Mobile Game Development

‘Max’s Mission’

an educational application to support the development of computational thinking skills in primary school children

Project Report

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STATEMENT OF ORIGINALITY

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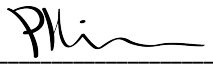
Signed: 

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Marco Gilardi – Project supervisor

Dr Paul Newbury – Project supervisor

Shipham CEVC First School Years 3 & 4 – Research Participants

Westdene Primary School Year 5 – Research Participants

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SUMMARY

The aim of this project was to create an educational iPad application. This would take form of a game to aid in the teaching of the new Computing curriculum in primary schools, which requires that children be introduced to the concept of programming.

The app aims to develop the computational thinking skills of the user. The game requires the user to select from a bank of instructions to create an algorithm which will cause the character to move around the screen towards an end goal. The user has to consider how to overcome the problems of each level, and is encouraged to break each problem down into smaller parts in order to arrive at a solution. These skills are fundamental to computer programming.

The application was tested on children aged 7-10 across two schools. The research took the form of a pre-test to gauge the participants current knowledge, time using the app, and then a post-test to compare and gauge any improvement in skills. Only half of the participants played the app between tests in order to give a control group and a test group.

The results received were very promising. Improvements could be seen in the computational thinking skills after only 20 minutes playing the app. Additionally, the primary response from the children very good, with all of them saying they enjoyed playing the game and would play it again.

CONTENTS

1 INTRODUCTION

This report summarizes the process that was undertaken to create a mobile game to help school aged children develop their computational thinking skills, from the initial design through to testing. As computers are now a part of everyday life, it is becoming more and more important for us to understand how things work in the digital world. It is essential for those entering the workplace to be skilled in 'Computational Thinking'. This has lead to a change in the National Curriculum in the UK, with the traditional subject of 'ICT' being dropped, and the new subject of 'Computing' being introduced [1]. This requires children as young as five years old to be open to the idea of programming. It is no longer sufficient for them to simply be able to use computer software; they now need to have a greater understanding of the programming behind that software.

This project aimed to create a mobile game that will aid children in developing their skills of 'Computational thinking'. The app functions with multiple levels, where the aim of the game is to guide the character, Max, through a series of obstacles using only the instructions provided for that level. These instructions include basic actions for the character to undertake, for example 'Move up 5', but also include logical operations such as 'loop constructs'. This encourages the user to think logically about how to overcome and solve problems. Each level is progressively more complex and more complicated logic is introduced within the later levels. The user then gains a score based on the number of attempts and the time taken to solve each level.

When the user has entered the instructions in the order that they think will accomplish the task, they click on the 'Run' button. This sends the instructions onto a stack for the character to follow. If at any point the character is asked to do an action it cannot perform, a message is sent to the user to let them know they have failed the level and that they need to try again. This in turn increases the number of attempts for that level which is then shown to the user on the screen. An example of an instruction that would cause the level to be failed would be if the character is positioned one space above a wall and is asked to move down. Similarly, if the character is asked to move out of bounds of the arena, this also causes the level to be failed. A similar message is shown if the character performs all instructions, but does not achieve the objective.

All scores are saved locally on the device. When the device is connected to the internet, the app sends all new scores to a database on a server. This ensures all data is saved securely and no data from the user is ever lost. This was essential for the testing and evaluating stage, as all scores for each participant were automatically safely stored, which is covered later in section 5.6. However, it could also be useful in enabled a teacher to monitor the scores of the students.

The main development has been for an iPad running iOS. This is due to the iPad having a larger screen than a phone, which makes it easier for the target audience to use.

This report will take the following form: in Chapter 2 the professional considerations that were applied to this project are discussed in terms of the BCS Code of Conduct and how it was applied, ethical compliance and the Pegi rating system. Chapter 3 reviews software that is currently on the market and research papers on the use of computer software in education. Chapter 4 discusses the design process undertaken to develop the app with Chapter 5 explaining how this design was implemented. Chapter 6 discusses the testing carried out as part of the development process. Chapter 7 explains the methodology for the test research that was undertaken with a sample group of the target audience. In Chapter 8 the results of the experiment are analyzed and

discussed. Finally, in Chapter 9 conclusions and ideas for future development are discussed. References and appendices can be found in Chapter 11.

2 PROFESSIONAL CONSIDERATIONS

The BCS Code of Conduct was read and followed throughout this project.

2.1 GAME DEVELOPMENT CONSIDERATIONS

In particular, the following points from the Code of Conduct [2] were taken into account regarding game development:

> *1a 'you should have due regard for public health, privacy, security and wellbeing of others and the environment'*. The game only uses images and ideas that are suitable for young children.
>
> *1b 'have due regard for the legitimate rights of Third Parties'.* The game does not use any media that is subject to copyright.
>
> *1c 'conduct your professional activities without discrimination on the grounds of sex, sexual orientation, marital status, nationality, colour, race, ethnic origin, religion, age or disability, or of any other condition or requirement'.* The game does not show or promote discrimination in any form.
>
> *1d 'promote equal access to the benefits of IT and seek to promote the inclusion of all sectors in society wherever opportunities arise'.* Consideration was given to including a selection of character sprites of different gender and ethnic backgrounds from which the user can select.

For the game to be most acceptable to be used in a school environment, the application must warrant the lowest PEGI rating of 3. This states that 'some violence in a comical context (typically Bugs Bunny or Tom & Jerry cartoon-like forms of violence) is acceptable. The child should not be able to associate the character on the screen with real life characters, they should be totally fantasy. The game should not contain any sounds or pictures that are likely to scare or frighten young children. No bad language should be heard' [3]. These stipulations were abided by during the development of the game.

2.2 USER EVALUATION CONSIDERATIONS

As this application was designed for the use of young children it was necessary to involve children in the testing process. This required that that point 2e from the BCS Code of Conduct was to be particularly followed:

> *2e 'respect and value alternative viewpoints and, seek, accept and offer honest criticisms of work.'* The game was tested with children, parents and members of the teaching profession. Their opinions were valued and respected at all times.

Ethical compliance was also reviewed. It was found that testing by children is in conflict of point 6 of the 'Ethical Compliance Form for UG and PGT Projects, School of Engineering and Informatics' form that 'No participant was under the age of 18'. Therefore the project was deemed to be high risk. Consequently, ethical approval was required through the relevant C-REC. The ethical review forms used can be found in Appendix 1.

In addition to ethical review being approved, a DBS check was carried out due to the fact the testing was to be undertaken in a school environment. The DBS certificate that was presented can be found in Appendix 2.

3 LITERATURE REVIEW

3.1 COMPUTER GAMES IN EDUCATION

Many studies have been carried out investigating the significance of using computer games in Education. In 2009 a study, by author Marina Papastergiou, assessed the learning effectiveness and motivational appeal of a computer game for learning computer memory concepts [4]. The study showed that the gaming approach was both more effective in promoting students' knowledge of computer memory concepts and more motivational than the non-gaming approach. The results suggest that within higher education computer science, educational computer games can be exploited as effective and motivational learning tools.

Children learn best when they are interested and motivated and are given opportunities for hands on practise. By providing these opportunities in the form of a game, the children will be motivated to practise their skills as they gain satisfaction from achieving a positive outcome.

As discussed in the paper 'Using Serious Games in Computer Science Education' by author Lasse Hakulinen, for a game to be a successful teaching aid it must contain enough entertainment to motivate students, but also include good learning objectives [5]. It also comments that a disadvantage to game based learning is that time taken to learn how to play the game could be used to actually study the course content. Consequently, the biggest challenge in creating an ideal educational game would be creating a game that is quick to learn, but still offers profound learning goals.

Based on the research undertaken in this paper, results showed that students with a greater prior knowledge of the subject did not learn as much by playing the game. This raises the question of whether students with less preliminary knowledge learn more from these particular games than more advanced students. There is also the argument that, as students have a wide variety of learning styles, a computer-based approach will not necessarily appeal to all, and this could affect their potential learning.

3.2 LEARNING ANALYTICS

As the development of educational games increases, so does the data relating to these games and education within games. Finding appropriate techniques for analyzing and evaluating this data can prove hard due to the diversity of the data. The emerging fields of Learning Analytics (LA) and Educational Data Mining (EDM) attempts to address this issue by exploring models and techniques for making efficient and effective use of educational data. The paper, 'Learning Analytics and Serious Games: Trends and Considerations' [6] by authors Laila Shoukry, Stefan Göbel and Ralf Steinmetz, suggests that when dealing with data gathered from educational games, it should be quantified based on learning goals, setting and tasks as well as game genre, mechanics and platform.

It also states that due to games being played on multiple platforms, with different interaction mechanics, activity logs cannot be a sole source for analysis. Ideally, games should be initially designed in a way where all game mechanics reflect learner states to make learning analytics more efficient.

In order to effectively compare different games with different motivations, conditions can be defined on generic or game-specific variables and events. This could reflect aspects such as learning, strategies and motivation.

3.3 GAME DESIGN ASSESSMENT

In addition to the need to analyze the data received from these serious games, it is also necessary to find a means to assess the games design in order to ensure the game delivers discussable results. The paper 'Purposeful by Design? A Serious Game Design Assessment Framework' by authors Konstantin Mitgutsch and Narda Alvarado discusses how the design of serious games are mainly based in terms of their content and not in terms of their intention [7]. By using a framework a constructive structure for assessing purpose-based games is introduced. The SGDA framework was applied to two purpose-based, serious games and concluded that a structured discussion about the game design elements in relation to the games purpose is possible. Their findings state that if serious games are designed to impact their players, their purpose needs to be considered in all design components. While it was necessary for the application in this project to be a fun and entertaining game, the need for it to be an effective teaching aid was always at the forefront of any design decisions.

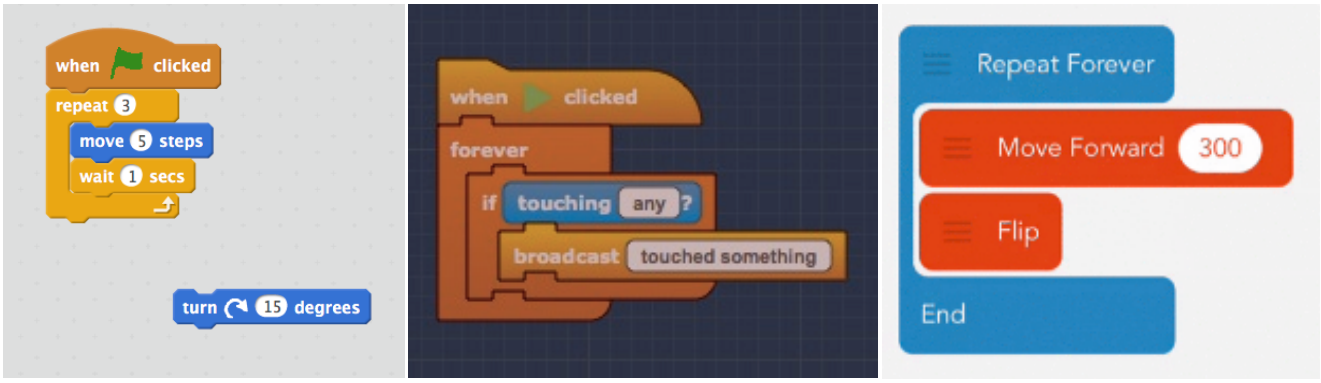
3.4 CURRENT SOFTWARE

Before considering the requirements for the project, research was carried out to ascertain the nature of applications and software available in this field. This gave information as to which applications and software currently on the market are more successful.

A popular piece of software that is similar to the one being created in this project is called Scratch [8]. This is a piece of computer software for creating animations that features a drag and drop interface using different instructions. The similarity lays in the use of interlocking puzzle pieces to give the character instructions. Unlike this project, Scratch does not give an end objective. The user needs to set their own objectives, which can be too broad a concept for young children.

Expanding on Scratch, another popular application, 'Tynker [9]', introduces challenges for the user to complete in order to progress the game. For example objectives such as 'make the character move to the wall, then jump over it' or, 'when the time is 6am, make the sun rise'. This gives the user a sense of direction and accomplishment. The game offers a wide range of objectives, however does not allow the user to progress through increasingly harder levels as they gain experience.

Like Scratch and Tynker, HopScotch [10] also uses the 'puzzle piece' design for the instructions. This design is very popular throughout many pieces of software (see Figure 3.1) making them simple and intuitive for the target audience. Therefore this style was used for this application. Both HopScotch and Scratch offers the user the option to use all available instructions at the beginning, creating what could be a confusing start for some users. Tynker works in a way where each objective only provides the type of instructions needed for that particular task. This creates an easier learning environment for the user, but some could argue only having the instructions needed to complete the task could render it too easy.



[a] [b] [c]

[a] Scratch Interface, [b] Tynker Interface, [c] HopScotch Interface

Fig 3.1 Various software interfaces

From researching current software, it became apparent that the most successful apps currently are those with a limited number of instructions or options to choose from. This ensures that the user is able to assimilate the information, and therefore make decisions, quickly and effectively. Giving too many instructions at the beginning makes it difficult for a novice user to understand and get started on the game. In this project, this problem was overcome by introducing the user to simple instructions in the initial levels. As the user progresses through the game, more complicated algorithms are needed, building on the knowledge learned in previous levels.

As well as researching the current software that was similar in nature to the one being developed, research had to also be undertaken to ascertain what software was going to be used for development. The most popular game engine software at the time of development was Unity [11]. The documentation suggested it was simple enough for any beginner to pick up and use, but still offers all the powerful features that experts need. Other software was looked at such as Unreal Development Kit (UDK) [12] and GameMaker [13], however they seemed to lack functionalities that would be needed during development. UDK is targeted more at creating 3D games and GameMaker is designed more for novice programmers. As Unity was highly talked about and offered everything that was needed for this development, it was the chosen game engine for this project.

3.5 CURRENT PAPER

This paper aims to further research the effectiveness of computer games in education by looking at whether the application created causes any improvement in the users' computing knowledge. During the development of the game, key features found in this research were acknowledged. For example, specific variables were used to measure the users' data in order to help with the analytics and also the use of a solid design framework to ensure the game is being designed as an effective teaching aid, and not just a game.

The concept for the game was chosen to be simple enough to be quick to learn, but also to offer sufficient learning goals as discussed in 3.1. The game was designed to appeal to as many students as possible so as to make it accessible for the majority of users. Consequently, the game was kept as gender neutral as possible and no particular theme (such as football) was used to avoid demotivating some students.

4 DESIGN

4.1 REQUIREMENTS

4.1.1 MINIMUM FUNCTIONALITIES

Listed below are the essential (E) requirements that were set out before beginning any software design. These requirements were essential for the functioning of the application in order for it to achieve its main goal of introducing children to the world of programming.

E1. The game must have at least 3 levels, each progressively harder and introducing new concepts.
E2. Each level must have:
  E2.1 A set of instructions from which the user can choose.
  E2.2 The ability to place these instructions in any order.
  E2.3 The ability to run these instructions.
  E2.4 A character that follows the instructions chosen by the user, providing they are possible.
  E2.5 A world, including a character and a series of obstacles that the user must navigate the character through.
  E2.6 A score to be given to the user based on the number of times the level has been attempted before being completed successfully. A maximum score will be given if the user navigates the character correctly in one try, with deductions with each unsuccessful attempt.
E3. The user must be able to move the instructions via the touchscreen using drag and drop to place them in the desired order.
E4. Once one level is completed successfully, the user should be lead to the next level.
E5. When all levels are completed, a screen should be displayed congratulating the user and prompting them to start again and achieve a better score.
E6. The application must be playable by children from ages 5 onwards.
E7. The users' progress of their current level must be cached.
E8. The application must run on an iPad, using an up to date version of iOS.
E9. The application must be capable of saving scores locally and to an online database.

4.1.2 ANALYSIS OF MINIMUM FUNCTIONALITIES

The objective of this application is to improve children's computational thinking in a fun environment that will motivate them to practise and improve their skills. The game will have multiple levels (E1) to give the user a sense of progress and achievement. In addition, because each level will include new concepts for the user to encounter, it will help to broaden and develop their skills.

The nature of the game will be for the user to navigate a character through various obstacles by selecting from a bank of instructions and placing them in the correct order. It is therefore a fundamental part of the game that the character follows the instructions given (E2.4) and that the user is able to freely choose and order the instructions in the way that they feel is most appropriate to solve the task (E2.1) (E2.2). If the character does not follow the instructions given to it by the user, it would render the activity of choosing those instructions pointless.

As this game is designed to improve computational and logical thinking, it is necessary for all the required instructions to be chosen and ordered before being carried out by the character. Therefore, the character should not respond to these instructions until the algorithm has been completed. This will be implemented by the use of a 'Run' button in the corner of the screen (E2.3). This also enables the user to review the algorithm before running it.

The game will have multiple levels, with each level becoming more challenging by introducing new concepts (E1) and more obstacles (E2.5). Progress through the game will happen automatically as each level is completed successfully (E4). The progress of which level the user has reached will also be saved (E7) to enable them to freely stop and start playing the game. This is important as it may not be desirable for the user to complete the game in one sitting.

The game will include a scoring system (E2.6). In addition to this being a motivational challenge, it will also encourage the children to think about how to solve the logical problems they are faced with. It will discourage the use of random guesswork and help to broaden their understanding.

As the application is targeted at school-aged children to aid with their learning, it needs to appeal to and be used by that age group (E6). A simple interface with bold colours and intuitive actions will be implemented to gain this. To help the user to understand what is happening at different points of the game, a screen will need to be shown to let them know they have completed the game (E5).

As the chosen device for this project, the application must run on an iPad (E8) using the latest version of iOS. This will ensure the application will run as expected on any iPad with up to date software.

In order to be able to analyze the game and test whether it achieves its aim of being a teaching aid, the data from each user needs to be stored (E9). Having the scores saved locally first and then to an online database will minimize the risk of any data loss. Having all scores saved in a database helps with the analysis of data.

4.1.3 ADDITIONAL FUNCTIONALITIES

Listed below are additional (A) requirements for the application. Although not necessary for the application to achieve its main goal, they will enhance the gaming experience for the user.

A1. A title screen to begin the game or view the instructions.
A2. A level select screen to select unlocked levels.
A3. A selection of playable characters from which the user can choose at the start of the game.
A4. A high scores screen to showcase the highest scores achieved for each level.
A5. Unlockable items for achieving certain goals through out the game such as achieving a maximum score. These might include extra playable characters or bonus levels.
A6. The ability for the user to print out achievement certificates for each level that is successfully completed.
A7. The ability for the user to create their own worlds and scenarios for other users to play.
A8. The ability for the user to upload their own created levels for other users to download and try for themselves.
A9. The levels should be randomly generated within certain constraints, so no repeated level is ever exactly the same.

A10. A number of hint tokens to help them on a level when they are stuck. These would be part of the unlockables mentioned in requirement A4. When used, they would give the position of one of the instructions.
A11. The application should be compatible with mobile phones and available on multiple platforms.

4.1.4 ANALYSIS OF ADDITIONAL FUNCTIONALITIES

Many of the additional functionalities are simply designed to make the application a more fun and interesting game to play, making it more appealing to the target audience. It will be a better teaching aid if the users are motivated and enjoy using it.

Having a high score showcase (A4), unlockable items (A5) and a print out certificate feature (A6) will all help with the motivation of the user. In addition, the ability of having hints (A10) will encourage the user to keep trying even if they are finding a level difficult.

In addition to improving the enjoyment of the game, some of these additional features provide opportunities for further learning. The ability for the user to create their own levels (A7) will consolidate their knowledge, as they would have to understand and create the logic themselves. Having the levels change each time the user plays it (A9), gives them further opportunities to practice their logical thinking. If the level was exactly the same every time the user played it, they could easily memorize the solution then gain a maximum score next time they play that level. Having a different layout of the level every time the user plays it gives another degree of certainty that they have actually understood the task given to them.

By including a high score feature (A4), it will introduce a sense of competition between the multiple users of the application. This will encourage the users to keep playing to improve, which in turn will broaden and reinforce their 'computational thinking' skills. Once the user has progressed through the game, the user may want to replay certain levels (A2) to achieve a higher score. This will help to consolidate their knowledge on the aspects that that level focuses on.

To ensure the target audience is able to play the game successfully, the application must be easy to use with a high level of intuition. Including instructions and a title screen will aid in this (A1).

