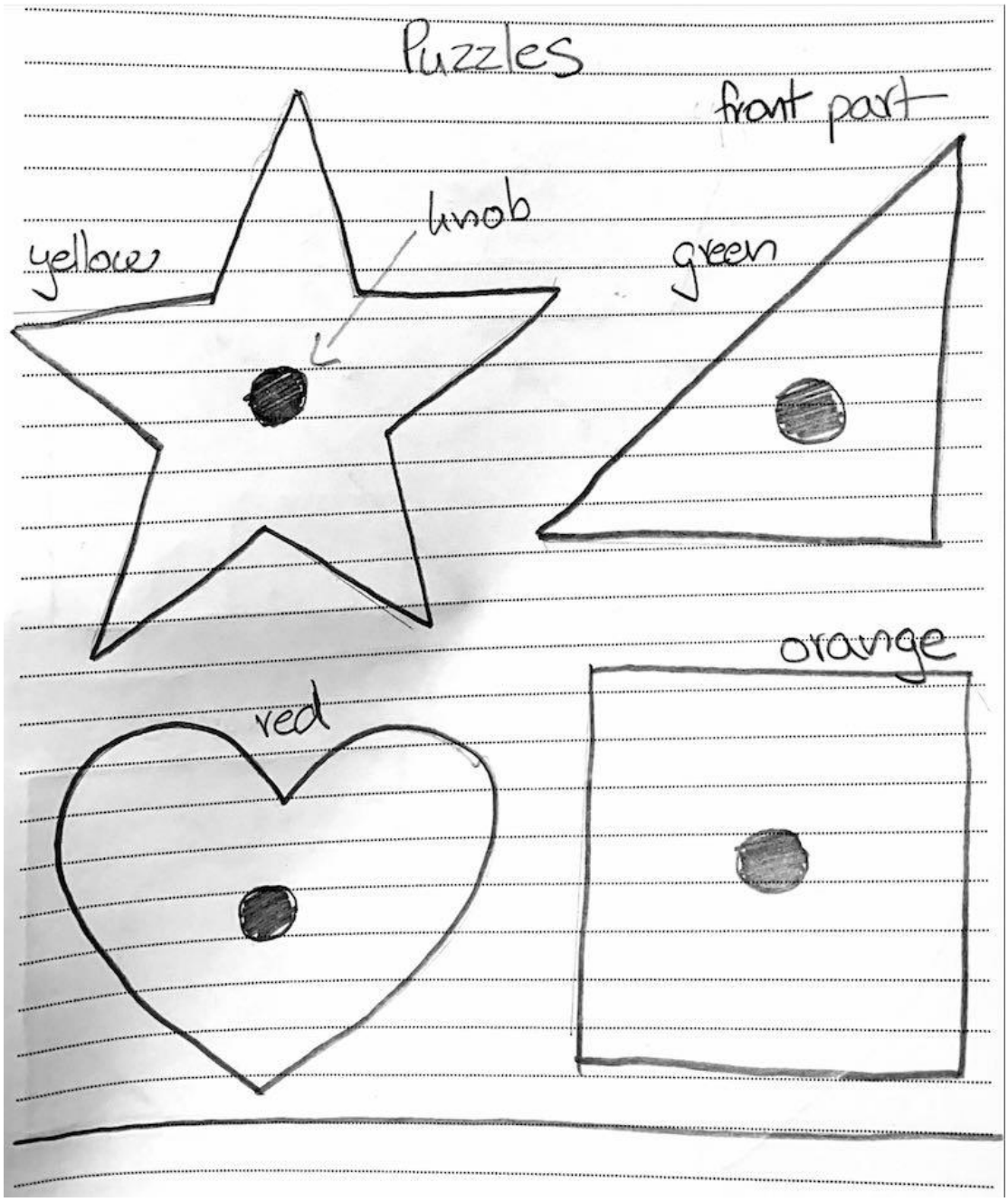
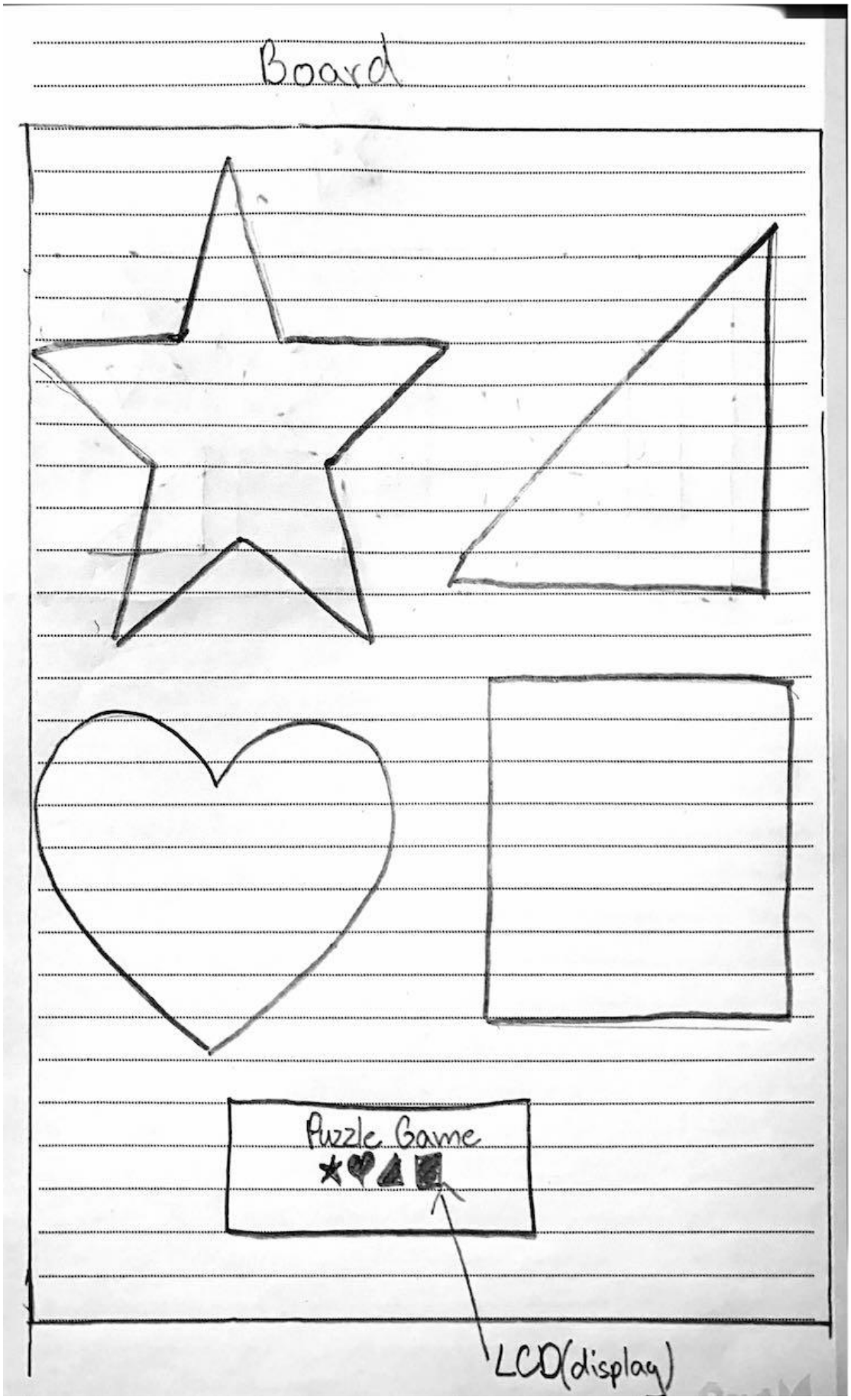