Although the game is principally designed for use on an iPad (E8), it should also be compatible with mobile phones and multiple platforms. This would make the application accessible to more people and therefore target a larger audience.

A useful feature of the application that could especially be helpful within schools would be the ability to upload created worlds for other users to download (A8). For example, the class teacher could make levels that target a particular problem area for the students to download and complete for homework at home.

4.1 INITIAL DESIGN

Before any code, initial plans for the level design were designed in Photoshop, based on the initial requirements set out. This gave an indication of how the game would function and what functionality the levels would need. The first design can be seen below (fig 4.1).

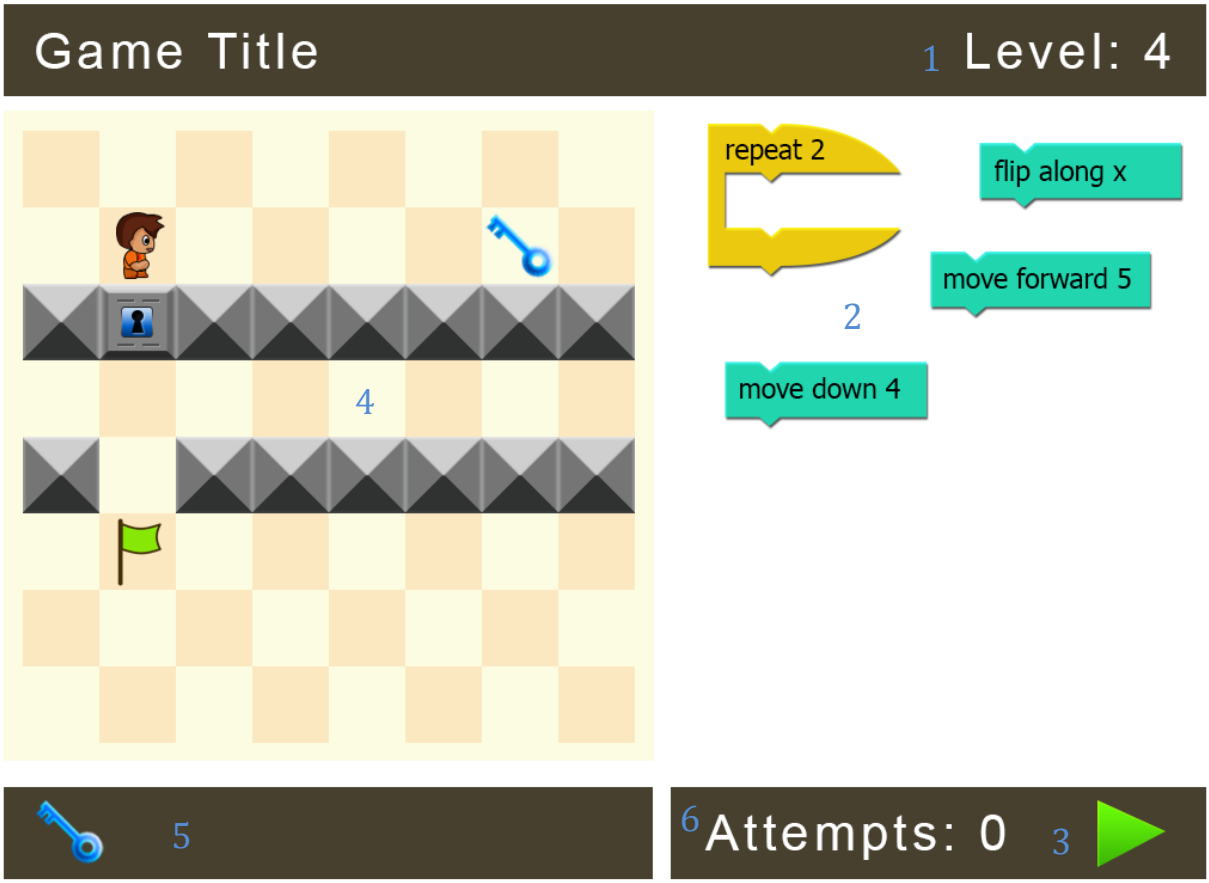


Fig 4.1 Initial game screen design

Below are labels for the corresponding numbers in figure 4.1.

1. Level number to indicate the current level being played
2. Instructions for the user to arrange in order to direct the character
3. 'Run' button, that once clicked will start the character following the instructions
4. Level arena with obstacles and items
5. Inventory space to show any items the character has collected
6. Number of attempts the user has used on the level so far.

By comparing figures 4.1 and 4.2 it's clear that only a few minor alterations were made to the original design. The initial design did not include displaying the time taken for the level, the level information button or a back button. When starting to implement the game, it came apparent that these were needed to improve the users' experience. During development the colour scheme was also chosen to be bright and appealing to students and cemented through all game screens.

Fig 4.2 Final game screen design (Level 10)

4.2 SOFTWARE DESIGN

Completing the initial design, gave a clear understanding of the requirements and functionalities needed. This then enabled an initial class diagram to be completed (see fig 4.3).

As shown in figure 4.3, the game starts with the home class. This holds an instance of the LevelManger class, which in turn holds all the levels. The LevelManager class is used to display which levels are locked and unlocked on the level select screen, using the LevelInformation and LevelButton classes. Having a LevelManager class makes it clear to see which levels the game has and which components these levels consist of.

Having every level inherit from a single Level class creates less code duplication, as all levels require the same methods. Each level only differs from the level number shown, the instructions and what items are in the arena. These are set in the individual level classes.

The level class contains an instance of Character, which inherits from the PhysicsEngine. The PhysicsEngine class is provided through Unity and is used for the collision detection of the character. The LevelClass also contains instances of Obstacle and Item, which are used when building each level. It also contains numerous instruction objects.

The drag class inherits from InputsManager and is used for the movement of the instructions. It uses methods such as 'OnDrag' and 'OnEndDrag' to determine what to do with the instruction at any given point of the input. For example, while 'OnDrag', the instruction position is being changed to the current position of the user's finger. Then when 'OnEndDrag' is called, the

instruction is either left at that position or made a child of another instruction; or, if the desired destination was out of bounds, returned to its original position.

The Level class also contains an instance of the DatabaseManager. This was used in order for the app to send the current score data for that level to the database. The score data for each level was stored in the Score class. Having instances of Score for each level made it possible to save all the required information into a list which could then be saved to a file by the SaveLoad class when the Save method is called.

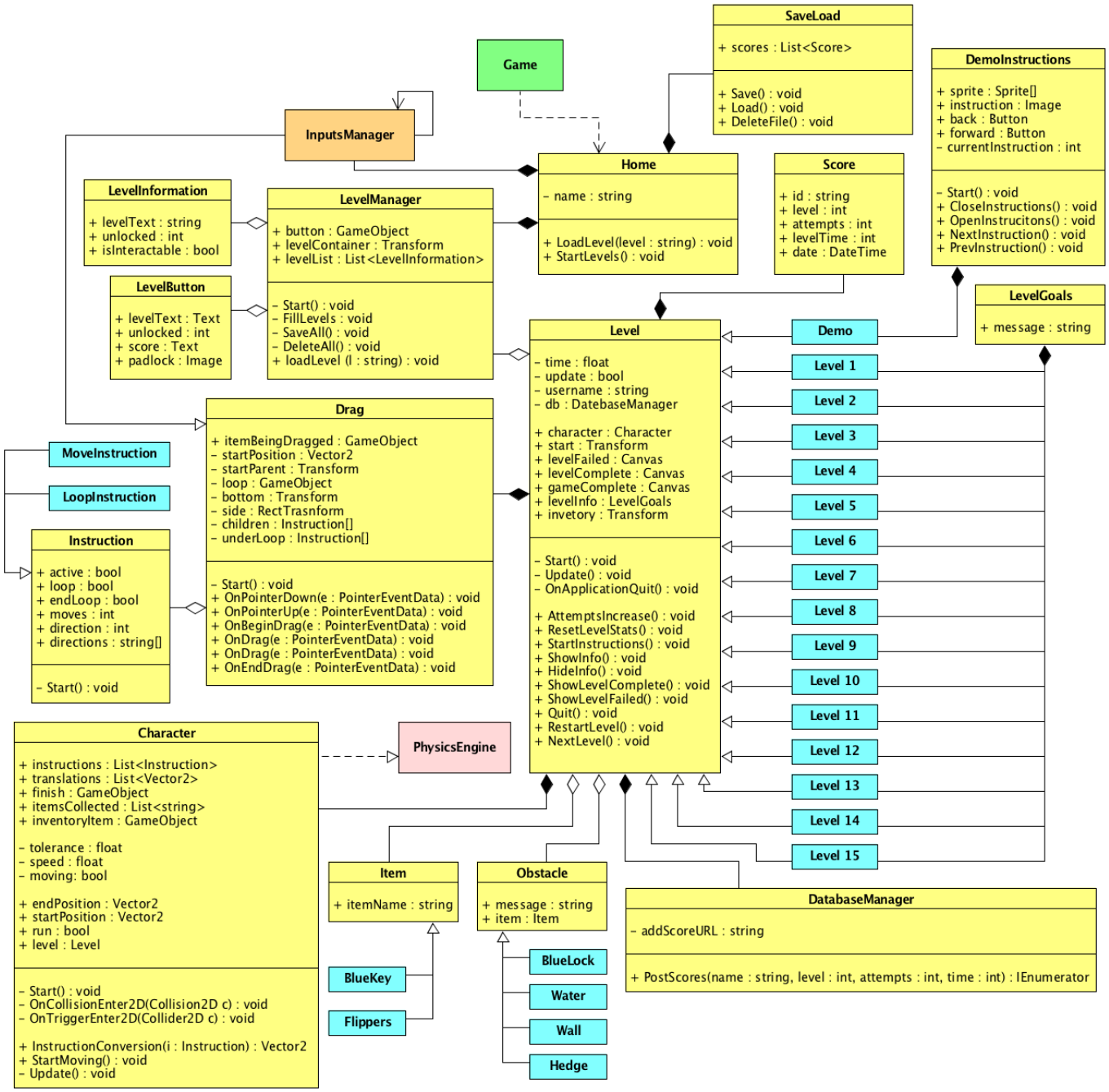


Fig 4.3 Initial class diagram

5 IMPLEMENTATION

Once all the main design work was complete, the task of implementation commenced. The game engine software chosen was Unity. This gave a secure platform to develop in and the ability to use C# as the language which is popular for game development.

The first task was to establish the GUI of the main level screen. This was achieved by splicing the main Photoshop design into separate parts, for example the main world area, and then importing them as sprites to be used on the separate elements within Unity.

5.1 SPRITES

The majority of the sprites used in the game were created in Adobe Photoshop for the sole use of this game. Only the water block sprite was obtained from an external source [14].

5.1.1 CHARACTER SPRITE

In order to animate the character, multiple sprites had to be made for each key movement of the animation (see fig. 5.1). These sprites could then loop giving the effect of the character walking.

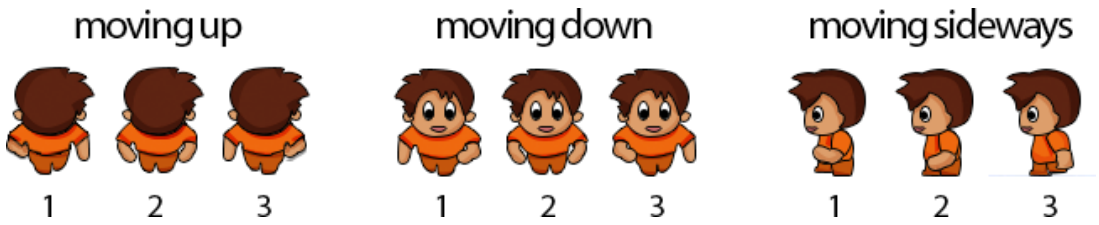


Fig 5.1 Character sprites at each stage of animation

An animation clip was made for each direction the character could go; left, right, up and down. In all cases, the animation started with sprite 2, then changed to sprite 1, back to 2 and finishing with 3. This then looped for the duration of the characters movements. Conditions had to be set up on the animations in order to determine which animation was required. This was achieved with a simple case statement (see fig. 5.2) using integers to classify each animation. Once the character was moving, the correct integer was set on the character so as to perform the correct animation.

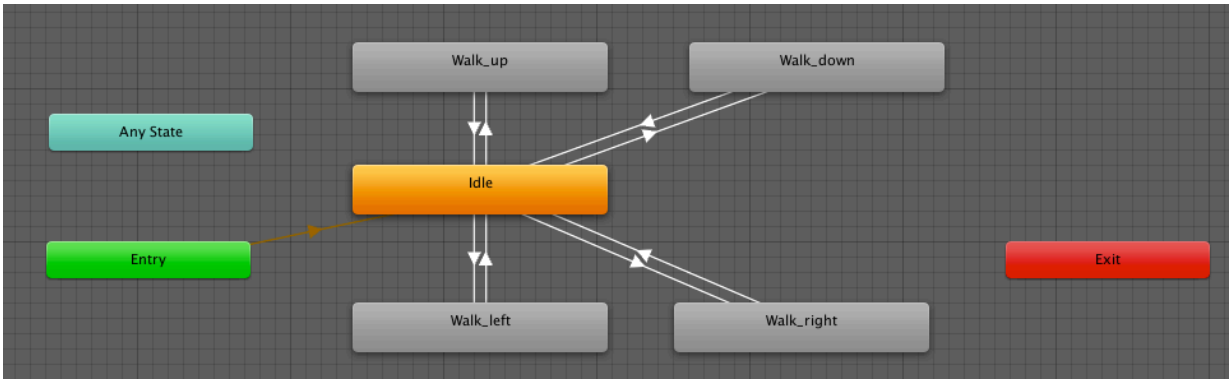


Fig 5.2 Case statement in a visual form

5.1.2 LOOP INSTRUCTION SPRITE

The loop instruction sprite had to work in particular way, as it needed to resize with the number of instructions were currently inside it. This was achieved by splitting the sprite into three main sections; the top, the bottom and the left connector (see fig. 5.3).

Fig 5.3 Composition of the loop instruction sprite

This enabled the sprite to resize according to how many elements were inside the loop instruction. First, a calculation was made to count the children inside the loop construct; this number was then multiplied by their heights. This gave the y position (minus the triangular ends) that the bottom half of the sprite needed to be in relation to the top. The height of the left connector could then be resized with the same calculated number (see fig. 5.4).

```
float heightOfChildren = 0;
    //Adding up all height of children in loop
Instruction[] children = loop.GetComponentsInChildren<Instruction>();
heightOfChildren = (children.Length) * 46f;
//Bottom of the loop            //Top of the loop
bottom.transform.position.y = loop.transform.position.y - heightOfChildren;
side.sizeDelta = new Vector2(side.rect.width,heightOfChildren);
```

Fig 5.4 C# code changing the position and size of the loop sprite

5.2 MOVING THE CHARACTER

One of the main tasks in implementing the game was giving the instructions to the character. Once the user clicks the run button, all of the children of the 'Start' instruction are sent to a stack ready to be performed. If any child of the 'Start' instruction is a loop instruction, then all children inside the loop are found. These instructions are then sent to the stack for many times as the loop instruction displays (see fig. 5.5 for the C# code and fig 5.6 for a visual example). This then gives an accurate set of instructions for the character to start following.

```
if (instructions.Count > 0) {
    foreach (Instruction i in instructions) {
        //If a loop instruction
        if(i.loop){
            int loopTimes = i.moves;
            Instruction[] loopInstructions = i.gameObject.transform.GetComponentsInChildren<Instruction>();
            for(int x = 0; x < loopTimes; x++){
                foreach(Instruction l in loopInstructions){
                    translations.Add (instructionConversion(l) );
                    run=true;
                }
            }
        }else if(!i.loop){      //If not a loop instruction
            Instruction[] normInstructions = i.gameObject.transform.GetComponentsInChildren<Instruction>();
            foreach(Instruction l in normInstructions){
                translations.Add (instructionConversion(l) );
                run = true;
            }
        }
    }
}
```

Fig 5.5 C# code for sending accurate translations to the stack

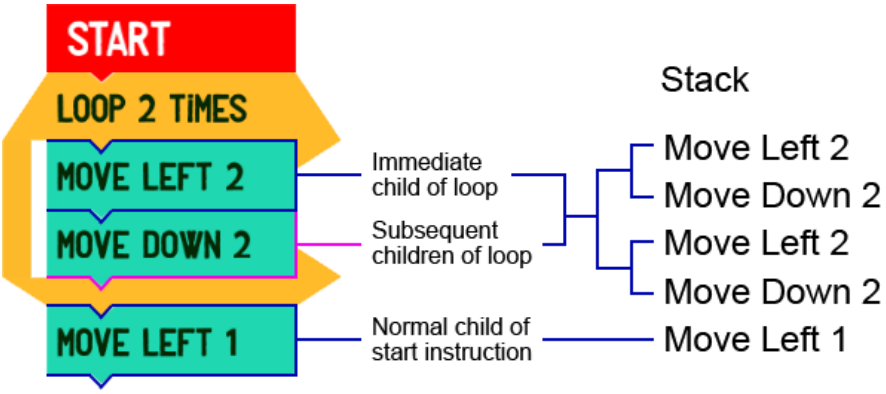


Fig 5.6 Accurately sending instructions to stack

Before the character can start performing the instructions, a conversion is needed from the instruction values to actual pixel translations for the character sprite. This was achieved by taking the number of moves for that instruction and multiplying that number by 64, this being the width in pixels of each square in the arena (see fig. 5.7).

Fig 5.7 Arena square width

The direction was then taken into account. If the direction was right or left, then the translation had to be in the x-axis, and for an up or down instruction, in the y-axis. Finally, if the direction was either left or down, the translation had to be negative, so the results were multiplied by negative 1. Every instruction is converted into their relevant pixel translations, and sent to a new stack for the character to execute. See figure 5.8 for the C# code for how the conversion was done and figure 5.9 for a visual form.

```
public Vector2 instructionConversion(Instruction i){
    int moves = i.moves;
    int direction = i.direction;

    Vector2 vect;
    if (direction == 0) {
        vect = new Vector2 (0, 1);
    } else if (direction == 1) {
        vect = new Vector2 (0, -1);
    } else if (direction == 2) {
        vect = new Vector2 (-1, 0);
    } else {
        vect = new Vector2 (1, 0);
    }
    vect = vect * moves * 64;
    return vect;
}
```

Fig 5.8 C# code for the conversion of instruction values to pixel translations

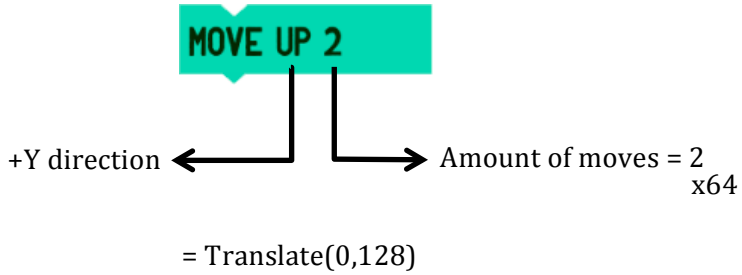


Fig 5.9 Visual form of the conversion from instruction values to pixel translations

5.3 LEVEL COMPLETE / FAILED

On completion of all the instructions, a simple test could be carried to ascertain whether the character had ended on the square with the finish flag. If the character finishes with the same x and y co-ordinates as the finish flag, then the level was completed and the level completed message could be shown. However if the character completes all the given instructions, and does not end up with the same coordinates as the finish flag, we know the level was not completed correctly, so the level failed screen can be shown.

If at any point a collision is made between the character and an obstacle, or the boundary, the level is also failed. Each obstacle has a particular 'level failed' message that is accessed and shown upon on a collision with that object.

5.4 LEVEL SELECT

As the game has multiple levels, a level select screen was required so the user could select any level to play from any levels they had already played and unlocked. This was done by storing the information on unlocked values as key value pairs in a list, with the integer 1 representing unlocked, and 0 meaning locked and the key being the string 'level' followed by the level number.

When the level select screen is loading, a loop cycles through all the levels in the game. If the integer corresponding to that level is a 1, it will display the image for that level with the ability for the user to click it. If the corresponding integer is a 0, the level will not be interactive and will be displayed greyed out with a lock symbol present. This renders it only possible for the user to open levels they have unlocked while also having a clear representation of which levels are unlocked.