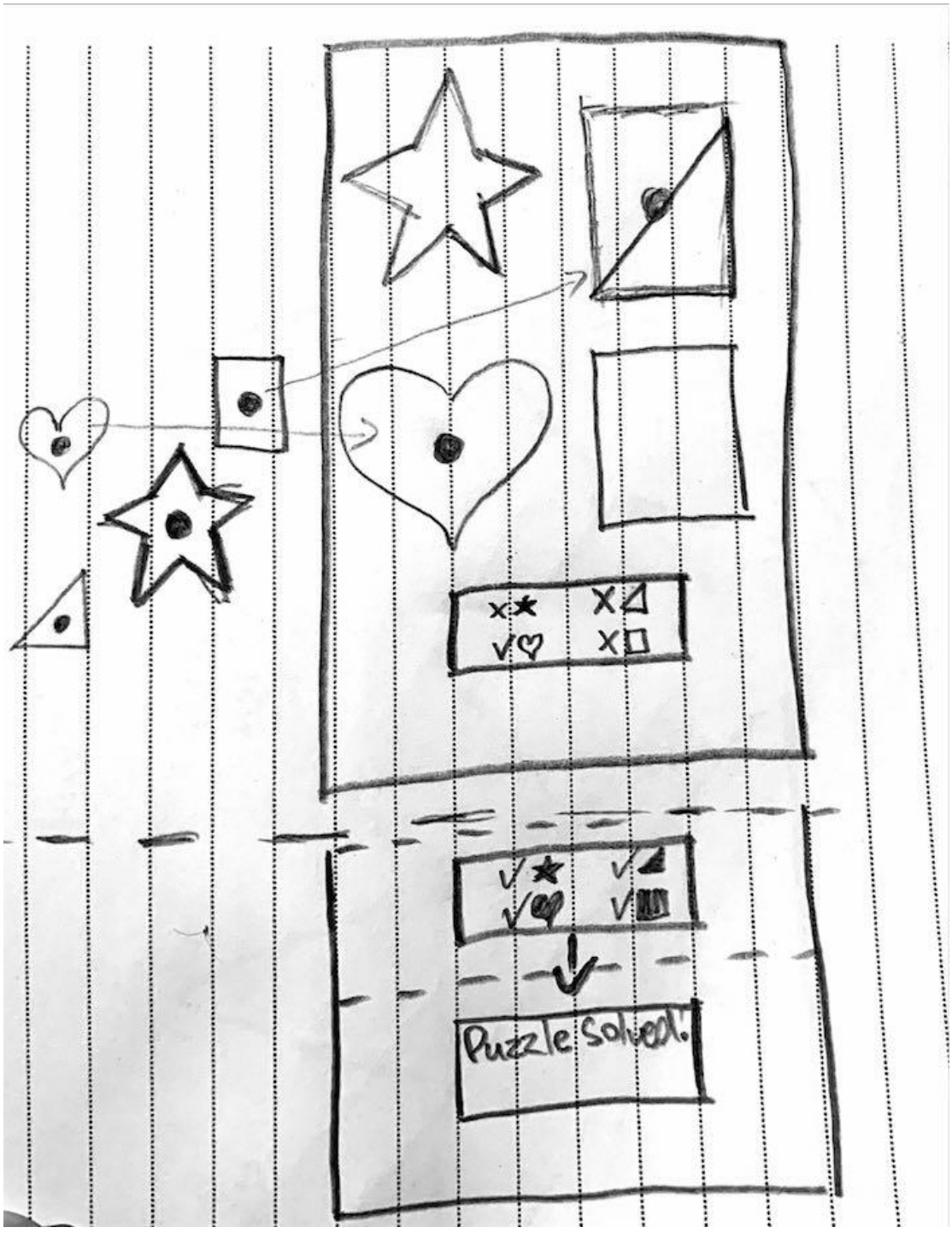
Appendixes

1. Prototyping