5.5 SAVING / LOADING

As the user plays through the levels, their score is stored locally in a list of score objects that are created when a level is completed. This object contains the information of the user ID, the level number, the number of attempts taken for that level, the time taken to complete it and also the current date and time. As this data was originally just being stored in temporary memory, this score data was lost if the app was closed. To solve this issue, the list of score objects was saved to a file that could then be loaded when the app was loaded again.

To save the scores, a file was created at the root of the application and a serialized version of the score list was written to this file. Then, to load the score list again, the file could be read, deserialized and stored locally in the same 'scoreList' variable. Form here, new scores could be added to the list, while keeping the old ones present.

5.6 THE DATABASE

Mainly for research purposes, all scores that had been written to the score list then had to be stored to an online database. As well as ensuring no data was lost, this made it easier to analyze the data of each user to aid in the research section of this project.

To achieve this, a MySQL database was set up to hold all the information required. This included everything that was found in the score object previously mentioned; the user ID, the level number, the attempts taken, the time taken and the current time and date.

To enable the app to post scores to the MySQL database, a simple php script was created and stored on the server. The app sends a post request to a php script at a dedicated URL (see fig 5.10). This script took all the required variables from the url and then performed the 'insert' command to insert a new entry into the database (see fig 5.11). This in turn made it possible to go to a particular URL, followed by a '?' and then the variables to add in the required information, resulting in that information being added into the database. For a pipeline of this process see figure 5.12.

```
public IEnumerator PostScores(string name, int level, int attempts, int time, string t)
{
    string post_url = addScoreURL + "name=" + WWW.EscapeURL(name) +
                                    "&level=" + level +
                                    "&attempts=" + attempts +
                                    "&time=" + time +
                                    "&datetime=" + t;

    WWW hs_post = new WWW("http://"+post_url);
    yield return hs_post;
```

Fig 5.10 C# code to send data to the php script

```
$name = mysql_real_escape_string($_GET['name'], $db);
$level = mysql_real_escape_string($_GET['level'], $db);
$attempts = mysql_real_escape_string($_GET['attempts'], $db);
$time = mysql_real_escape_string($_GET['time'], $db);
$datetime = mysql_real_escape_string($_GET['datetime'], $db);

$query = "insert into scores values ('$name', '$level', '$attempts', '$time', '$datetime' );";
$result = mysql_query($query) or die('Query failed: ' . mysql_error());
```

Fig 5.11 PHP script to create the MySQL command

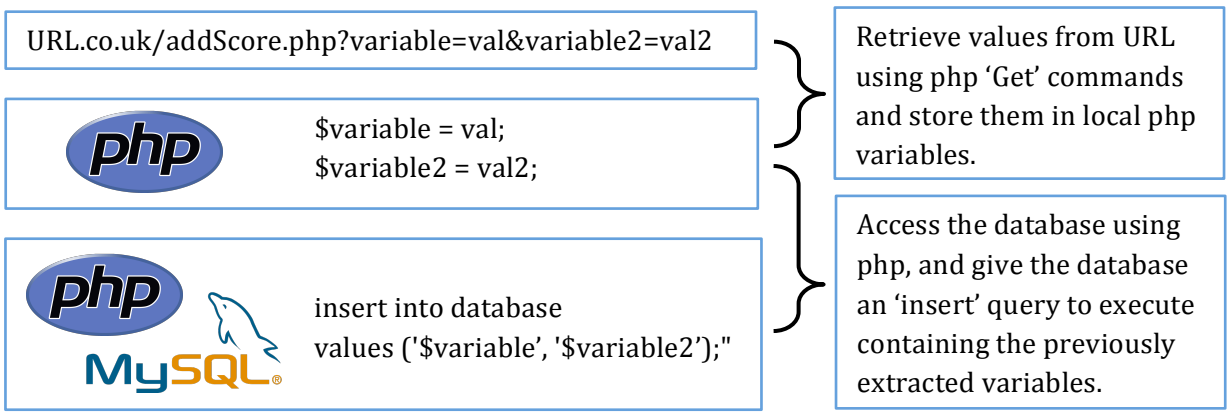


Fig 5.12 Pipeline of retrieving data from URL and storing in MySQL database

For the application to store all the score data to the database, a method was created to cycle through all the score objects in the score list, extract the required data from that object and then open a www request to the desired URL, including the extracted data. A yield return was used with each www request sent, to ensure that the request had been sent and completed, before the application opened up the next one.

As the database was set up using both the user ID number and the date and time as primary keys, every single entry would be unique. This meant no data would ever be overwritten. Initially, the database was set up only using the date and time the score was saved, however this was not sufficient as it would be theoretically possible for two people to save a score at exactly the same time on different devices.

A simple webpage was also set up to display all the data currently in the database. This was done by creating an HTML table with the required headings and then cycling through each entry, extracting the data for each heading, and inserting the correct HTML tags to format the table correctly (see fig 5.13). This created a clear, well formatted table to display all the information in the database (see fig 5.14).

```
$sql = "SELECT * FROM scores ORDER BY datetime";
$data = mysql_query($sql,$db);
echo "
<h1>Max's Mission Results</h1>
<table border=1>
<tr>
    <th>Name</th>
    <th>Level</th>
    <th>Attempts</th>
    <th>Time (Seconds)</th>
    <th>Time</th>
    <th>Date</th>
</tr>";

while($record = mysql_fetch_array($data)){
    echo "<tr>";
    echo "<td>".$record['name']."</td>";
    echo "<td>".$record['level']."</td>";
    echo "<td>".$record['attempts']."</td>";
    echo "<td>".$record['time']."</td>";
    echo "<td>".date('H:i:s', strtotime($record['datetime']))."</td>";
    echo "<td>".date('d-m-y', strtotime($record['datetime']))."</td>";
    echo "</tr>";
}
echo "</table>";
mysql_close($db);

?>
```

Fig 5.13 HTML and PHP code to extract data from the MySQL database and present it in a table

Max's Mission Results

Name	Level	Attempts	Time (Seconds)	Time	Date
404	1	1	7	09:04:43	03-03-16
402	1	1	8	09:04:45	03-03-16
404	2	1	10	09:04:57	03-03-16
402	2	1	10	09:04:58	03-03-16

Fig 5.14 MySQL database in a HTML table

6 SELF TESTING

Before the app was to be tested by the target audience, during and after development, tests were carried out to ensure the game was functioning as expected. A basic list of tests was created and then checked off when completed. Many of these tests were based on the initial requirements that were decided during the design stage. The tests carried out and the results can be seen below.

User Experience	
Is the movement of the instructions restricted to a given space?	Yes, the user cannot move the instructions outside of the designated instructions area. This helps with the ease of use of the game. The instructions can always be seen on the screen.
Is the user able to move the instructions around freely?	The user can move the instructions anywhere on the screen by the use of a touch input and drop them anywhere they wish, inside the previously mentioned restricted space.
Can the user attach any number of instructions together?	Yes, if the user drops an instruction onto another, the instruction is joined to it, making it a child. Then when moving the parent instruction, all child instructions move with it.
At any point of the game, is it clear which instructions will be executed?	The use of the 'start' block makes it clear which instructions are to be executed, as all instructions attached to this are the ones that the character will perform. This gives a clear visual representation of the instructions and the order they will be performed.
Does the user know what to do at all times?	A demo level is provided that includes instructions on how to play the game and what each element in the game means. During the game, the user can click the information button in order to bring up the goal of the current level.
Can the user move more than one instruction at a time?	Currently, the user cannot move more than one instruction at a time, unless they are attached to one another. The app only responds to one touch input, so multiple touch inputs do not work.

Software Functionality	
Does the game include multiple levels that unlock as you progress through the game?	Yes, when the user selects 'New Game', it clears any levels previously unlocked. As the user completes each level, the user can then select this from the level select screen that can be accessed from the home screen.

Does the character follow the instructions accurately and as expected?	When the 'Run' button is pressed, the character performs the instructions given in the correct order and stops moving when all instructions have executed, or when they cannot be executed.
Is the progress of the user saved?	On launching the app, the latest data for the user is loads. This includes the ID number and the levels unlocked.
Are the scores securely and reliably saved?	Initially, all scores are saved locally and when connected to the internet are sent to an online database, ensuring no data is ever lost.
Can data ever be overwritten by mistake?	As the primary key for the database includes both the ID number and time the score was completed, no data will ever be overwritten by a participant entering the wrong ID by mistake.
How are the levels generated?	Currently, the levels are not randomly generated so there is no difference in the levels if you were to play the game again. This was good for the testing part of this project, as it meant every participant had the same levels to play. However, if this app were to be released for general use, randomly generated levels would make the game a more rewarding experience.

7 EXPERIMENT: METHODOLOGY

The aim of the experiment was to test the app with a sample of primary school children and seek their views and opinions. Firstly, ethical approval was sought from the School of Informatics Cluster-based Research Ethics Committee (CREC) and approved (see Appendix 1) and DBS clearance obtained (see Appendix 2). A letter outlining the nature and purpose of the study was sent to a number of schools inviting them to take part (see Appendix 3). For the two schools that agreed, information was forwarded to parents of students concerned seeking their permission (see Appendix 4). Only students whose parents returned the consent form (see Appendix 5) were included in the study.

The experiment consisted of 39 participants ranging from the ages of seven to ten (Years 3, 4 and 5). The participants from year 3 and 4 were from Shipham CEVC First School and the year 5's from Westdene Primary School. For more background on the research participants please see Appendix 6. As the application was primarily targeted towards primary school children, this age range was perfect as it gave a wide spread of the target ages.

The experiment took the form of three main stages; a pre-test, time spent to play the app, and then a post-test. With each year group, all participants completed both tests, however only half of them played the app between completing them. This gave a control group and test group. These results gave a clear indication whether the app had succeeded in its primary goal of being a teaching aid.

Every participant was given a unique ID number that would distinguish them apart within the experiment whilst maintaining anonymity. Information such as age and gender were associated with these numbers in order for further comparison after the tests had been completed.

7.1 PRE AND POST TESTS

Both pre-tests and post-tests took the form of a paper test, similar in fashion to the app (see Appendix 7). Both tests consisted of three puzzles of increasing difficulty, with the puzzles in the post-test being identical in solution to the pre-test. However, the post-test used different 'stories' and a slightly different layout so as to appear different to the students. This made it easy to compare the two tests, as theoretically participants should produce the same answers for each test, assuming there was no change in their knowledge between the two tests.

All puzzles consisted of five main instructions to select from; a loop construct, and four movement instructions, up, down, left and right. All instructions had the option for the participant to write in the number of squares the character should move. Puzzle one was the simplest of the three, only needing three movement instructions to complete. This gauged their basic understanding of how logical instructions are performed one after another.

Puzzle two was slightly more complex as it involved the character having to pick up an item before finishing the main goal of getting home. This level was created so the most efficient solution would use a loop, with that solution only using two instructions, but being repeated three times. This was designed in this manor to gauge whether the participant had any knowledge of loop constructs, whether they understood why it would be more efficient to use one, and if they could use them effectively.

The final puzzle was the most difficult. It lead the participant to use a loop again, but also additional instructions before and after the loop. This again gauged the participants understanding of loop constructs and also gave an insight on their ability to recognize when a loop would be the most efficient.

7.2 PLAYING THE APP

On completion of the pre-test, the test group was given time to play the app. Both test and control groups consisted of a mix of ability, age and gender to give as good a spread as was possible within the constraints of the class.

The playing of the app took part in a classroom environment. Two separate devices were used to enable two students to play simultaneously in order to reduce the time taken for testing. The two participants had their individual device in front of them and were taken through the demo level so they could get a good understanding of how the game functions, how to move the instructions and so on. This ensured that the time spent on each level was purely the time they took to work out the answer, and not the time spent working out how to play the game.

Once they were comfortable with how the app functioned, they began a new game on the app by entering their unique ID and selecting new game. This ensured that all saved data for each level was linked to their ID for further analysis later. Each participant had 20 minutes to play the app, once they had completed the demo level. Some participants grasped the concept of the app faster within the demo level, however they all played the main levels for the same time.

7.3 QUESTIONNAIRE

As well as collecting the data on how well the app improved the students computational thinking skills, research was undertaken to canvas the students opinions of the app. For example did they enjoy the game, did they encounter any problems and did they have any suggestions for improvements.

This data was just as valid as any other, as the app would not be a success if the target audience did not enjoy playing it, even if it did work as a teaching aid. The app really had to excel in both areas for it to be a success.

This data was gathered by the use of a questionnaire (see Appendix 8) that each participant completed after they had played the app. Control group participants also completed this questionnaire as they were given an opportunity to play the app after completing the post-tests.

8 EXPERIMENT: DATA ANALYSIS AND DISCUSSION OF RESULTS

The experiment was designed in order to gain information in regard to the following questions:

- Is the application successful in improving the students computational thinking skills?
- Does the game progress through the levels at an appropriate degree of challenge?
- Does the game motivate the students to learn?

The third point is of equal importance as no matter how efficiently the game teaches the children, it can only do this if they are keen to use it. The raw data sheets can be found in Appendix 9.

8.1 IS THE APPLICATION AN EFFECTIVE TEACHING AID?

8.1.1 EVIDENCE FROM ANALYSIS OF PRE AND POST TEST PUZZLES

The data compares how successfully the students completed the paper puzzles before and after using the application. The students were split into two groups: the test group that spent 20 minutes playing the app before completing the second puzzles, and a control group that did not use the app at this stage.

Initially, the puzzles were reviewed, and each student was given a score based on how many puzzles they completed correctly. One point was given to every puzzle correctly answered, giving a maximum score of 3. This then enabled a t-Test to be carried out to compare the mean scores in both pre and post tests, with the null hypothesis of 'There is no difference between means in the pre and post test scores' and the alternative hypothesis of 'There is a difference between means in the pre and post test scores'.

The test group had a mean pre-test score of 1.1 with variance 1.147 and the post-test mean score was 1.8 with variance 0.484. This gave P values of 0.001535708 for a one-tail test and 0.003071415 for a two-tail test. With a significance level of 0.05, as the P values are lower than this, there is evidence to reject the null hypothesis and conclude that for the test group, students were more successful in completing the puzzles after using the app.

For the control group, the results show a mean pre-test score of 1.684 with variance 0.673 and the post-test mean score of 1.579 with variance 0.702. This gave P values of 0.165282466 for a one-tail test and 0.330564931 for a two-tail test. With a significance level of 0.05, as the P values are higher than this, there is no evidence to reject the null hypothesis and therefore it can be concluded that for the control group, students were no more successful in completing the puzzles after using the app.

Ho: "There is no difference between means in the pre and post test scores" Null Hypothesis
Ha: "There is a difference between means in the pre and post test scores" Alternative Hypothesis

t-Test: Paired Two Sample for Means of Test Group	*Pre*	*Post*
Mean	1.1	1.8
Variance	1.14736842	0.48421053
Observations	20	20
Hypothesized Mean Difference	0	
P(T<=t) one-tail	0.00153571	
P(T<=t) two-tail	0.00307142	

There is evidence to reject the null hypothesis with a level of significance of a=0.05, p<0.05

t-Test: Paired Two Sample for Means of Control Group	*Pre*	*Post*
Mean	1.68421053	1.57894737
Variance	0.67251462	0.70175439
Observations	19	19
Hypothesized Mean Difference	0	
P(T<=t) one-tail	0.16528247	
P(T<=t) two-tail	0.33056493	

There is no evidence to reject the null hypothesis with a level of significance of a=0.05, p<0.05

Fig 8.1 t-Test results for control and test group based on overall score

These results provide evidence that using the application does help in developing the users computational thinking skills.

In puzzles 2 and 3, the most efficient solution would involve the use of a loop construct, although it was possible successfully complete the puzzles without. The data was analyzed in order to ascertain whether there was any improvement in the students' ability to use loop constructs. Scores were given to each student for puzzles 2 and 3 as follows: 0 for no attempt to use a loop construct, 1 loop construct attempted, but errors made and 2 loop construct used successfully.

Again, a t-Test was undertaken with this data with a null hypothesis of 'There is no difference between means in the pre and post test scores' and the alternative hypothesis of 'There is a difference between means in the pre and post test scores'.

The test group had a mean pre-test score of 0.25 with variance 0.304 and the post-test mean score was 1.15 with variance 1.397. This gave P values of 0.00228499 for a one-tail test and 0.00922513 for a two-tail test. With a significance level of 0.05, as the P values are lower than this, there is evidence to reject the null hypothesis and conclude that for the test group, students were more successful in attempting to use a loop construct after using the app.

For the control group, the results show a mean pre-test score of 0.526 with variance 0.930 and the post-test mean score of 0.684 with variance 1.006. This gave P values of 0.13400673 for a one-tail test and 0.26801347for a two-tail test. With a significance level of 0.05, as the P values

are higher than this, there is no evidence to reject the null hypothesis and therefore it can be concluded that for the control group, students were no more successful in using loop constructs after using the app.

Ho: "There is no difference between means in the pre and post test scores" Null Hypothesis
Ha: "There is a difference between means in the pre and post test scores" Alternative Hypothesis

t-Test: Paired Two Sample for Means of Test Group	*Pre*	*Post*
Mean	0.25	1.15
Variance	0.30263158	1.39736842
Observations	20	20
Hypothesized Mean Difference	0	
P(T<=t) one-tail	0.00228499	
P(T<=t) two-tail	0.00922513	

There is evidence to reject the null hypothesis with a level of significance of a=0.05, p<0.05

t-Test: Paired Two Sample for Means of Control Group	*Pre*	*Post*
Mean	0.52631579	0.68421053
Variance	0.92982456	1.00584795
Observations	19	19
Hypothesized Mean Difference	0	
P(T<=t) one-tail	0.13400673	
P(T<=t) two-tail	0.26801347	

There is no evidence to reject the null hypothesis with a level of significance of a=0.05, p<0.05

Fig 8.2 t-Test results for control and test group based on a score given in relation to the use of loop constructs used

These results indicate that there were significant improvements in programming skills for those students that used the app compared to those that did not.

The combination of the two tests has shown that the app is a useful and efficient aid in teaching computational thinking.

Having established the app was successful as a teaching aid, the data was further analysed in order to ascertain whether the app is more successful in different year groups or gender.

8.1.2 EVIDENCE FROM ANALYSIS OF IN APP DATA

Further evidence that the application is an effective teaching aid can be gained from the data collected on how well the participants completed each level. As the participants were playing the game, data stating the level number and the number of attempts and time taken on that level were sent to an online database.

The average time taken for each level was graphed in order to discover which levels participants found most challenging. The graphs show that levels 1 and 2 were completed quickly as these

were straightforward levels requiring one or two simple instructions. The graph also shows that a peak in time taken occurred at levels 3, 6, 11 and 13. These were the levels where a main new concept was introduced. For example level 3 was the first level to include obstacles and level 6 was the first to use a loop construct. Expanding on this, in level 10 it was necessary for the participants to use more than one instruction inside the loop, then at level 11 to use an additional instruction outside the loop.

Subsequent levels show a decrease in time, which would indicate that the students had learned how to implement the concept.

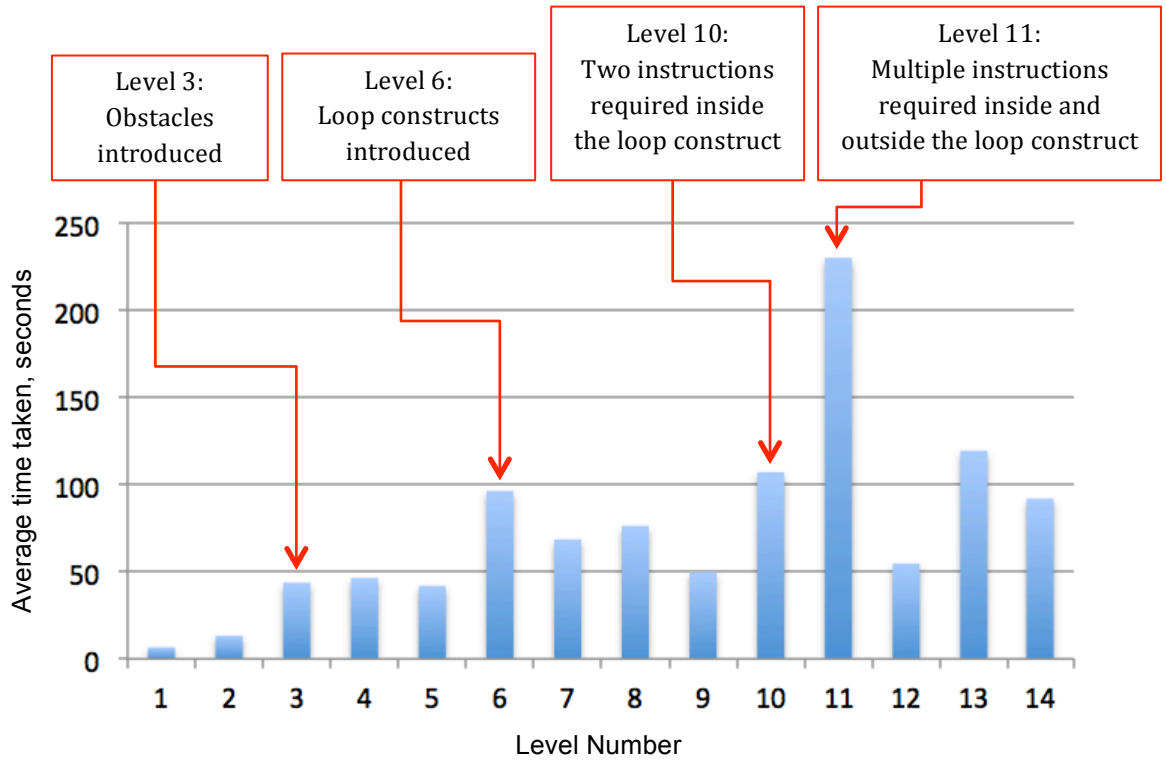


Fig 8.3 Graph showing average time taken to complete each level

This provides further clear evidence that the application is effective as an aid for teaching computational thinking skills. This conclusion is also supported when looking at the average number of attempts for each level. Once again, a peak can be seen at levels 3, 6, 10 and 11 with a subsequent fall (see figure 8.4).

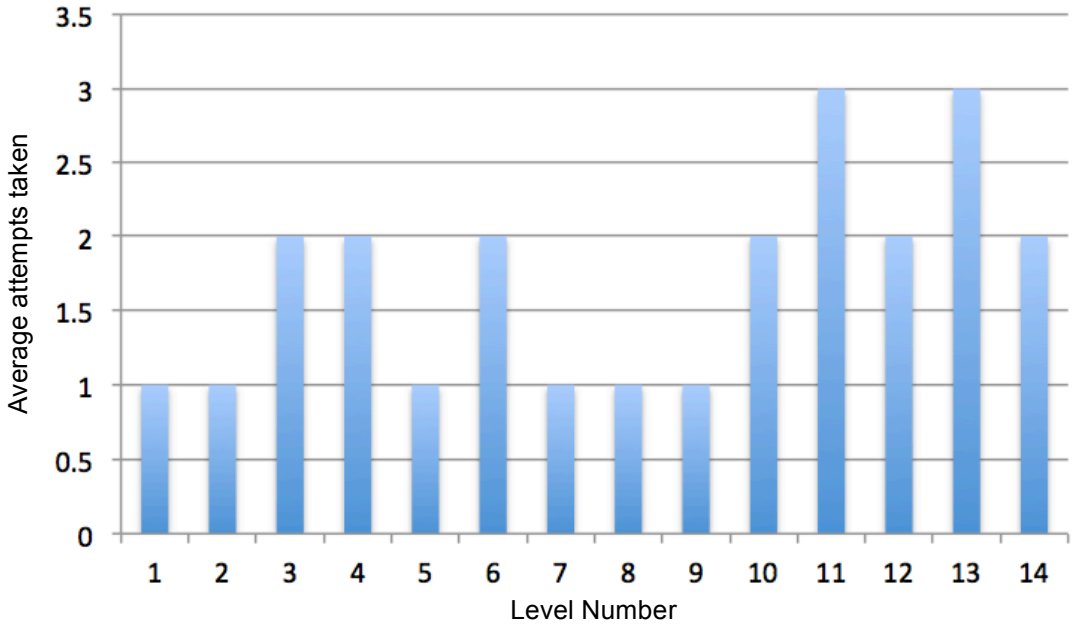


Fig 8.4 Graph showing average attempts taken to complete each level

One important factor when designing a teaching aid is that the levels are set at an appropriate level of challenge. It is important the students are able to complete the earlier levels without too much difficulty, mainly to gain confidence in their ability and using the app. The levels should then get gradually more complex so that their skills can be developed and built upon. There should not be a rapid increase in complexity from one level to the next as students will be demotivated if they are unable to complete it.

The in app data was reviewed to analyze the maximum level reached by each student within the 20 minutes allowed for the research. These results for the 39 participants were plotted on a graph, which can be seen in figure 8.5.

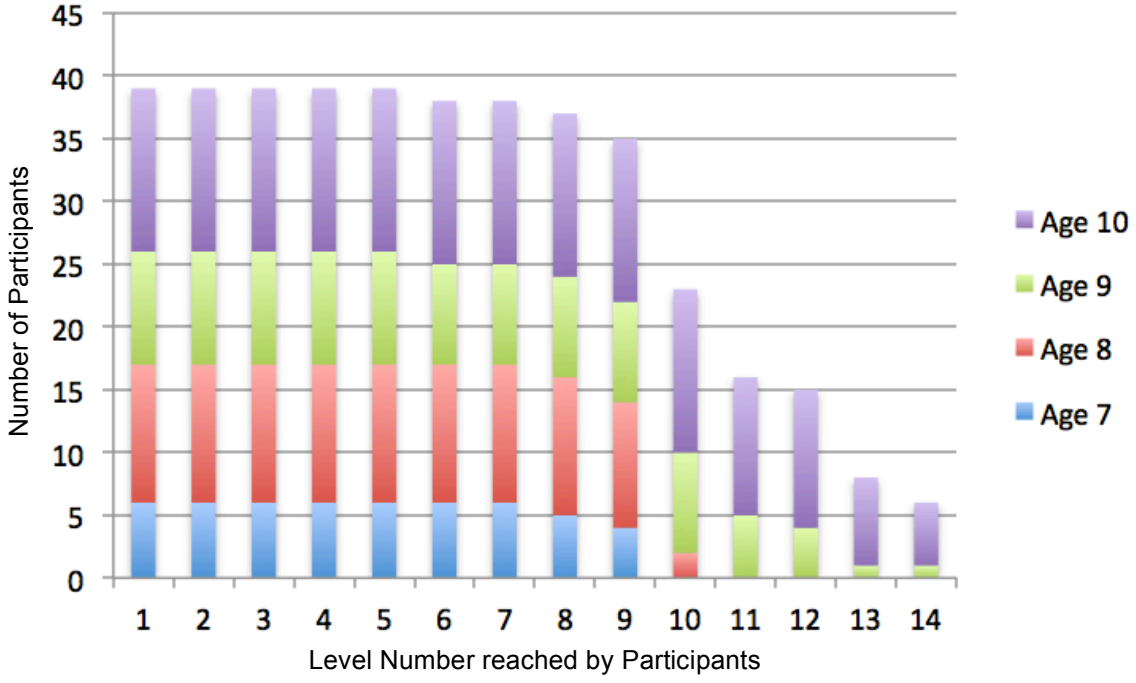


Fig 8.5 Graph showing the number and age spread of participants that reached each level

The graph shows that while all pupils succeeded in completing the initial levels, there was a gradual fall in the number of participants completing the higher levels. As might be expected, this fall off began at a lower level for the younger children, as their skills would naturally be at a lower level. This provides evidence that the application is set at an appropriate level of challenge and increased in complexity at an appropriate rate for this age group.

The data from the pre and post tests has provided evidence that the app does work as an effective teaching tool, a major factor in this being that the levels are of an appropriate level of difficulty and increases at an appropriate rate.

8.3 DOES THE APP MOTIVATE STUDENTS TO LEARN?

As shown above, there is evidence that the use of the app does improve a students computational thinking skills and that the levels were set at a suitable level of difficulty. The fact that the levels are set at the correct difficulty level will help motivate the students, which is an important factor for the teaching aid to be most effective. In order to gain further evidence of their opinions of the game, all students were asked to complete a questionnaire about their experience using the app. Both the test and control groups completed this questionnaire, as the control group were given the option to play the app after completing the puzzles in order to gain their feedback. A copy of the questionnaire can be found in Appendix 8.

Children were asked to circle the most appropriate face to gauge their feelings in response to each question. These were converted to a numerical value as shown in figure 8.6. As well as answering the 7 questions, the students were also given the opportunity to give any additional comments.

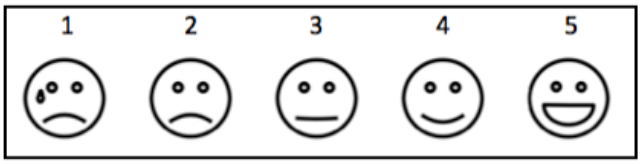


Fig 8.6 Questionnaire face to score conversion

Question 1 simply asked if the children enjoyed playing the game. This scored a mean score of 4.66 out of 5, with boys being marginally more positive (4.79) than girls (4.58). Interestingly, when comparing the students by year group, 100% of year 3 and 4 children gave this question a maximum score of 5. This indicates that the game appeals slightly more to a younger age group. This was supported by many of the comments made by the students, such as 'I really enjoyed the game' and 'I loved it, it was awesome!'

In addition to this, question 4 asked if they liked the colours and layout of the game. This scored a mean score of 4.47 with again the younger year groups giving higher scores than the older ones.

Questions 2, 6 and 7 were also aimed at discovering whether the children enjoying playing the game and would want to play it again. They asked if the children wanted to play the game at home, whether they wanted to play the game again and if the game was a fun way to learn respectively. The response again was positive with the mean for all answers being over 4.2, with boys again being slightly more positive than girls. Also, as with question 1, year 3 and 4 children gave marginally higher scores than year 5, reinforcing the statement that the game is slightly more appealing to younger children. This was supported by some of the comments made, with one student saying 'I like that it is a game but it can teach you lots'.

Question 5 asked the students if they found the game easy. One of the main challenges in teaching is to set the lessons at an appropriate level for the ability of the students. Where tasks are set that are too easy, the students can quickly become bored and demotivated. Conversely, if tasks are too challenging, students can feel they have no chance in success and again become demotivated. Therefore it is important that a teaching aid application gives an appropriate level of challenge for the user. As might have been expected, this question did not score as highly as the others with a mean score of 3.92. This indicates that most students found the game posed an appropriate level of challenge. For those students who gave the higher scores, it could be argued that the game was not sufficiently challenging, however this would be remedied by having further levels of increasing complexity. It should be noted that all students had a limited time to play and had to complete the most straightforward levels first.

Question 3 asked if the instructions were easy to understand and was designed to find out whether the game was simple to begin playing. As with all applications of this type, if the initial instructions are too complex, the user can become frustrated and loose their enthusiasm. This scored a mean of 4.26 indicating it was not too difficult in understanding how to play the game.

9 CONCLUSIONS AND FUTURE WORK

The aim of this project was to create an educational iPad application that would develop the computational thinking skills of the students. The app was developed successfully using the Unity game engine and took the form of a puzzle game called 'Max's Mission' whereby users were required to select instructions to navigate the character Max around obstacles to the required goal. The completed game functioned well with an appealing design.

The functionality of the game was tested during development and then further research was undertaken using a sample of 39 students from years 3, 4 and 5. The results of this experiment provided clear evidence that the application was successful in improving the students' computational thinking skills. This is inline with other research discussed in Chapter 3, that for many students, the use of computer software is a successful tool in education. In addition, the research also provided evidence that the pupils enjoyed the game and on the whole would use it repeatedly. This would be important if the game were to be released as a marketable product.

Upon undertaking the research and obtaining written feedback from the target audience and verbal feedback from the teachers, some ideas for future development became apparent that would aid in the games success if it were to be developed further.

9.1 FURTHER DEVELOPMENT

9.1.1 RESTARTING THE LEVEL

Currently, if the user fails a level and restarts it, the instructions reset to their initial position. When testing the app, it came apparent that if the user fails a level, it would be helpful for them to be able to see their original solution they gave in order to debug their algorithm. With the instructions returning to their original position, it relies on the user remembering what they had previously done. This problem could be overcome if the position of the instructions were to stay in place on the screen if the level is failed. This gives the user their incorrect solution and the option to change it.

9.1.2 HIGHLIGHTING CURRENT INSTRUCTIONS

Building on the last point, it would be useful to the user if they could see which instruction the character was currently executing (see fig 9.1). This would enable them to see the effect of each instruction on how the character moves. While any instruction in a loop was being executed, the loop instruction would be highlighted telling the user that the loop is currently being executed, and also the current instruction inside the loop that is being executed will be highlighted. An indication of how many times the loop had performed an iteration could also be displayed (see fig 9.2).

Fig 9.1 Game screen – Instruction being highlighted when executing

Fig 9.2 Game screen – Loop instruction being highlighted when executing

This information could then also be used if the level was failed. The last instruction to be executed could stay highlighted, giving the user information on where their solution failed. This would aid in the understanding for the user and make it clearer how each process will be completed.

9.1.3 GAME STORYLINE

An idea suggested by one of the research participants was that the game would benefit from having a storyline. Currently, each level is a new scene and does not follow on from the last, making it less interesting to some people. It would improve the users' experience if that game had some purpose and an overall goal, such as 'Max is lost in the woods and needs to back to his home', with each level being a stage of his journey. This would entice the user to keep playing, as they will feel they have achieved more at the end when they have completed an overall goal.

9.1.4 GENERATING LEVELS

As mentioned in the testing section of this report, currently the levels are not randomly generated, rendering level one to always be the same, with the same solution. Consequently a user could play the level once, learn the solution, and then on restarting the level would solve it immediately, giving them a high score. Not only is this undesirable from the point of view that the scores would not be a true reflection of their skills, it also means when the user has completed the app once, they would not be inclined to play it again.

If each level was randomly generated, based on certain criteria for each level, the game would become more enjoyable for the user and also more appealing to replay. It would also give more learning opportunities. For each level, a set of rules would be set detailing certain aspects that the level had to fulfill, for example, 'The level should include a lock and its corresponding key' and 'the level should include a set of 8 water blocks, inline with each other'. Once the level arena was randomly generated, an algorithm would have to run to solve the current level. Once the solution had been found, the solution would have to be split up into corresponding instructions. Finally, a few dummy instructions would be generated in order for the level to be a challenge. This would ensure that each level was different every time it was played and it was solvable. However, it could mean that some of the generated levels are too easily solved. Even with detailing the requirements, the exact difficulty could not be guaranteed.

An alternative solution would be to design a variety of levels for each level. Then when loading the level, a random one was selected. This would of course involve more manual work, but would guarantee that every level was interesting and give the required challenge.

9.2 FURTHER RESEARCH

It would be interesting to use the results from this experiment to attempt to ascertain a profile of the pupils for whom this teaching approach is most successful. For example is this application more effective in teaching boys or girls or with a particular age range. Consideration could also be given to whether the improvement in skills is affected by their initial knowledge.

Further research could be undertaken expanding the sample to include participants with a wider range of age and ability, including students with special educational needs.

10 REFERENCES AND APPENDICES

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Appendix 1 (i): Ethical Review – Application Form

Ethical Review Application (ER/PH233/2) Paul Hickman	
Project Title	Max's Mission: An educational app for the development of computational thinking skills
Status	Approved
Department	Informatics
Email	ph233@sussex.ac.uk
Applicant Status	UG
Phone	
Supervisor	Gilardi, Marco
Project Start Date	20-Sep-2015
Project End Date	18-Apr-2016
External Funding in place	No
External Collaborators	No
Funder/ Project Title	
Name of Funder	

Appendix 1 (i): Ethical Review – Application Form

Ethical Review Application ER/PH233/2 (continued)

Project Description

In the new national curriculum for primary aged children which came compulsory this year that the new topic of computing was introduced and replaces the old subject of ICT. The new computing subject requires that the children are introduced to the concepts of computer programming. It is no longer sufficient for the children to simply be able to use computer software like word processing packages; they now need to have a greater understanding of the programming behind that software.

A mobile game is being developed to aid in the teaching of the logical process that are a fundamental part of programming. This mobile game takes the form of an app that will run on an apple iPad. The game aims to develop the computational thinking skills and logical thought process of the user. 'Max's Mission' is a puzzle game where a character, Max, has to be navigated past a series of obstacles such as walls and locked doors to reach the finish flag. The game consists of a number of levels of increasing complexity. At each level the player is given a bank of instructions from which to select, for example 'Move forward 4 spaces' and 'Turn around'. These are presented as interlocking puzzle pieces. The player is asked to select instructions and place them in the order needed for the character to reach their goal. They then click a 'Run' button which causes the character to follow the given instructions from beginning to end. If an attempt fails, the player is prompted to start again and a counter records the number of tries and the time taken for them to complete the level. If the attempt is successful, the player progresses to the next level.

At the end of each level, the player receives a score to gauge their success. This will be calculated from data about the amount of attempts made and the time taken to complete the level.

Part of the development for any application is that it should be tested by a representative sample from the target audience. The test process aims to find out

• Whether the app runs as expected and without errors
• Whether the app is successful in developing the children's computational thinking skills
• If the children enjoy playing the app
• Whether the instructions given are clear and understandable

'Max's Mission' is a game designed for children aged 7-11 and as such should be tested by children that fall within this age range. The study will take a sample of children from within this age bracket and will be carried out as follows:

I will visit the school and work with individual pupils with a member of staff present. At the beginning of the study, the selected pupils will be given a written logic puzzle to complete similar in nature to the requirements of the game. They will then be introduced to the app and invited to play the game for a short period of time. Their scores, times and the levels reached will be recorded as will any comments made by them and any notable reactions they have to the game. Notes will also be taken with regards to any problems with the functioning of the game, including lack of clarity of instructions and any bugs found. The children will then be given another opportunity to complete the same written puzzle in order to assess any progress made.

The children will also be asked to complete a short questionnaire in the form of 'smiley face' tick boxes about their enjoyment of the game.

After completion of the data collection process, the data will be analysed to see whether the app has been effective in it's goals of teaching. This will be done by comparing the two tests carried out by the participants.

Appendix 1 (i): Ethical Review – Application Form

Ethical Review Form Section A (ER/PH233/2) (cont.)

Ethical Review Form Section A (ER/PH233/2)	
Question	**Response**
>> Checklist	
A1. Will your study involve participants who are particularly vulnerable or unable to give informed consent or in a dependent position (e.g. people under 18, people with learning difficulties, over-researched groups or people in care facilities)?	Yes
A2. Will participants be required to take part in the study without their consent or knowledge at the time (e.g. covert observation of people in non-public places), and / or will deception of any sort be used?	No
A3. Will it be possible to link identities or information back to individual participants in any way?	No
A4. Might the study induce psychological stress or anxiety, or produce humiliation or cause harm or negative consequences beyond the risks encountered in the everyday life of the participants?	No
A5. Will the study involve discussion of sensitive topics (e.g. sexual activity, drug use, ethnicity, political behaviour, potentially illegal activities)?	No
A6. Will any drugs, placebos or other substances (such as food substances or vitamins) be administered as part of this study and will any invasive or potentially harmful procedures of any kind will be used?	No
A7. Will your project involve working with any substances and / or equipment which may be considered hazardous?	No
A8. Will financial inducements (other than reasonable expenses, compensation for time or a lottery / draw ticket) be offered to participants?	No
>> Risk Assessment	
A9. If you have answered 'Yes' to ANY of the above questions, your application will be considered as HIGH risk. If however you wish to make a case that your application should be considered as LOW risk please enter the reasons here:	

Appendix 1 (i): Ethical Review – Application Form

Ethical Review Form Section C (ER/PH233/2)	
Question	**Response**
>> C.1 Risk Checklist - Participants	
C1. Does the study involve participants who are particularly vulnerable, or unable to give informed consent, or in a dependent position (e.g. children (under 18), people with learning difficulties, over-researched groups or people in care facilities, including prisons)?	Yes
C2. Is Criminal Records Bureau clearance necessary for this project? If yes, please ensure you complete Section C.6.	No
C3. Will participants be asked to take part in the study without their consent or knowledge at the time (e.g. covert observation of people) or will deception of any sort be involved? Please refer to the British Psychological Society Code of Ethics and Conduct for further information.	No
C4. Could the study induce psychological stress or anxiety, or produce humiliation, or cause harm or negative consequences beyond the risks encountered in normal life?	No
C5. Are alcoholic drinks, drugs, placebos or other substances (such as food substances or vitamins) to be administered to the study participants?	No
C6. Can you think of anything else that might be potentially harmful to participants in this research?	
>> C.2 Risk Checklist - Researcher(s) Safety and Wellbeing	
C7. Does the project involve working with any substances and/or equipment which may be considered hazardous? (Please refer to the University's Control of Hazardous Substances Policy).	No
C8. Could the nature or subject of the research potentially have an emotionally disturbing impact on the researcher(s)?	No
C8a. If yes, briefly describe what measures will be taken to help the researcher(s) to manage this.	
C9. Could the nature or subject of the research potentially expose the researcher(s) to threats of physical violence and / or verbal abuse?	No
C9a. If yes, briefly describe what measures will be taken to mitigate this.	
C10. Does the research involve any fieldwork - Overseas or in the UK?	No
C10a. If yes, where will the fieldwork take place?	
C11. Will any researchers be in a lone working situation?	No
C11a. If yes, briefly describe the location, time of day and duration of lone working. What precautionary measures will be taken to ensure safety of the researcher(s)?	
C12. Can you think of anything else that might be potentially harmful to the researcher(s) in this research?	
>> C.3 Data Collection and Analysis (Please provide full details)	

Appendix 1 (i): Ethical Review – Application Form

Ethical Review Form Section C (ER/PH233/2) (cont.)