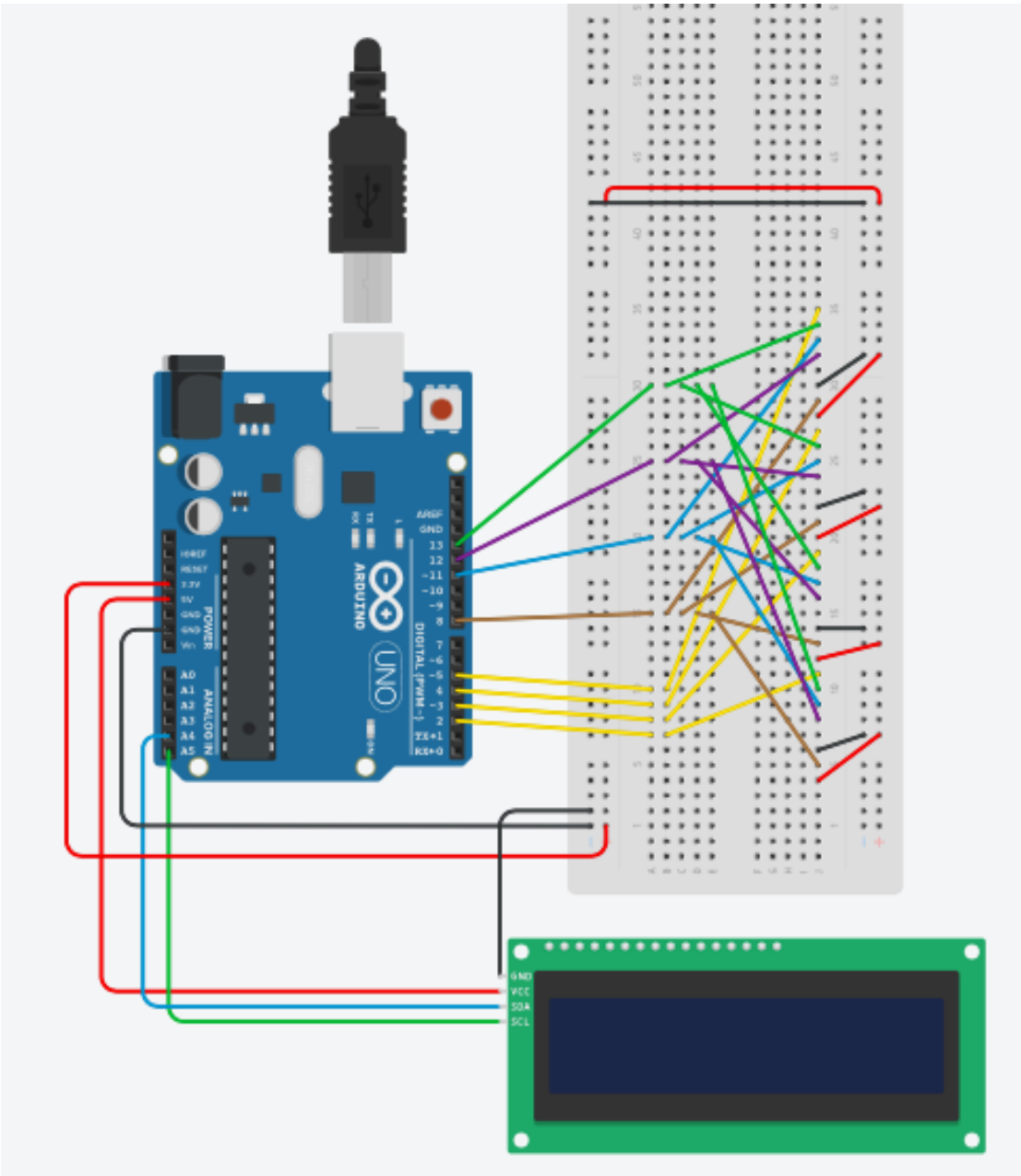



Puzzles
front part
knob
yellow
green
orange
red


Board
Puzzle Game
LCD(display)


Puzzle Solved!