C13. PARTICIPANTS: How many people do you envisage will participate, who they are, and how will they be selected?	The number of participants for this study will be at least 15 students from a select school. The age group I hope to you use will be from year 4 / 5 which means the students will be of the ages 8/9/10. This is due to the app being targeted towards an average age of about 9 - being the average age of key stage 2 student.
C14. RECRUITMENT: How will participants be approached and recruited?	Emails will be sent out to the headteacher of local schools outlining the study and how the app functions, with the information sheets attached. Obviously, some schools will not have time to take part in the study, due to their time table and other activities they have planned, so the more schools contacted, the more chance there is of one accepting. Local schools will be chosen to make it easier for me to meet in person and be there when the study tales place. A school from all interested ones will then be picked at random, as the study will probably only be taken in one school.
C15. METHOD: What research method(s) do you plan to use; e.g. interview, questionnaire/self-completion questionnaire, field observation, audio/audio-visual recording?	A questionnaire will be presented to the participants on completion of playing the app, getting their opinions on the app and how it functions. To gain knowledge of how effective the app was in teaching, the participants will complete a short test before and after playing the app, testing the same skills as the app attempts to improve.
C16. LOCATION: Where will the project be carried out e.g. public place, in researcher's office, in private office at organisation?	The study will be taken out in the school that is chosen. Primarily, I will want to be there with the participant playing the app so I can gain more information while watching them attempt each level. Due to the app having to be on a specific device, the participants will have to play the app one by one. A time limit of 15 minutes per student will have to be allocated to make sure every participant plays the app. How this will work will have to be discussed with the chosen school once they have agreed to take part. Ideally, every student will take the initial test together before the study day. Then on the chosen study day, one by one each participant will be given the opportunity to play the app and fill out the questionnaire. This will take place within the general classroom setting whilst the remainder of the class are engaged in other activities with the class teacher. At the end of the day, or even the next day, every participant will complete the second test. My intention is to carry out the study in a location where there is always a member of school staff present and therefor a DBS check would not be strictly necessary, unless required by the school. In which case I would be willing to complete it.
>> C.4 Ethical Considerations (Please provide full details)	

Appendix 1 (i): Ethical Review – Application Form

Ethical Review Form Section C (ER/PH233/2) (cont.)

C17. INFORMED CONSENT: Please describe the process you will use to ensure your participants are freely giving fully informed consent to participate. This will usually include the provision of an Information Sheet and will normally require a Consent Form unless it is a purely self-completion questionnaire based study or there is justification for not doing so. (Please state this clearly).	Once a school has opted in to taking part in the study, they will be have to send out the consent forms to the parents/carers of all participants asking them whether they want their child to take part in the study. A separate information sheet will be provided to the parents letting them know about the study and how it will run.
C18. RIGHT OF WITHDRAWAL: Participants should be able to withdraw from the research at any time. Participants should also be able to withdraw their data if it is linked to them and should be told when this will no longer be possible (e.g. once it has been included in the final report). Please describe the exact arrangements for withdrawal from participation and withdrawal of data for your study.	If a child or child's carer want to withdraw at any point they are free to do so up to seven days after completion of the study. This date will be agreed with he school and given to parents as part for the initial information sheet. Any parent wishing to withdraw their consent will be asked to contact the school. The school will then link that child to their unique ID number and pass the request to remove data relating to that ID number from the study. The data gathered is all anonymous to me and so not linked to a child in particular. The tests and questionnaires are linked together by a unique reference number that only the teacher of that class will be able to link to names.
C19. OTHER ETHICAL ISSUES: If you answered YES to anything in C.1 you must specifically address this here. Please also consider whether there are other ethical issues you should be covering here. Please also make reference to the professional code of conduct you intend to follow in your research.	The study will use participants under the age of 18. Throughout the project, the BCS code of conduct will be followed.
>> C.5 Data Protection, Confidentiality, and Records Management	
C20. Will you ensure that the processing of personal information related to the study will be in full compliance with the Data Protection Act 1998 (DPA)?	Yes
C20a. If you are processing any personal information outside of the European Economic Area (EEA) you must explain how compliance with the DPA will be ensured.	
C21. Will you take steps to ensure the confidentiality of personal information?	Yes
C21a. Please provide details of anonymisation procedures and of physical and technical security measures here:	The teacher of the class will give each participant a unique reference number to identify them throughout the study. The will then enable me to link a child's test to their questionnaire. The child's name will never be used so all data is anonymous.
C22. Will all personal information related to this study be retained and shared in a form that is fully anonymised?	Yes
C22a. If you answered "no" to the above question you must ensure that these arrangements are detailed in the Information Sheet and that participant consent will be in place. If relevant, please outline arrangements here:	

Ethical Review Form Section C (ER/PH233/2) (cont.)

C23. Will the Principal Investigator take full responsibility during the study, for ensuring appropriate storage and security of information (including research data, consent forms and administrative records) and, where appropriate, will the necessary arrangements be made in order to process copyright material lawfully?	Yes
C23a. If you answered "no" to the above question, please give further details:	
C24. Who will have access to personal information relating to this study?	The class teacher and maybe other members of the school staff will be the only ones that have access to the participants personal information. I will know the age and gender of each participant of the study by their unique reference number.
C25. Data management responsibilities after the study. State how long study information including research data, consent forms and administrative records will be retained, in what format(s) and where the information will be kept.	Parental consent forms will be retained by the researcher until the 18th of April 2016 when the final project report is submitted. In addition, other hard copy information such as the initial and post study paper tests and any observational notes made by the researcher will also be retained until the 18th of April 2016. The participants scores obtained whilst playing the app will be saved electronically on the device used to play the game and will be deleted once the final report has been submitted.
>> C.6 Other Ethical Clearances and Permissions	
C26. Are any other ethical clearances or permissions required?	No
C26a. If yes, please give further details including the name and address of the organisation. If other ethical approval has already been received please attach evidence of approval, otherwise you will need to supply it when ready.	

Appendix 1 (ii): Ethical Review - Certificate

University of Sussex

Certificate of Approval	
Reference Number	ER/PH233/2
Title Of Project	Max's Mission: An educational app for the development of computational thinking skills
Principal Investigator (PI):	Marco Gilardi
Student	Paul Hickman
Collaborators	
Duration Of Approval	3 months and 2 weeks
Expected Start Date	20-Sep-2015
Date Of Approval	04-Jan-2016
Approval Expiry Date	18-Apr-2016
Approved By	David Reby
Name of Authorised Signatory	
Date	04-Jan-2016

*NB. If the actual project start date is delayed beyond 12 months of the expected start date, this Certificate of Approval will lapse and the project will need to be reviewed again to take account of changed circumstances such as legislation, sponsor requirements and University procedures.

Please note and follow the requirements for approved submissions:

Amendments to protocol

* Any changes or amendments to approved protocols must be submitted to the C-REC for authorisation prior to implementation.

Feedback regarding the status and conduct of approved projects

* Any incidents with ethical implications that occur during the implementation of the project must be reported immediately to the Chair of the C-REC.

Feedback regarding any adverse and unexpected events

* Any adverse (undesirable and unintended) and unexpected events that occur during the implementation of the project must be reported to the Chair of the Social Sciences C-REC. In the event of a serious adverse event, research must be stopped immediately and the Chair alerted within 24 hours of the occurrence.

For Life Sciences and Psychology projects

* The principal investigator is required to provide a brief annual written statement to the committee, indicating the status and conduct of the approved project. These reports will be reviewed at the annual meeting of the committee. A statement by the PI to the C-REC indicating the status and conduct of the approved project will be required on the Approval Expiration Date as stated above.

Appendix 2: DBS Certificate

Enhanced Certificate

Disclosure & Barring Service

No DBS Fee Charged

Certificate Number 001521969731

Date of Issue: 08 MARCH 2016

Applicant Personal Details

Surname: HICKMAN

Forename(s): PAUL

Other Names: NONE DECLARED

Date of Birth: 01 OCTOBER 1994

Place of Birth: WESTON-SUPER-MARE

Gender: MALE

Employment Details

Position applied for:
CHILD WORKFORCE RESEARCHER

Name of Employer:
UNIVERSITY OF SUSSEX PSYCHOLOG

Countersignatory Details

Registered Person/Body:
SAFETY NET

Countersignatory:
ELIZABETH WARNOCK

Police Records of Convictions, Cautions, Reprimands and Warnings

NONE RECORDED

Information from the list held under Section 142 of the Education Act 2002

NONE RECORDED

DBS Children's Barred List information

NONE RECORDED

DBS Adults' Barred List information

NOT REQUESTED

Other relevant information disclosed at the Chief Police Officer(s) discretion

NONE RECORDED

Enhanced Certificate

This document is an Enhanced Criminal Record Certificate within the meaning of sections 113B and 116 of the Police Act 1997.

THIS CERTIFICATE IS NOT EVIDENCE OF IDENTITY

Continued on page 2

Appendix 2: DBS Certificate

Certificate Number 001521969731

Use of certificate information

The information contained in this certificate is confidential and all recipients must keep it secure and protect it from loss or unauthorised access. This Certificate must only be used in accordance with the Disclosure and Barring Service's (DBS) Code of Practice and any other guidance issued by the DBS. Particular attention must be given to the guidance in the fair use of the information in respect of those whose Certificate reveals a conviction or similar information. The DBS will monitor the compliance of Registered Bodies with this Code of Practice and other guidance.

This Certificate is issued in accordance with Part V of the Police Act 1997, which creates a number of offences. These offences include forgery or alteration of Certificates, obtaining Certificates under false pretences, and using a Certificate issued to another person as if it was one's own.

This Certificate is not evidence of the identity of the bearer, nor does it establish a person's entitlement to work in the UK.

Certificate content

The personal details contained in this Certificate are those supplied by or on behalf of the person to whom the Certificate relates at the time the application was made and that appear to match any conviction or other details linked to that identity.

The information contained in this Certificate is derived from police records, and from records held of those who are unsuitable to work with children and/or adults, where indicated. The police records are those held on the Police National Computer (PNC) that contains details of Convictions, Cautions, Reprimands and Warnings in England and Wales, and most of the relevant convictions in Scotland and Northern Ireland may also be included. The DBS reserves the right to add new data sources. For the most up to date list of data sources which are searched by the DBS please visit the DBS website.

The Other Relevant Information is disclosed at the discretion of the Chief Police Officers or those of an equivalent level in other policing agencies, who have been approached by the DBS, with due regard to the position sought by the person to whom the Certificate relates.

Certificate accuracy

The DBS is not responsible for the accuracy of police records.

If the person to whom this Certificate relates is aware of any inaccuracy in the information contained in the Certificate, he or she should contact the Countersignatory immediately, in order to prevent an inappropriate decision being made on their suitability. This Countersignatory will advise how to dispute that information, and if requested arrange for it to be referred to the DBS on their behalf. The information should be disputed within 3 months of the date of issue of the Certificate.

The DBS will seek to resolve the matter with the source of the record and the person to whom the Certificate relates. In some circumstances it may only be possible to resolve a dispute using fingerprints, for which consent of the person to whom the Certificate relates will be required.

If the DBS upholds the dispute a new Certificate will be issued free-of-charge. Details of the DBS's disputes and complaints procedure can be found on the DBS's website.

Contact us

Post:	Disclosure and Barring Service PO Box 165 Liverpool L69 3JD	Telephone:	Customer Services: Welsh line: Minicom: General Information	03000 200 190 03000 200 191 03000 200 192 03000 200 190

Web: www.gov.uk/dbs
Email: customerservices@dbs.gsi.gov.uk

If you find this certificate and are not able to return it to the person to whom it relates, please return it to the DBS at the address above or hand it in at the nearest police station.

End of Details

University of Sussex

PARTICIPANT INFORMATION SHEET (PARENTS & CARERS)

STUDY TITLE
Research for the development of "Max's Mission: An educational app for the development of computational thinking skills".

INVITATION
Your child is invited to take part in a research study as part of the development process for an educational app that takes the form of a game to be played on an iPad. With all app development, an essential part is the testing phase. This is required to gain an insight on how well the app runs and whether it achieves its aims and goals. As the app is targeted towards school aged children, it is necessary to test the app with children of this age.

The app being created aims to develop the skills of computational thinking that are fundamental to the Programming aspect of the new Computing Curriculum in primary schools. Children need to be able to develop skills in problem solving and logical thinking such as the sequencing of instructions to achieve an end goal. This way of thinking will help them to understand the logical processes that lie behind computer programs.

The app takes the form of a game where a character has to be navigated past a series of obstacles such as walls and locked doors to reach the finish flag. The game consists of a number of levels of increasing complexity. At each level the player is given a bank of instructions from which to select, for example 'Move forward 4 spaces' or 'Turn around'. These are presented as interlocking puzzle pieces. The player is asked to select instructions and place them in the order needed for the character to reach his goal. They then click a 'Run' button that causes the character to follow the given instructions from beginning to end. If an attempt fails, the player is prompted to start again and a counter records the number of tries together with the time taken to complete the level. If the attempt is successful, the player progresses to the next level.

At the end of each level, the player receives a score to gauge their success. This will be calculated from data about the amount of attempts made and the time taken to complete the level.

Further information about the study is provided in this document.

WHAT IS THE PURPOSE OF THE STUDY?
Part of the development process of any app is for it to be tested by the final users in order to further refine and develop it. Therefore the purpose of this study is to obtain information on the following points:

- Is the app successful in developing the children's computational thinking skills?
- Do the children enjoy playing the app?
- Are the instructions given clear and understandable?
- Does the app run as expected, without errors?

WHY HAS MY CHILD BEEN INVITED TO PARTICIPATE?
The app is designed for children aged 7 to 11 years and therefore the testing of the app needs to be undertaken by children within this age range. Your child has been invited to take part as they match the target audience of the game.

DOES MY CHILD HAVE TO TAKE PART?
There is of course no obligation to take part. However, if you do agree for your child to take part, you will be given this information sheet to keep and will be required to sign a consent form. If you do decide to take part, you will be free to withdraw your child or their results without giving a reason up to seven days following completion of the testing.

The results for individual pupils will be used solely for the purpose of this research and will have no impact on any scores or grades given by the school.

WHAT WILL HAPPEN IF MY CHILD TAKES PART?
I will visit the school and work with individual pupils with a member of staff present. At the beginning of the study, the selected pupils will be given a written logic puzzle to complete similar in nature to the requirements of the game. They will then be introduced to the app and invited to play the game for a short period of time. Their scores, times and the levels reached will be recorded. They will then be given another opportunity to complete the same puzzle in order to assess any progress made.

The children will also be asked to complete a short questionnaire in the form of 'smiley face' tick boxes about their enjoyment of the game.

WHAT ARE THE POSSIBLE DISADVANTAGES AND RISKS OF TAKING PART?
There is no cost to the school or individual pupils for taking part in this study other than the time taken for the children to complete the puzzles, play the game and fill out the questionnaires.

WHAT ARE THE POSSIBLE BENEFITS OF TAKING PART?
It is anticipated that the pupils will benefit from playing this app by improving their computational thinking skills and encouraging them to get involved in computing.

WILL MY CHILD'S INFORMATION IN THIS STUDY BE KEPT CONFIDENTIAL?
All data collected will be kept confidential and be used only for the purpose of this study. Individual pupils' personal information will not be recorded by name; instead each pupil will be identified by a number allocated to them by the school. The age and gender of each pupil taking part in the study will be recorded, but will be linked to the results using their unique reference number.

WHAT SHOULD I DO IF I WANT MY CHILD TO TAKE PART?
If you are willing for your child to take part in the study. Please complete the consent form and return it your child's school.

WHO IS ORGANISING THE RESEARCH?
My name is Paul Hickman and I am a third year undergraduate at the University of Sussex and am undertaking this study as part of my final year project for a degree in Computing for Digital Media under the supervision of Dr Marco Gilardi.

WHAT WILL HAPPEN TO THE RESULTS OF THE RESEARCH STUDY?
The results of individual pupils will be amalgamated and will provide information to help further develop this app. The amalgamated results will be included in the documentation for my final year project, and the information will be reviewed only by members of the University and potentially used for an academic paper.

WHO HAS APPROVED THIS STUDY?
This study has been approved by the Sciences & Technology Cross-Schools Research Ethics Committee (crecscitec@sussex.ac.uk). The project reference number is ER/PH233/2.

CONTACT FOR FURTHER INFORMATION
Thank you for taking the time to read this information. For further information or if you have any concerns regarding this research, please contact Dr Marco Gilardi at M.Gilardi@sussex.ac.

The University of Sussex has insurance in place to cover its legal liabilities in respect of this study.

16/11/15

University of Sussex

PARTICIPANT INFORMATION SHEET (SCHOOLS)

STUDY TITLE
Research for the development of "Max's Mission: An educational app for the development of computational thinking skills".

INVITATION
Your school is invited to take part in a research study as part of the development process for an educational app that takes the form of a game to be played on an iPad. With all app development, an essential part is the testing phase. This is required to gain an insight on how well the app runs and whether it achieves its aims and goals. As the app is targeted towards primary school aged children, it is necessary to test the app with children of this age.

The app being created aims to develop the skills of computational thinking that are fundamental to the Programming aspect of the new Computing Curriculum in primary schools. Children need to be able to develop skills in problem solving and logical thinking such as the sequencing of instructions to achieve an end goal. This way of thinking will help them to understand the logical processes that lie behind computer programs.

The app takes the form of a game where a character has to be navigated past a series of obstacles such as walls and locked doors to reach the finish flag. The game consists of a number of levels of increasing complexity. At each level the player is given a bank of instructions from which to select, for example 'Move forward 4 spaces' or 'Turn around'. These are presented as interlocking puzzle pieces. The player is asked to select instructions and place them in the order needed for the character to reach his goal. They then click a 'Run' button that causes the character to follow the given instructions from beginning to end. If an attempt fails, the player is prompted to start again and a counter records the number of tries together with the time taken to complete the level. If the attempt is successful, the player progresses to the next level.

At the end of each level, the player receives a score to gauge their success. This will be calculated from data about the amount of attempts made and the time taken to complete the level.

Further information about the study is provided in this document. Please take time to read it carefully.

WHAT IS THE PURPOSE OF THE STUDY?
Part of the development process of any app is for it to be tested by the final users in order to further refine and develop it. Therefore the purpose of this study is to obtain information on the following points:

- Is the app successful in developing the children's computational thinking skills?
- Do the children enjoy playing the app?
- Are the instructions given clear and understandable?
- Does the app run as expected, without errors?

WHY HAS MY SCHOOL BEEN INVITED TO PARTICIPATE?
The app is designed for children aged 7 to 11 years and therefore the testing of the app needs to be undertaken by children within this age range. Your school has been invited to take part as your pupils match the target audience of the game.

DOES MY SCHOOL HAVE TO TAKE PART?
There is of course no obligation to take part. However, if you do agree to take part, you will be given this information sheet to keep and will be asked to pass information to parents and obtain their consent. If you do decide to take part, you will be free to withdraw at any time up to the mutually agreed date of the study without giving a reason.

The results for individual pupils will be used solely for the purpose of this research and will have no impact on any scores or grades given by the school.

WHAT WILL HAPPEN IF MY SCHOOL TAKES PART?
I will visit the school and work with individual pupils with a member of staff present. At the beginning of the study, the selected pupils will be given a written logic puzzle to complete similar in nature to the requirements of the game. They will then be introduced to the app and invited to play the game for a short period of time. Their scores, times and the levels reached will be recorded. They will then be given another opportunity to complete the same puzzle in order to assess any progress made.

The children will also be asked to complete a short questionnaire in the form of 'smiley face' tick boxes about their enjoyment of the game.

WHAT ARE THE POSSIBLE DISADVANTAGES AND RISKS OF TAKING PART?
There is no cost to the school or individual pupils for taking part in this study other than the time taken for the children to complete the puzzles, play the game and fill out the questionnaires.

WHAT ARE THE POSSIBLE BENEFITS OF TAKING PART?
It is anticipated that the pupils will benefit from playing this app by improving their computational thinking skills and encouraging them to get involved in computing.

WILL INFORMATION IN THIS STUDY BE KEPT CONFIDENTIAL?
All data collected will be kept confidential and be used only for the purpose of this study. Individual pupils' personal information will not be recorded by name; instead each pupil will be identified by a number allocated to them by the school. The age and gender of each pupil taking part in the study will be recorded, but will be linked to the results using their unique reference number.

WHAT SHOULD I DO IF I WANT MY SCHOOL TO TAKE PART?
If you are willing for your school to take part in the study please contact my supervisor, Dr Marco Gilardi, at the email address given below, with your agreement. I will then provide copies of the parent information sheet and consent form to be passed on to the parents and carers of the children concerned.

WHO IS ORGANISING THE RESEARCH?
My name is Paul Hickman and I am a third year undergraduate at the University of Sussex and am undertaking this study as part of my final year project for a degree in Computing for Digital Media under the supervision of Dr Marco Gilardi.

WHAT WILL HAPPEN TO THE RESULTS OF THE RESEARCH STUDY?
The results of individual pupils will be amalgamated and will provide information to help further develop this app. The amalgamated results will be included in the documentation for my final year project, and the information will be reviewed only by members of the University and potentially used for an academic paper.

WHO HAS APPROVED THIS STUDY?
This study has been approved by the Sciences & Technology Cross-Schools Research Ethics Committee (crecscitec@sussex.ac.uk). The project reference number is ER/PH233/2.

CONTACT FOR FURTHER INFORMATION
Thank you for taking the time to read this information. For further information or if you have any concerns regarding this research, please contact Dr Marco Gilardi at M.Gilardi@sussex.ac.

The University of Sussex has insurance in place to cover its legal liabilities in respect of this study.

16/11/15

University of Sussex

CONSENT FORM FOR PROJECT PARTICIPANTS

PROJECT TITLE: **Max's Mission: An educational app for the development of computational thinking skills.**

Project Approval Reference:

I agree that my child _____ may take part in the above University of Sussex research project. I have read and understood the Information Sheet, which I may keep for my records. I understand that agreeing to take part means that my child may, under the supervision of a member of school staff:

- Play an app installed on an iPad supplied by the research study.
- Complete a questionnaire about their enjoyment and understanding of the game.
- Complete a short assessment in the form of a puzzle.

I understand that any information provided about or by my child is confidential, and that no information disclosed will lead to the identification of any individual in the reports on the project, either by the researcher or by any other party.

I understand that the results of my child will be anonymized by the use of a unique reference number. This will only be used to match the questionnaire and assessment results and any reference to individual names will be destroyed when the study has been completed.

I understand that my child's participation is voluntary, that they can choose not to participate in part or all of the project, and that they can withdraw at any stage of the project without being penalised or disadvantaged in any way.

I consent to the processing of my child's personal information for the purposes of this research study. I understand that such information will be treated as strictly confidential and handled in accordance with the Data Protection Act 1998.

Name: _____

Relationship to Child: _____

Signature: _____ Date: _____

Details of the Participants' Prior Experience in Programming

School Staff were asked to summarise the previous learning experiences in relation to computer programming of the participants.

Shipham CEVC First School

'Pupils are introduced to programming in Year Two using programmable toys such as Beebots and on screen turtle programs such as Tizzy's First Tools. The mixed Year Three/Four Class are taught programming for one term each academic year during a dedicated Computing lesson of one hour per week. They use Scratch to work on projects such as creating a maze game or an e-card. They also use Lego WeDo, which enables them to program a Lego model including responding to sound and motion sensors.'

Westdene Primary School

'Since Year Two, this cohort have been learning to programme, first by using programmable toys like Beebots, before moving onto Scratch on the computer. They have since done two units based on Scratch, either programming a game or 'remixing' one. Some of the cohort have probably also done Code Club - an after-school club for children to learn programming, again using Scratch, but in a smaller group setting and with project packs to follow with step-by-step instructions. In Code Club they also use Kodu - Microsoft's 3D game development software.'

University of Sussex

MAX'S PUZZLES

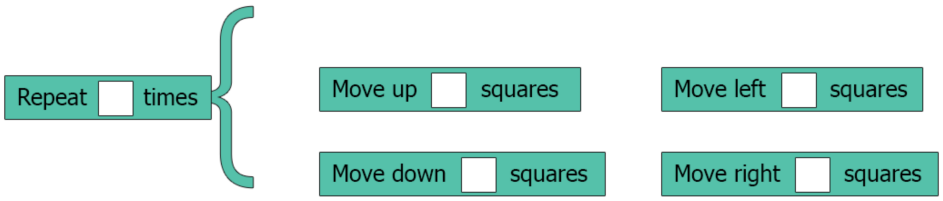
CHILD'S REFERENCE NUMBER: **DATE:**

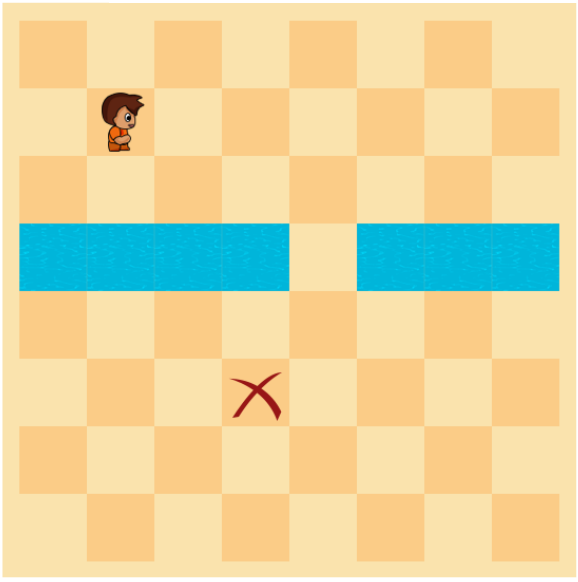
AGE: **YEAR GROUP:**

BOY / GIRL

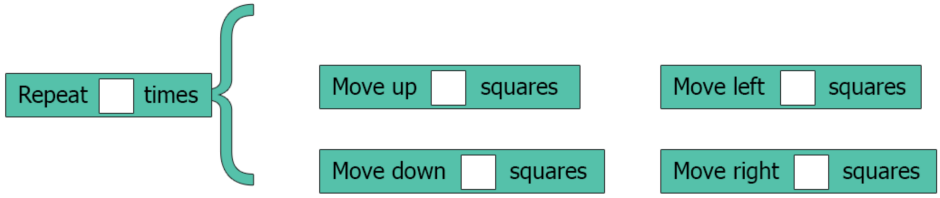
1. Using any of the instructions below, direct Max to the X and find the treasure! You can use the instructions more than once. Write your answer to the right of the diagram.

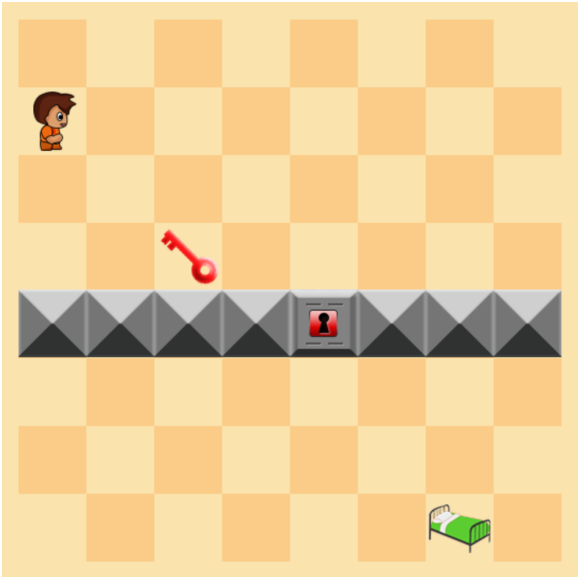
Remember, Max can't walk through water!



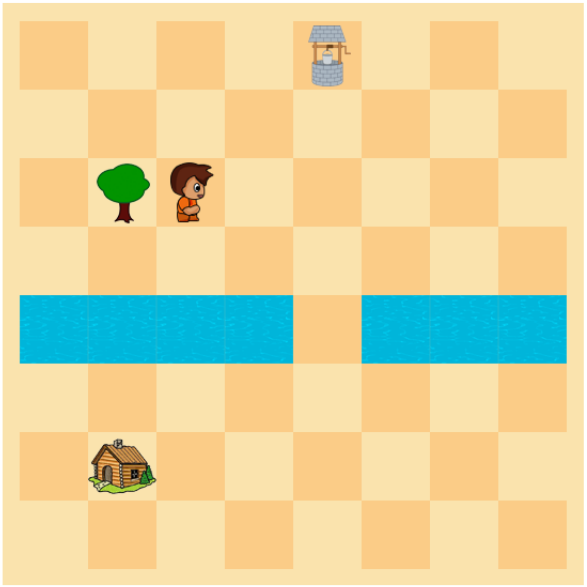


2. For this one, Max needs to get back to his bed. He will need to get the key before he can open the door though!





3. This one is a little more tricky. Give it your best shot! Max needs to get two buckets of water from the well to water his tree, but he can only carry one bucket at a time. When he has done that, he needs to go home.



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MAX'S PUZZLES 2

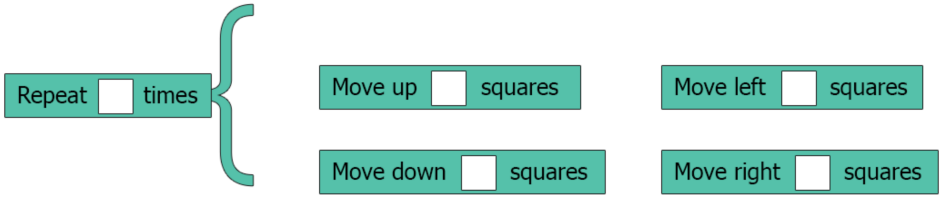
CHILD'S REFERENCE NUMBER: **DATE:**

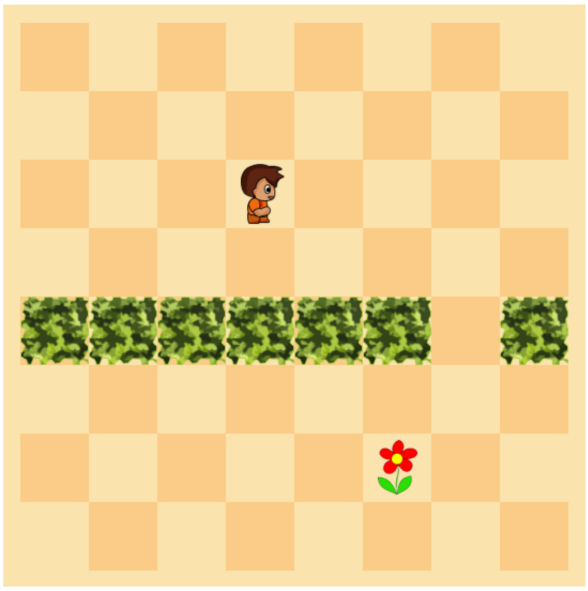
AGE: **YEAR GROUP:**

BOY / GIRL

1. Using any of the instructions below, direct Max to his flower! You can use the instructions more than once. Write your answer to the right of the diagram.

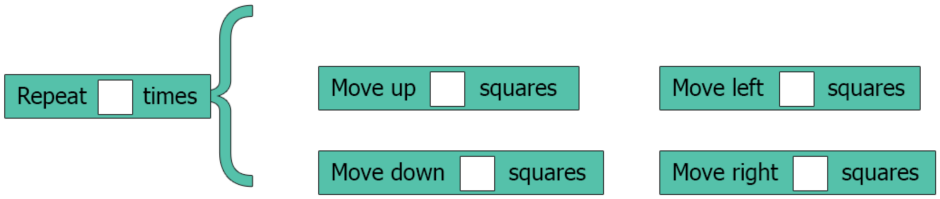
Remember, Max can't walk through hedges!

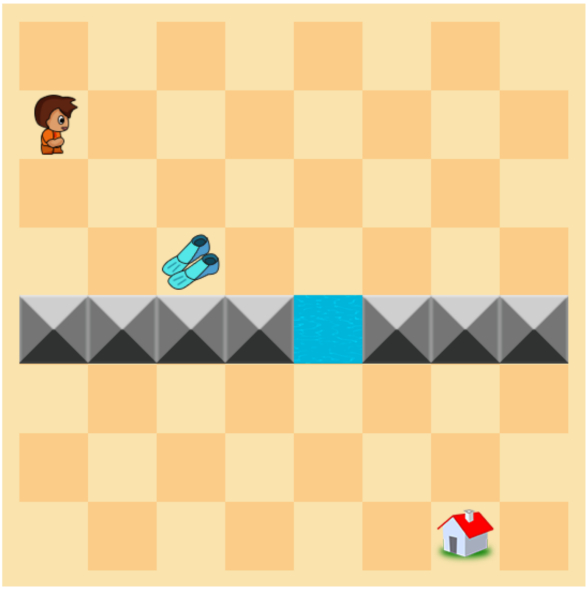




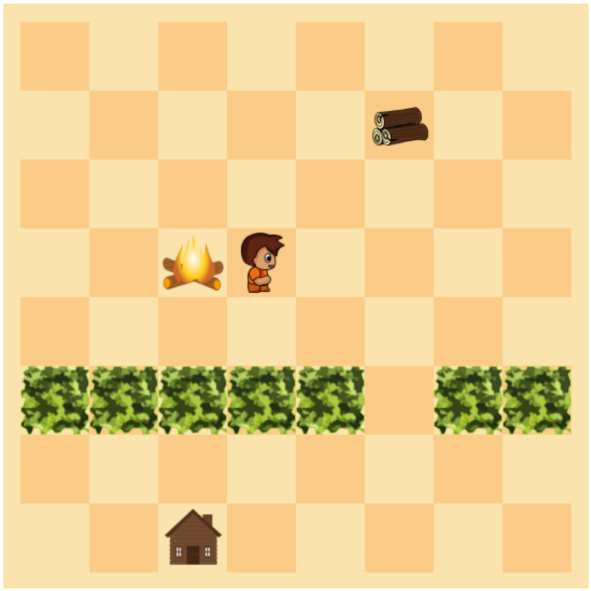
Now turn over

2. For this one, Max needs to visit his friend's house. He will need to get the flippers before he can swim through the water though!





3. This one is a little bit harder. Give it your best try! Max needs to get two logs to put on his fire, but he can only carry one log at a time. When he has done that, he needs to go back to his log cabin at the bottom.



University of Sussex

QUESTIONAIRE FOR PROJECT PARTICIPANTS

CHILD'S REFERENCE NUMBER: **DATE:**

1. I enjoyed playing the game. 
2. I would play this game at home. 
3. The instructions were easy to understand. 
4. I liked the colours and layout of the game. 
5. I found the game easy. 
6. I want to play the game again. 
7. The game was a fun way to learn. 

I would also like to say...

Appendix 9 (i): Raw Data – Demographic - Written up by Marco Gilardi [15]

ID	Gender	Age	Year Group	Group
301	Girl	7	3	Control
302	Girl	7	3	Test
303	Girl	7	3	Test
304	Girl	7	3	Control
305	Boy	8	3	Test
306	Girl	8	3	Control
307	Girl	8	3	Test
308	Girl	8	3	Control
309	Girl	7	3	Control
310	Girl	7	3	Test
311	Girl	8	3	Test
401	Boy	8	4	Control
402	Girl	8	4	Test
403	Girl	8	4	Test
404	Boy	8	4	Test
405	Girl	9	4	Control
406	Boy	8	4	Control
407	Girl	8	4	Control
408	Boy	9	4	Test
501	Girl	9	5	Test
502	Boy	10	5	Control
503	Girl	9	5	Test
504	Boy	10	5	Test
505	Girl	9	5	Test
506	Girl	9	5	Test
507	Girl	9	5	Control
508	Girl	9	5	Control
509	Girl	10	5	Test
510	Boy	10	5	Test
511	Girl	10	5	Control
512	Girl	10	5	Control
513	Boy	10	5	Test
514	Boy	10	5	Control
515	Boy	9	5	Control
516	Boy	10	5	Test
517	Boy	10	5	Test
518	Girl	10	5	Control
519	Girl	10	5	Control
520	Boy	10	5	Control

Sample size	Age	Freq	Gender	Freq	Group	Freq
39	*7*	15.38%	*Girl*	64.10%	*Control*	48.72%
	8	28.21%	*Boy*	35.90%	*Test*	51.28%
	9	23.08%		100.00%		100.00%
	10	33.33%				
		100.00%				

Group/Gender	*Test*	*Control*	
Girl	12	13	*25*
Boy	8	6	*14*
	20	*19*	*39*

Age/Gender	*7*	*8*	*9*	*10*	
Girl	6	7	7	5	*25*
Boy	0	4	2	8	*14*
	6	*11*	*9*	*13*	*39*

Year/Gender	*3*	*4*	*5*	
Girl	10	4	11	*25*
Boy	1	4	9	*14*
	11	*8*	*20*	*39*

0: Failure 1: Success

Test Group										
Reference	Puzzle 1		Puzzle 2		Puzzle 3		Year	Age	Gender	Score (Sum of successes)	
	Pre	Post	Pre	Post	Pre	Post				Pre	Post
302	0	1	0	0	0	0	3	7	Girl	0	1
303	0	1	0	0	0	0	3	7	Girl	0	1
305	0	1	0	1	0	0	3	8	Boy	0	2
307	1	1	0	0	1	0	3	8	Girl	2	1
310	1	1	0	0	0	0	3	7	Girl	1	1
311	0	1	0	1	0	0	3	8	Girl	0	2
402	0	0	0	1	0	0	4	8	Girl	0	1
403	0	1	0	0	0	0	4	8	Girl	0	1
404	1	1	1	1	0	0	4	8	Boy	2	2
408	0	1	0	1	0	0	4	9	Boy	0	2
501	0	1	0	1	0	0	5	9	Girl	0	2
503	1	1	1	1	1	1	5	9	Girl	3	3
504	1	1	0	1	0	1	5	10	Boy	1	3
505	1	1	1	1	0	0	5	9	Girl	2	2
506	1	1	1	1	0	0	5	9	Girl	2	2
509	1	1	1	1	1	1	5	10	Girl	3	3
510	0	1	1	1	1	0	5	10	Boy	2	2
513	1	1	0	1	0	0	5	10	Boy	1	2
516	1	1	1	1	0	0	5	10	Boy	2	2
517	1	1	0	0	0	0	5	10	Boy	1	1

Control Group										
							Year	Age	Gender	Score (Sum of successes)	
										Pre	Post
301	1	1	0	0	0	0	3	7	Girl	1	1
304	1	1	1	1	0	0	3	7	Girl	2	2
306	1	1	1	0	0	0	3	8	Girl	2	1
308	1	1	1	1	0	0	3	8	Girl	2	2
309	1	1	0	1	0	0	3	7	Girl	1	2
401	1	1	1	1	0	0	4	8	Boy	2	2
405	0	0	0	0	0	0	4	9	Girl	0	0
406	1	1	1	1	0	0	4	8	Boy	2	2
407	1	1	1	1	0	0	4	8	Girl	2	2
502	1	1	1	0	0	0	5	10	Boy	2	1
507	1	1	0	0	0	0	5	9	Girl	1	1
508	0	0	0	0	0	0	5	9	Girl	0	0
511	1	1	1	1	1	1	5	10	Girl	3	3
512	1	1	1	1	0	0	5	10	Girl	2	2
514	1	1	1	1	0	0	5	10	Boy	2	2
515	1	1	1	1	0	0	5	9	Boy	2	2
518	1	1	1	0	0	0	5	10	Girl	2	1
519	1	1	0	0	0	0	5	10	Girl	1	1
520	1	1	1	1	1	1	5	10	Boy	3	3