2. Wiring



3. Source Code

https://github.com/Anna8295/Puzzle-Game

```
// DEFINES
// Provides debugging information over serial connection if defined
#define DEBUG


// LIBRARIES
```

```
// SPI library
#include <SPI.h>
// Download and install from https://github.com/miguelbalboa/rfid
#include <MFRC522.h>
// LiquidCrystal_I2C library for the LCD display
#include <LiquidCrystal_I2C.h>

// CONSTANTS
// The number of RFID readers
const byte numReaders = 4;
// Each reader has a unique Slave Select pin
const byte ssPins[] = {2, 3, 4, 5};
// They'll share the same reset pin
const byte resetPin = 8;
// The sequence of NFC tag IDs required to solve the puzzle
const String correctIDs[] = {"53707434", "53b25934", "322cd91e", "53609634"};
// The custom characters/symbols for LCD
//symbol chcek
const byte Check[8] = {
  0b00000,
  0b00001,
  0b00011,
  0b10110,
  0b11100,
  0b01000,
  0b00000,
  0b00000
};
//symbol cross
const byte Cross[8] = {
  0b00000,
  0b00000,
  0b10001,
  0b01010,
  0b00100,
  0b01010,
  0b10001,
  0b00000
};
//symbol heart
```

```
const byte Heart[8] = {
  0b00000,
  0b01010,
  0b11111,
  0b11111,
  0b01110,
  0b00100,
  0b00000,
  0b00000
};
//symbol square
const byte Square[8] = {
  0b00000,
  0b00000,
  0b11111,
  0b11111,
  0b11111,
  0b11111,
  0b11111,
  0b00000
};
//symbol triangle
const byte Triangle[8] = {
  0b00000,
  0b00000,
  0b00001,
  0b00011,
  0b00111,
  0b01111,
  0b11111,
  0b00000
};
//symbol star
const byte Star[8] = {
  0b00000,
  0b00100,
  0b10101,
  0b01110,
  0b01010,
  0b10001,
```

```
  0b00000,
  0b00000
};
// GLOBALS
// object with 3 parameter(adress, columns,rows) - adress, dimensions of the display
LiquidCrystal_I2C lcd(0x27, 16, 2);
// Initialise an array of MFRC522 instances representing each reader
MFRC522 mfrc522[numReaders];
// The tag IDs currently detected by each reader
String currentIDs[numReaders];
/**
 * Initialisation
 */
void setup() {

  #ifdef DEBUG
  // Initialise serial communications channel with the PC
  Serial.begin(9600);
  Serial.println(F("Serial communication started"));
  #endif

  // reader's select pin as HIGH - don't cause interference on the SPI bus
  for (uint8_t i=0; i<numReaders; i++) {
    pinMode(ssPins[i], OUTPUT);
    digitalWrite(ssPins[i], HIGH);
  }

  // Initialise the SPI bus
  SPI.begin();

  for (uint8_t i=0; i<numReaders; i++) {

    // Initialise the reader
    mfrc522[i].PCD_Init(ssPins[i], resetPin);

    // Set the gain to max (if necessary)
    //mfrc522[i].PCD_SetAntennaGain(MFRC522::PCD_RxGain::RxGain_max);

  #ifdef DEBUG
    // some information to the serial monitor
```

```
  Serial.print(F("Reader #"));
  Serial.print(i);
  Serial.print(F(" initialised on pin "));
  Serial.print(String(ssPins[i]));
  Serial.print(F(". Antenna strength: "));
  Serial.print(mfrc522[i].PCD_GetAntennaGain());
  Serial.print(F(". Version : "));
  mfrc522[i].PCD_DumpVersionToSerial();
#endif

  // Slight delay before activating next reader
  delay(100);
}

#ifdef DEBUG
Serial.println(F("--- END SETUP ---"));
#endif

// displaying some information on the LCD display
//initialise the LCD
lcd.init();
// backlight on
lcd.backlight();
// create a the characters
lcd.createChar(0, Heart);
lcd.createChar(1, Star);
lcd.createChar(2, Square);
lcd.createChar(3, Triangle);
lcd.createChar(4, Check);
lcd.createChar(5, Cross);
// Clears the LCD screen
lcd.clear();
// Print a message to the lcd.