Test Group				
Reference	Puzzle 2		Puzzle 3	
	Pre	Post	Pre	Post
302	0	1	0	1
303	0	2	1	1
305	0	0	0	0
307	0	1	0	1
310	0	0	0	0
311	0	2	0	1
402	0	2	0	1
403	0	0	1	1
404	0	0	0	0
408	0	2	0	1
501	0	0	0	0
503	0	0	0	0
504	0	0	0	0
505	0	0	0	0
506	0	0	1	1
509	0	0	0	0
510	0	0	0	1
513	1	0	1	1
516	0	0	0	1
517	0	1	0	1

2	Used loop successfully
1	Attempted to use a loop
0	Didn't use a loop

Score (Sum of loop scores)	
Pre	Post
0	2
1	3
0	0
0	2
0	0
0	3
0	3
1	1
0	0
0	3
0	0
0	0
0	0
0	0
1	1
0	0
0	1
2	1
0	1
0	2

Control Group				
304	0	0	0	0
309	2	2	1	1
308	0	0	1	0
301	0	0	1	1
306	0	0	0	0
401	2	2	1	1
406	0	0	1	1
407	0	0	0	1
405	0	0	0	0
502	0	0	0	0
507	0	0	0	0
508	0	0	0	0
511	0	0	0	0
512	0	0	1	1
514	0	0	0	0
515	0	0	0	1
518	0	1	0	1
519	0	0	0	0
520	0	0	0	0

Score (Sum of loop scores)	
Pre	Post
0	0
3	3
1	0
1	1
0	0
3	3
1	1
0	1
0	0
0	0
0	0
0	0
0	0
1	1
0	0
0	1
0	2
0	0
0	0

Puzzle 1 Post Entire Sample					Sample Size	39
Pre / Year	***3***	***4***	***5***			
0	0	2	1	*3*		
1	11	6	19	*36*		
	11	*8*	*20*	*39*		

Pre / Year	***3***	***4***	***5***	
0	0.00%	5.13%	2.56%	*7.69%*
1	28.21%	15.38%	48.72%	*92.31%*
	28.21%	*20.51%*	*51.28%*	*100.00%*

Pre / Age	***7***	***8***	***9***	***10***	
0	0	1	2	0	*3*
1	6	10	7	13	*36*
	6	*11*	*9*	*13*	*39*

Pre / Age	***7***	***8***	***9***	***10***	
0	0.00%	2.56%	5.13%	0.00%	*7.69%*
1	15.38%	25.64%	17.95%	33.33%	*92.31%*
	15.38%	*28.21%*	*23.08%*	*33.33%*	*100.00%*

Pre/Gender	***Boy***	***Girl***	
0	0	3	*3*
1	14	22	*36*
	14	*25*	*39*

Pre/Gender	***Boy***	***Girl***	
0	0.00%	7.69%	*7.69%*
1	35.90%	56.41%	*92.31%*
	35.90%	*64.10%*	*100.00%*

Puzzle 1 Post Test Group					Sample Size	20
Pre / Year	***3***	***4***	***5***			
0	0	1	0	*1*		
1	6	3	10	*19*		
	6	*4*	*10*	*20*		

Pre / Year	***3***	***4***	***5***	
0	0.00%	5.00%	0.00%	*5.00%*
1	30.00%	15.00%	50.00%	*95.00%*
	30.00%	*20.00%*	*50.00%*	*100.00%*

Pre / Age	***7***	***8***	***9***	***10***	
0	0	1	0	0	*1*
1	3	5	5	6	*19*
	3	*6*	*5*	*6*	*20*

Pre / Age	***7***	***8***	***9***	***10***	
0	0.00%	5.00%	0.00%	0.00%	*5.00%*
1	15.00%	25.00%	25.00%	30.00%	*95.00%*
	15.00%	*30.00%*	*25.00%*	*30.00%*	*100.00%*

Pre/Gender	***Boy***	***Girl***	
0	0	1	*1*
1	8	11	*19*
	8	*12*	*20*

Pre/Gender	***Boy***	***Girl***	
0	0.00%	5.00%	*5.00%*
1	40.00%	55.00%	*95.00%*
	40.00%	*60.00%*	*100.00%*

Puzzle 1 Post Control Group					Sample Size	19
Pre / Year	***3***	***4***	***5***			
0	0	1	1	*2*		
1	5	3	9	*17*		
	5	*4*	*10*	*19*		

Pre / Year	***3***	***4***	***5***	
0	0.00%	5.26%	5.26%	*10.53%*
1	26.32%	15.79%	47.37%	*89.47%*
	26.32%	*21.05%*	*52.63%*	*100.00%*

Pre / Age	***7***	***8***	***9***	***10***	
0	0	0	2	0	*2*
1	3	5	2	7	*17*
	3	*5*	*4*	*7*	*19*

Pre / Age	***7***	***8***	***9***	***10***	
0	0.00%	0.00%	10.53%	0.00%	*10.53%*
1	15.79%	26.32%	10.53%	36.84%	*89.47%*
	15.79%	*26.32%*	*21.05%*	*36.84%*	*100.00%*

Pre/Gender	***Boy***	***Girl***	
0	0	2	*2*
1	6	11	*17*
	6	*13*	*19*

Pre/Gender	***Boy***	***Girl***	
0	0.00%	10.53%	*10.53%*
1	31.58%	57.89%	*89.47%*
	31.58%	*68.42%*	*100.00%*

Puzzle 2 Post Entire Sample						Sample Size	39
Pre / Year	***3***	***4***	***5***				
0	6	2	6	*14*			
1	5	6	14	*25*			
	11	*8*	*20*	*39*			
Pre / Age	***7***	***8***	***9***	***10***			
0	4	3	3	4	*14*		
1	2	8	6	9	*25*		
	6	*11*	*9*	*13*	*39*		
Pre/Gender	***Boy***	***Girl***					
0	2	12	*14*				
1	12	13	*25*				
	14	*25*	*39*				

Pre / Year	3	4	5	
0	15.38%	5.13%	15.38%	*35.90%*
1	12.82%	15.38%	35.90%	*64.10%*
	28.21%	*20.51%*	*51.28%*	*100.00%*

Pre / Age	7	8	9	10	
0	10.26%	7.69%	7.69%	10.26%	*35.90%*
1	5.13%	20.51%	15.38%	23.08%	*64.10%*
	15.38%	*28.21%*	*23.08%*	*33.33%*	*100.00%*

Pre/Gender	Boy	Girl	
0	5.13%	30.77%	*35.90%*
1	30.77%	33.33%	*64.10%*
	35.90%	*64.10%*	*100.00%*

Puzzle 2 Post Test Group						Sample Size	20
Pre / Year	***3***	***4***	***5***				
0	4	1	1	*6*			
1	2	3	9	*14*			
	6	*4*	*10*	*20*			
Pre / Age	***7***	***8***	***9***	***10***			
0	3	2	0	1	*6*		
1	0	4	5	5	*14*		
	3	*6*	*5*	*6*	*20*		
Pre/Gender	***Boy***	***Girl***					
0	1	5	*6*				
1	7	7	*14*				
	8	*12*	*20*				

Pre / Year	3	4	5	
0	20.00%	5.00%	5.00%	*30.00%*
1	10.00%	15.00%	45.00%	*70.00%*
	30.00%	*20.00%*	*50.00%*	*100.00%*

Pre / Age	7	8	9	10	
0	15.00%	10.00%	0.00%	5.00%	*30.00%*
1	0.00%	20.00%	25.00%	25.00%	*70.00%*
	15.00%	*30.00%*	*25.00%*	*30.00%*	*100.00%*

Pre/Gender	Boy	Girl	
0	5.00%	25.00%	*30.00%*
1	35.00%	35.00%	*70.00%*
	40.00%	*60.00%*	*100.00%*

Puzzle 2 Post Control Group						Sample Size	19
Pre / Year	***3***	***4***	***5***				
0	2	1	5	*8*			
1	3	3	5	*11*			
	5	*4*	*10*	*19*			
Pre / Age	***7***	***8***	***9***	***10***			
0	1	1	3	3	*8*		
1	2	4	1	4	*11*		
	3	*5*	*4*	*7*	*19*		
Pre/Gender	***Boy***	***Girl***					
0	1	7	*8*				
1	5	6	*11*				
	6	*13*	*19*				

Pre / Year	3	4	5	
0	10.53%	5.26%	26.32%	*42.11%*
1	15.79%	15.79%	26.32%	*57.89%*
	26.32%	*21.05%*	*52.63%*	*100.00%*

Pre / Age	7	8	9	10	
0	5.26%	5.26%	15.79%	15.79%	*42.11%*
1	10.53%	21.05%	5.26%	21.05%	*57.89%*
	15.79%	*26.32%*	*21.05%*	*36.84%*	*100.00%*

Pre/Gender	Boy	Girl	
0	5.26%	36.84%	*42.11%*
1	26.32%	31.58%	*57.89%*
	31.58%	*68.42%*	*100.00%*

Puzzle 3 Post Entire Sample						Sample Size	39
Pre / Year	***3***	***4***	***5***				
0	11	8	15	*34*			
1	0	0	5	*5*			
	11	*8*	*20*	*39*			
Pre / Age	***7***	***8***	***9***	***10***			
0	6	11	8	9	*34*		
1	0	0	1	4	*5*		
	6	*11*	*9*	*13*	*39*		
Pre/Gender	***Boy***	***Girl***					
0	12	22	*34*				
1	2	3	*5*				
	14	*25*	*39*				

Pre / Year	***3***	***4***	***5***				
0	28.21%	20.51%	38.46%	*87.18%*			
1	0.00%	0.00%	12.82%	*12.82%*			
	28.21%	*20.51%*	*51.28%*	*100.00%*			
Pre / Age	***7***	***8***	***9***	***10***			
0	15.38%	28.21%	20.51%	23.08%	*87.18%*		
1	0.00%	0.00%	2.56%	10.26%	*12.82%*		
	15.38%	*28.21%*	*23.08%*	*33.33%*	*100.00%*		
Pre/Gender	***Boy***	***Girl***					
0	30.77%	56.41%	*87.18%*				
1	5.13%	7.69%	*12.82%*				
	35.90%	*64.10%*	*100.00%*				

Puzzle 3 Post Test Group						Sample Size	20
Pre / Year	*3*	*4*	*5*				
0	6	4	7	17			
1	0	0	3	3			
	6	4	10	20			
Pre / Age	*7*	*8*	*9*	*10*			
0	3	6	4	4	*17*		
1	0	0	1	2	*3*		
	3	*6*	*5*	*6*	*20*		
Pre/Gender	***Boy***	***Girl***					
0	7	10	*17*				
1	1	2	*3*				
	8	*12*	*20*				

Pre / Year	***3***	***4***	***5***				
0	30.00%	20.00%	35.00%	*85.00%*			
1	0.00%	0.00%	15.00%	*15.00%*			
	30.00%	*20.00%*	*50.00%*	*100.00%*			
Pre / Age	***7***	***8***	***9***	***10***			
0	15.00%	30.00%	20.00%	20.00%	*85.00%*		
1	0.00%	0.00%	5.00%	10.00%	*15.00%*		
	15.00%	*30.00%*	*25.00%*	*30.00%*	*100.00%*		
Pre/Gender	***Boy***	***Girl***					
0	35.00%	50.00%	*85.00%*				
1	5.00%	10.00%	*15.00%*				
	40.00%	*60.00%*	*100.00%*				

Puzzle 3 Post Control Group						Sample Size	19
Pre / Year	***3***	***4***	***5***				
0	5	4	8	*17*			
1	0	0	2	*2*			
	5	*4*	*10*	*19*			
Pre / Age	***7***	***8***	***9***	***10***			
0	3	5	4	5	*17*		
1	0	0	0	2	*2*		
	3	*5*	*4*	*7*	*19*		
Pre/Gender	***Boy***	***Girl***					
0	5	12	*17*				
1	1	1	*2*				
	6	*13*	*19*				

Pre / Year	***3***	***4***	***5***				
0	26.32%	21.05%	42.11%	*89.47%*			
1	0.00%	0.00%	10.53%	*10.53%*			
	26.32%	*21.05%*	*52.63%*	*100.00%*			
Pre / Age	***7***	***8***	***9***	***10***			
0	15.79%	26.32%	21.05%	26.32%	*89.47%*		
1	0.00%	0.00%	0.00%	10.53%	*10.53%*		
	15.79%	*26.32%*	*21.05%*	*36.84%*	*100.00%*		
Pre/Gender	***Boy***	***Girl***					
0	26.32%	63.16%	*89.47%*				
1	5.26%	5.26%	*10.53%*				
	31.58%	*68.42%*	*100.00%*				

Puzzle 1 Pre Entire Sample						Sample Size	39
Pre / Year	***3***	***4***	***5***				
0	4	4	3	*11*			
1	5	6	17	*28*			
	9	*10*	*20*	*39*			
Pre / Age	***7***	***8***	***9***	***10***			
0	2	4	4	1	*11*		
1	4	7	5	12	*28*		
	6	*11*	*9*	*13*	*39*		
Pre/Gender	***Boy***	***Girl***					
0	3	8	*11*				
1	11	17	*28*				
	14	*25*	*39*				

Pre / Year	***3***	***4***	***5***				
0	10.26%	10.26%	7.69%	*28.21%*			
1	12.82%	15.38%	43.59%	*71.79%*			
	23.08%	*25.64%*	*51.28%*	*100.00%*			
Pre / Age	***7***	***8***	***9***	***10***			
0	5.13%	10.26%	10.26%	2.56%	*28.21%*		
1	10.26%	17.95%	12.82%	30.77%	*71.79%*		
	15.38%	*28.21%*	*23.08%*	*33.33%*	*100.00%*		
Pre/Gender	***Boy***	***Girl***					
0	7.69%	20.51%	*28.21%*				
1	28.21%	43.59%	*71.79%*				
	35.90%	*64.10%*	*100.00%*				

Puzzle 1 Pre Test Group						Sample Size	20
Pre / Year	***3***	***4***	***5***				
0	4	3	2	*9*			
1	2	1	8	*11*			
	6	*4*	*10*	*20*			
Pre / Age	***7***	***8***	***9***	***10***			
0	2	4	2	1	*9*		
1	1	2	3	5	*11*		
	3	*6*	*5*	*6*	*20*		
Pre/Gender	***Boy***	***Girl***					
0	3	6	*9*				
1	5	6	*11*				
	8	*12*	*20*				

Pre / Year	***3***	***4***	***5***				
0	20.00%	15.00%	10.00%	*45.00%*			
1	10.00%	5.00%	40.00%	*55.00%*			
	30.00%	*20.00%*	*50.00%*	*100.00%*			
Pre / Age	***7***	***8***	***9***	***10***			
0	10.00%	20.00%	10.00%	5.00%	*45.00%*		
1	5.00%	10.00%	15.00%	25.00%	*55.00%*		
	15.00%	*30.00%*	*25.00%*	*30.00%*	*100.00%*		
Pre/Gender	***Boy***	***Girl***					
0	15.00%	30.00%	*45.00%*				
1	25.00%	30.00%	*55.00%*				
	40.00%	*60.00%*	*100.00%*				

Puzzle 1 Pre Control Group						Sample Size	19
Pre / Year	***3***	***4***	***5***				
0	0	1	1	*2*			
1	3	5	9	*17*			
	3	*6*	*10*	*19*			
Pre / Age	***7***	***8***	***9***	***10***			
0	0	0	2	0	*2*		
1	3	5	2	7	*17*		
	3	*5*	*4*	*7*	*19*		
Pre/Gender	***Boy***	***Girl***					
0	0	2	*2*				
1	6	11	*17*				
	6	*13*	*19*				

Pre / Year	***3***	***4***	***5***				
0	0.00%	5.26%	5.26%	*10.53%*			
1	15.79%	26.32%	47.37%	*89.47%*			
	15.79%	*31.58%*	*52.63%*	*100.00%*			
Pre / Age	***7***	***8***	***9***	***10***			
0	0.00%	0.00%	10.53%	0.00%	*10.53%*		
1	15.79%	26.32%	10.53%	36.84%	*89.47%*		
	15.79%	*26.32%*	*21.05%*	*36.84%*	*100.00%*		
Pre/Gender	***Boy***	***Girl***					
0	0.00%	10.53%	*10.53%*				
1	31.58%	57.89%	*89.47%*				
	31.58%	*68.42%*	*100.00%*				

Puzzle 2 Pre Entire Sample						Sample Size	39
Pre / Year	***3***	***4***	***5***				
0	8	4	7	*19*			
1	3	4	13	*20*			
	11	*8*	*20*	*39*			
Pre / Age	***7***	***8***	***9***	***10***			
0	5	5	5	4	*19*		
1	1	6	4	9	*20*		
	6	*11*	*9*	*13*	*39*		
Pre/Gender	***Boy***	***Girl***					
0	5	14	*19*				
1	9	11	*20*				
	14	*25*	*39*				

Pre / Year	***3***	***4***	***5***		
0	20.51%	10.26%	17.95%	*48.72%*	
1	7.69%	10.26%	33.33%	*51.28%*	
	28.21%	*20.51%*	*51.28%*	*100.00%*	
Pre / Age	***7***	***8***	***9***	***10***	
0	12.82%	12.82%	12.82%	10.26%	*48.72%*
1	2.56%	15.38%	10.26%	23.08%	*51.28%*
	15.38%	*28.21%*	*23.08%*	*33.33%*	*100.00%*
Pre/Gender	***Boy***	***Girl***			
0	12.82%	35.90%	*48.72%*		
1	23.08%	28.21%	*51.28%*		
	35.90%	*64.10%*	*100.00%*		

Puzzle 2 Pre Test Group						Sample Size	20
Pre / Year	***3***	***4***	***5***				
0	6	3	4	*13*			
1	0	1	6	*7*			
	6	*4*	*10*	*20*			
Pre / Age	***7***	***8***	***9***	***10***			
0	3	5	2	3	*13*		
1	0	1	3	3	*7*		
	3	*6*	*5*	*6*	*20*		
Pre/Gender	***Boy***	***Girl***					
0	5	8	*13*				
1	3	4	*7*				
	8	*12*	*20*				

Pre / Year	***3***	***4***	***5***		
0	30.00%	15.00%	20.00%	*65.00%*	
1	0.00%	5.00%	30.00%	*35.00%*	
	30.00%	*20.00%*	*50.00%*	*100.00%*	
Pre / Age	***7***	***8***	***9***	***10***	
0	15.00%	25.00%	10.00%	15.00%	*65.00%*
1	0.00%	5.00%	15.00%	15.00%	*35.00%*
	15.00%	*30.00%*	*25.00%*	*30.00%*	*100.00%*
Pre/Gender	*Boy*	*Girl*			
0	25.00%	40.00%	*65.00%*		
1	15.00%	20.00%	*35.00%*		
	40.00%	*60.00%*	*100.00%*		

Puzzle 2 Pre Control Group						Sample Size	19
Pre / Year	***3***	***4***	***5***				
0	2	1	3	*6*			
1	3	3	7	*13*			
	5	*4*	*10*	*19*			
Pre / Age	***7***	***8***	***9***	***10***			
0	2	0	3	1	*6*		
1	1	5	1	6	*13*		
	3	*5*	*4*	*7*	*19*		
Pre/Gender	***Boy***	***Girl***					
0	0	6	*6*				
1	6	7	*13*				
	6	*13*	*19*				

Pre / Year	***3***	***4***	***5***		
0	10.53%	5.26%	15.79%	*31.58%*	
1	15.79%	15.79%	36.84%	*68.42%*	
	26.32%	*21.05%*	*52.63%*	*100.00%*	
Pre / Age	***7***	***8***	***9***	***10***	
0	10.53%	0.00%	15.79%	5.26%	*31.58%*
1	5.26%	26.32%	5.26%	31.58%	*68.42%*
	15.79%	*26.32%*	*21.05%*	*36.84%*	*100.00%*
Pre/Gender	***Boy***	***Girl***			
0	0.00%	31.58%	*31.58%*		
1	31.58%	36.84%	*68.42%*		
	31.58%	*68.42%*	*100.00%*		