lcd.setCursor(2, 0);
lcd.print("Puzzle Game");
lcd.setCursor(4, 1);
lcd.write(0);
lcd.setCursor(6, 1);
lcd.write(1);
lcd.setCursor(8, 1);
```

```
  lcd.write(2);
  lcd.setCursor(10, 1);
  lcd.write(3);
}

/**
 * Main loop
 */
void loop() {

  // Assume that the puzzle has been solved
  boolean puzzleSolved = true;

  // Assume that the tags have not changed since last reading
  boolean changedValue = false;

  // Loop through each reader
  for (uint8_t i=0; i<numReaders; i++) {

    // Initialise the sensor
    mfrc522[i].PCD_Init();

    // String to hold the ID detected by each sensor
    String readRFID = "";

    // If the sensor detects a tag and is able to read it
    if(mfrc522[i].PICC_IsNewCardPresent() && mfrc522[i].PICC_ReadCardSerial()) {
      // Extract the ID from the tag
      readRFID = dump_byte_array(mfrc522[i].uid.uidByte, mfrc522[i].uid.size);
    }

    // If the current reading is different from the last known reading
    if(readRFID != currentIDs[i]){
      // Set the flag to show that the puzzle state has changed
      changedValue = true;
      // Update the stored value for this sensor
      currentIDs[i] = readRFID;
    }

    // If the reading fails to match the correct ID for this sensor
```

```
  if(currentIDs[i] != correctIDs[i]) {
    // The puzzle has not been solved
    puzzleSolved = false;
  }

  // Halt PICC
  mfrc522[i].PICC_HaltA();
  // Stop encryption on PCD
  mfrc522[i].PCD_StopCrypto1();
}

#ifdef DEBUG
// If the changedValue flag has been set, at least one sensor has changed
if(changedValue){
  // show the current state of all sensors on serial monitor
  for (uint8_t i=0; i<numReaders; i++) {
    Serial.print(F("Reader #"));
    Serial.print(String(i));
    Serial.print(F(" on Pin #"));
    Serial.print(String((ssPins[i])));
    Serial.print(F(" detected tag: "));
    Serial.println(currentIDs[i]);

    //show the current state of all sensors on LCD display
    if(ssPins[i] == 2 && currentIDs[i]== "53707434"){
      lcd.clear();
      lcd.setCursor(1, 1);
      lcd.write(4);
      lcd.setCursor(2, 1);
      lcd.write(0);
    }else if(ssPins[i] == 2 && currentIDs[i] != "53707434"){
      lcd.clear();
      lcd.setCursor(1, 1);
      lcd.write(5);
      lcd.setCursor(2, 1);
      lcd.write(0);
    }

    if(ssPins[i] == 3 && currentIDs[i]== "53b25934"){
      lcd.setCursor(10, 1);
```

```
      lcd.write(4);
      lcd.setCursor(11, 1);
      lcd.write(2);
    }else if(ssPins[i] == 3 && currentIDs[i] != "53b25934"){
      lcd.setCursor(10, 1);
      lcd.write(5);
      lcd.setCursor(11, 1);
      lcd.write(2);
    }

    if(ssPins[i] == 4 && currentIDs[i]== "322cd91e"){
      lcd.setCursor(10, 0);
      lcd.write(4);
      lcd.setCursor(11, 0);
      lcd.write(3);
    }else if(ssPins[i] == 4 && currentIDs[i] != "322cd91e"){
      lcd.setCursor(10, 0);
      lcd.write(5);
      lcd.setCursor(11, 0);
      lcd.write(3);
    }

    if(ssPins[i] == 5 && currentIDs[i]== "53609634"){
      lcd.setCursor(1, 0);
      lcd.write(4);
      lcd.setCursor(2, 0);
      lcd.write(1);
    }else if(ssPins[i] == 5 && currentIDs[i] != "53609634"){
      lcd.setCursor(1, 0);
      lcd.write(5);
      lcd.setCursor(2, 0);
      lcd.write(1);
    }
    };
   Serial.println(F("---"));
}
#endif

// If the puzzleSolved flag is set, all sensors detected the correct ID
if(puzzleSolved){
```

```
    onSolve();
  }
  //after the solution, if one object is removed the game continues
  digitalWrite(resetPin, HIGH);
}
/**
 * Called when correct puzzle solution has been entered
 */
void onSolve(){

  #ifdef DEBUG
  // Print message on serial monitor
  Serial.println(F("Puzzle Solved!"));
  #endif

  // Clears the LCD screen
  lcd.clear();
  // Print a message to the LCD
  lcd.print("Puzzle Solved!");
}
/**
 * Helper function to return a string ID from byte array
 */
String dump_byte_array(byte *buffer, byte bufferSize) {
  String read_rfid = "";
  for (byte i=0; i<bufferSize; i++) {
    read_rfid = read_rfid + String(buffer[i], HEX);
  }
  return read_rfid;
}
```

4. Source Video

https://youtu.be/fMRair2TaWo