Puzzle 3 Pre Entire Sample						Sample Size	39
Pre / Year	***3***	***4***	***5***				
0	10	8	15	*33*			
1	1	0	5	*6*			
	11	*8*	*20*	*39*			
Pre / Age	***7***	***8***	***9***	***10***			
0	6	10	8	9	*33*		
1	0	1	1	4	*6*		
	6	*11*	*9*	*13*	*39*		
Pre/Gender	***Boy***	***Girl***					
0	12	21	*33*				
1	2	4	*6*				
	14	*25*	*39*				

Pre / Year	***3***	***4***	***5***		
0	25.64%	20.51%	38.46%	*84.62%*	
1	2.56%	0.00%	12.82%	*15.38%*	
	28.21%	*20.51%*	*51.28%*	*100.00%*	
Pre / Age	***7***	***8***	***9***	***10***	
0	15.38%	25.64%	20.51%	23.08%	*84.62%*
1	0.00%	2.56%	2.56%	10.26%	*15.38%*
	15.38%	*28.21%*	*23.08%*	*33.33%*	*100.00%*
Pre/Gender	***Boy***	***Girl***			
0	30.77%	53.85%	*84.62%*		
1	5.13%	10.26%	*15.38%*		
	35.90%	*64.10%*	*100.00%*		

Puzzle 3 Pre Test Group						Sample Size	20
Pre / Year	*3*	*4*	*5*				
0	5	4	7	16			
1	1	0	3	4			
	6	4	10	20			
Pre / Age	*7*	*8*	*9*	*10*			
0	3	5	4	4	*16*		
1	0	1	1	2	*4*		
	3	*6*	*5*	*6*	*20*		
Pre/Gender	***Boy***	***Girl***					
0	7	9	*16*				
1	1	3	*4*				
	8	*12*	*20*				

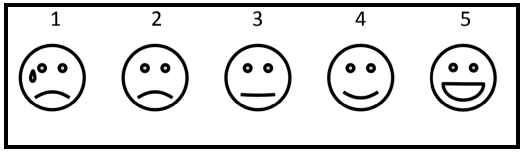
Pre / Year	***3***	***4***	***5***		
0	25.00%	20.00%	35.00%	*80.00%*	
1	5.00%	0.00%	15.00%	*20.00%*	
	30.00%	*20.00%*	*50.00%*	*100.00%*	
Pre / Age	***7***	***8***	***9***	***10***	
0	15.00%	25.00%	20.00%	20.00%	*80.00%*
1	0.00%	5.00%	5.00%	10.00%	*20.00%*
	15.00%	*30.00%*	*25.00%*	*30.00%*	*100.00%*
Pre/Gender	***Boy***	***Girl***			
0	35.00%	45.00%	*80.00%*		
1	5.00%	15.00%	*20.00%*		
	40.00%	*60.00%*	*100.00%*		

Puzzle 3 Pre Control Group						Sample Size	19
Pre / Year	***3***	***4***	***5***				
0	5	4	8	*17*			
1	0	0	2	*2*			
	5	*4*	*10*	*19*			
Pre / Age	***7***	***8***	***9***	***10***			
0	3	5	4	5	*17*		
1	0	0	0	2	*2*		
	3	*5*	*4*	*7*	*19*		
Pre/Gender	***Boy***	***Girl***					
0	5	12	*17*				
1	1	1	*2*				
	6	*13*	*19*				

Pre / Year	***3***	***4***	***5***		
0	26.32%	21.05%	42.11%	*89.47%*	
1	0.00%	0.00%	10.53%	*10.53%*	
	26.32%	*21.05%*	*52.63%*	*100.00%*	
Pre / Age	***7***	***8***	***9***	***10***	
0	15.79%	26.32%	21.05%	26.32%	*89.47%*
1	0.00%	0.00%	0.00%	10.53%	*10.53%*
	15.79%	*26.32%*	*21.05%*	*36.84%*	*100.00%*
Pre/Gender	***Boy***	***Girl***			
0	26.32%	63.16%	*89.47%*		
1	5.26%	5.26%	*10.53%*		
	31.58%	*68.42%*	*100.00%*		

ID	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Year	Age	Gender
301	5	5	5	5	3	5	5	3	7	Girl
302	5	4	4	5	5	5	4	3	7	Girl
303	5	5	3	5	2	5	4	3	7	Girl
304	5	4	3	4	5	5	5	3	7	Girl
305	5	4	5	5	5	5	5	3	8	Boy
306	5	4	4	5	3	5	4	3	8	Girl
307	5	5	5	5	4	5	5	3	8	Girl
308	5	4	3	4	4	5	5	3	8	Girl
309	5	5	5	5	4	5	5	3	7	Girl
310	5	5	4	5	3	5	5	3	7	Girl
311	5	5	5	5	5	5	5	3	8	Girl
401	5	5	5	5	4	5	5	4	8	Boy
402	5	5	4	5	4	5	5	4	8	Girl
403	5	5	4	5	4	5	5	4	8	Girl
404	5	5	4	4	4	5	5	4	8	Boy
405	5	5	3	5	3	5	5	4	9	Girl
406	5	5	4	4	4	5	5	4	8	Boy
407	5	4	3	5	4	4	5	4	8	Girl
408	5	5	5	5	3	5	5	4	9	Boy
502	5	4	4	5	4	5	5	5	10	Boy
503	4	4	4	5	4	3	5	5	9	Girl
504	5	5	4	5	3	4	5	5	10	Boy
505	3	2	4	4	5	2	3	5	9	Girl
506	5	4	5	4	4	5	5	5	9	Girl
507	4	3	2	2	3	3	5	5	9	Girl
508	3	2	5	3	5	2	2	5	9	Girl
509	4	3	5	5	4	3	4	5	10	Girl
510	5	4	5	4	3	5	5	5	10	Boy
511	4	4	5	5	3	5	4	5	10	Girl
512	3	3	4	5	4	2	4	5	10	Girl
513	5	5	5	3	5	5	4	5	10	Boy
514	4	5	5	5	3	4	5	5	10	Boy
515	4	5	5	5	4	4	5	5	9	Boy
516	5	5	4	5	4	5	5	5	10	Boy
517	4	1	4	2	5	2	2	5	10	Boy
518	5	3	5	5	4	3	4	5	10	Girl
519	5	5	5	3	5	5	5	5	10	Girl
520	5	5	4	4	4	5	5	5	10	Boy

Q1 I enjoyed playing the game.
Q2 I would play this game at home.
Q3 The instructions were easy to understand.
Q4 I liked the colours and layout of the game.
Q5 I found the game easy.
Q6 I want to play this game again.
Q7 The game was a fun way to learn.



Gender	Q1	Q2	Q3	Q4	Q5	Q6	Q7
Both	4.66	4.24	4.26	4.47	3.92	4.37	4.58
Girl	4.58	4.08	4.13	4.54	3.92	4.25	4.50
Boy	4.79	4.50	4.50	4.36	3.93	4.57	4.71

Year	Gender	Q1	Q2	Q3	Q4	Q5	Q6	Q7
3	Both	5.00	4.55	4.18	4.82	3.91	5.00	4.73
	Girl	5.00	4.60	4.10	4.80	3.80	5.00	4.70
	Boy	5.00	4.00	5.00	5.00	5.00	5.00	5.00
4	Both	5.00	4.88	4.00	4.75	3.75	4.88	5.00
	Girl	5.00	4.75	3.50	5.00	3.75	4.75	5.00
	Boy	5.00	5.00	4.50	4.50	3.75	5.00	5.00
5	Both	4.32	3.79	4.42	4.16	4.00	3.79	4.32
	Girl	4.00	3.30	4.40	4.10	4.10	3.30	4.10
	Boy	4.67	4.33	4.44	4.22	3.89	4.33	4.56

Age	Gender	Q1	Q2	Q3	Q4	Q5	Q6	Q7
7	Both	5.00	4.67	4.00	4.83	3.67	5.00	4.67
	Girl	5.00	4.67	4.00	4.83	3.67	5.00	4.67
	Boy *	N/A	N/A	N/A	N/A	N/A	N/A	N/A
8	Both	5.00	4.64	4.18	4.73	4.09	4.91	4.91
	Girl	5.00	4.57	4.00	4.86	4.00	4.86	4.86
	Boy	5.00	4.75	4.50	4.50	4.25	5.00	5.00
9	Both	4.13	3.75	4.13	4.13	3.88	3.63	4.38
	Girl	4.00	3.33	3.83	3.83	4.00	3.33	4.17
	Boy	4.50	5.00	5.00	5.00	3.50	4.50	5.00
10	Both	4.54	4.00	4.54	4.31	3.92	4.08	4.38
	Girl	4.20	3.60	4.80	4.60	4.00	3.60	4.20
	Boy	4.75	4.25	4.38	4.13	3.88	4.38	4.50

*There were no 7 year old boys in the sample

Appendix 9 (vi): Raw Data – App Results

Test / Control	ID	Level	Attempts	Time (Seconds)	Time	Date	Gender	Age	Year
Control	301	1	1	7	13:43:25	03/03/16	Girl	7	3
Control	301	2	1	10	13:43:41	03/03/16	Girl	7	3
Control	301	3	1	31	13:44:14	03/03/16	Girl	7	3
Control	301	4	2	54	13:45:15	03/03/16	Girl	7	3
Control	301	5	1	64	13:46:22	03/03/16	Girl	7	3
Control	301	6	1	58	13:47:22	03/03/16	Girl	7	3
Control	301	7	1	52	13:48:17	03/03/16	Girl	7	3
Control	301	8	1	41	13:49:02	03/03/16	Girl	7	3
Control	301	9	2	98	13:50:46	03/03/16	Girl	7	3
Test	302	1	1	7	11:21:34	03/03/16	Girl	7	3
Test	302	2	1	12	11:21:50	03/03/16	Girl	7	3
Test	302	3	1	37	11:22:30	03/03/16	Girl	7	3
Test	302	4	1	44	11:23:16	03/03/16	Girl	7	3
Test	302	5	1	30	11:23:48	03/03/16	Girl	7	3
Test	302	6	3	147	11:26:28	03/03/16	Girl	7	3
Test	302	7	1	43	11:27:15	03/03/16	Girl	7	3
Test	302	8	3	152	11:29:59	03/03/16	Girl	7	3
Test	302	9	1	34	11:30:39	03/03/16	Girl	7	3
Test	303	1	1	8	11:21:35	03/03/16	Girl	7	3
Test	303	2	1	10	11:21:49	03/03/16	Girl	7	3
Test	303	3	3	80	11:23:22	03/03/16	Girl	7	3
Test	303	4	1	90	11:24:55	03/03/16	Girl	7	3
Test	303	5	2	151	11:27:33	03/03/16	Girl	7	3
Test	303	6	1	144	11:30:00	03/03/16	Girl	7	3
Test	303	7	2	105	11:31:52	03/03/16	Girl	7	3
Control	304	1	1	12	13:57:42	03/03/16	Girl	7	3
Control	304	2	1	16	13:58:02	03/03/16	Girl	7	3
Control	304	3	1	47	13:58:51	03/03/16	Girl	7	3
Control	304	4	2	56	13:59:54	03/03/16	Girl	7	3
Control	304	5	1	39	14:00:36	03/03/16	Girl	7	3
Control	304	6	2	131	14:02:53	03/03/16	Girl	7	3
Control	304	7	3	210	14:06:35	03/03/16	Girl	7	3
Control	304	8	2	105	14:08:26	03/03/16	Girl	7	3
Control	304	9	1	53	14:09:22	03/03/16	Girl	7	3
Test	305	1	1	5	11:41:34	03/03/16	Boy	8	3
Test	305	2	1	19	11:41:58	03/03/16	Boy	8	3
Test	305	3	1	21	11:42:22	03/03/16	Boy	8	3
Test	305	4	2	27	11:42:54	03/03/16	Boy	8	3
Test	305	5	2	66	11:44:05	03/03/16	Boy	8	3
Test	305	6	2	125	11:46:14	03/03/16	Boy	8	3
Test	305	7	2	143	11:48:42	03/03/16	Boy	8	3
Test	305	8	1	62	11:49:46	03/03/16	Boy	8	3
Control	306	1	1	4	13:43:30	03/03/16	Girl	8	3
Control	306	2	1	12	13:43:45	03/03/16	Girl	8	3
Control	306	3	1	18	13:44:06	03/03/16	Girl	8	3
Control	306	4	1	24	13:44:32	03/03/16	Girl	8	3
Control	306	5	1	25	13:44:59	03/03/16	Girl	8	3
Control	306	6	1	56	13:45:58	03/03/16	Girl	8	3
Control	306	7	1	25	13:46:25	03/03/16	Girl	8	3
Control	306	8	1	36	13:47:03	03/03/16	Girl	8	3
Control	306	9	1	31	13:47:38	03/03/16	Girl	8	3
Control	306	10	3	235	13:51:40	03/03/16	Girl	8	3
Test	307	1	1	7	09:46:14	03/03/16	Girl	8	3
Test	307	2	2	17	09:46:42	03/03/16	Girl	8	3
Test	307	3	2	47	09:47:35	03/03/16	Girl	8	3
Test	307	4	1	53	09:48:33	03/03/16	Girl	8	3
Test	307	5	1	26	09:49:04	03/03/16	Girl	8	3
Test	307	6	2	109	09:51:20	03/03/16	Girl	8	3
Test	307	7	2	55	09:52:20	03/03/16	Girl	8	3
Test	307	8	1	55	09:53:19	03/03/16	Girl	8	3
Test	307	9	1	62	09:54:27	03/03/16	Girl	8	3

Appendix 9 (vi): Raw Data – App Results

Control	308	1	1	12	13:57:39	03/03/16	Girl	8	3
Control	308	2	1	13	13:57:57	03/03/16	Girl	8	3
Control	308	3	1	57	13:58:57	03/03/16	Girl	8	3
Control	308	4	2	60	14:00:06	03/03/16	Girl	8	3
Control	308	5	1	25	14:00:34	03/03/16	Girl	8	3
Control	308	6	1	76	14:01:54	03/03/16	Girl	8	3
Control	308	7	2	115	14:04:06	03/03/16	Girl	8	3
Control	308	8	2	241	14:08:16	03/03/16	Girl	8	3
Control	308	9	1	55	14:09:19	03/03/16	Girl	8	3
Control	309	1	1	5	14:22:26	03/03/16	Girl	7	3
Control	309	2	1	11	14:22:41	03/03/16	Girl	7	3
Control	309	3	1	65	14:23:49	03/03/16	Girl	7	3
Control	309	4	2	68	14:25:04	03/03/16	Girl	7	3
Control	309	5	4	99	14:26:55	03/03/16	Girl	7	3
Control	309	6	2	150	14:29:29	03/03/16	Girl	7	3
Control	309	7	2	91	14:31:07	03/03/16	Girl	7	3
Control	309	8	1	95	14:32:45	03/03/16	Girl	7	3
Control	309	9	1	33	14:33:22	03/03/16	Girl	7	3
Test	310	1	1	7	11:41:36	03/03/16	Girl	7	3
Test	310	2	1	16	11:41:55	03/03/16	Girl	7	3
Test	310	3	3	109	11:43:55	03/03/16	Girl	7	3
Test	310	4	1	40	11:44:38	03/03/16	Girl	7	3
Test	310	5	1	47	11:45:27	03/03/16	Girl	7	3
Test	310	6	2	112	11:47:25	03/03/16	Girl	7	3
Test	310	7	1	74	11:48:43	03/03/16	Girl	7	3
Test	310	8	2	103	11:50:33	03/03/16	Girl	7	3
Test	311	1	1	6	09:46:15	03/03/16	Girl	8	3
Test	311	2	1	13	09:46:32	03/03/16	Girl	8	3
Test	311	3	1	31	09:47:05	03/03/16	Girl	8	3
Test	311	4	1	109	09:48:57	03/03/16	Girl	8	3
Test	311	5	1	49	09:49:48	03/03/16	Girl	8	3
Test	311	6	1	159	09:52:29	03/03/16	Girl	8	3
Test	311	7	2	101	09:54:15	03/03/16	Girl	8	3
Test	311	8	1	37	09:54:53	03/03/16	Girl	8	3
Test	311	9	1	25	09:55:21	03/03/16	Girl	8	3
Control	401	1	1	5	14:22:14	03/03/16	Boy	8	4
Control	401	2	1	10	14:22:27	03/03/16	Boy	8	4
Control	401	3	3	69	14:23:46	03/03/16	Boy	8	4
Control	401	4	1	26	14:25:00	03/03/16	Boy	8	4
Control	401	5	2	47	14:25:57	03/03/16	Boy	8	4
Control	401	6	2	80	14:27:24	03/03/16	Boy	8	4
Control	401	7	2	75	14:28:47	03/03/16	Boy	8	4
Control	401	8	2	72	14:30:07	03/03/16	Boy	8	4
Control	401	9	2	49	14:31:05	03/03/16	Boy	8	4
Test	402	1	1	8	09:04:45	03/03/16	Girl	8	4
Test	402	2	1	10	09:04:58	03/03/16	Girl	8	4
Test	402	3	1	24	09:05:24	03/03/16	Girl	8	4
Test	402	4	2	69	09:06:41	03/03/16	Girl	8	4
Test	402	5	1	28	09:07:13	03/03/16	Girl	8	4
Test	402	6	1	83	09:08:40	03/03/16	Girl	8	4
Test	402	7	1	91	09:10:18	03/03/16	Girl	8	4
Test	402	8	1	53	09:11:14	03/03/16	Girl	8	4
Test	402	9	1	64	09:12:41	03/03/16	Girl	8	4
Test	403	1	1	12	10:07:00	03/03/16	Girl	8	4
Test	403	2	1	12	10:07:15	03/03/16	Girl	8	4
Test	403	3	1	36	10:07:55	03/03/16	Girl	8	4
Test	403	4	1	84	10:09:22	03/03/16	Girl	8	4
Test	403	5	1	37	10:10:02	03/03/16	Girl	8	4
Test	403	6	2	197	10:13:29	03/03/16	Girl	8	4
Test	403	7	1	82	10:14:55	03/03/16	Girl	8	4
Test	403	8	1	67	10:16:08	03/03/16	Girl	8	4
Test	403	9	1	31	10:16:44	03/03/16	Girl	8	4
Test	403	10	1	107	10:18:35	03/03/16	Girl	8	4

Appendix 9 (vi): Raw Data – App Results

Test	404	1	1	7	09:04:43	03/03/16	Boy	8	4
Test	404	2	1	10	09:04:57	03/03/16	Boy	8	4
Test	404	3	1	40	09:05:40	03/03/16	Boy	8	4
Test	404	4	2	54	09:06:40	03/03/16	Boy	8	4
Test	404	5	2	65	09:07:54	03/03/16	Boy	8	4
Test	404	6	1	92	09:11:30	03/03/16	Boy	8	4
Test	404	7	2	144	09:11:47	03/03/16	Boy	8	4
Test	404	8	1	134	09:14:04	03/03/16	Boy	8	4
Test	404	9	1	31	09:14:38	03/03/16	Boy	8	4
Control	405	1	1	8	14:41:46	03/03/16	Girl	9	4
Control	405	2	2	30	14:42:26	03/03/16	Girl	9	4
Control	405	3	2	52	14:43:30	03/03/16	Girl	9	4
Control	405	4	2	56	14:44:36	03/03/16	Girl	9	4
Control	405	5	2	72	14:45:55	03/03/16	Girl	9	4
Control	406	1	1	5	14:55:53	03/03/16	Boy	8	4
Control	406	2	1	12	14:56:10	03/03/16	Boy	8	4
Control	406	3	2	60	14:57:20	03/03/16	Boy	8	4
Control	406	4	3	56	14:58:34	03/03/16	Boy	8	4
Control	406	5	1	23	14:59:03	03/03/16	Boy	8	4
Control	406	6	2	122	15:01:17	03/03/16	Boy	8	4
Control	406	7	1	78	15:02:39	03/03/16	Boy	8	4
Control	406	8	1	79	15:04:03	03/03/16	Boy	8	4
Control	406	9	1	96	15:05:43	03/03/16	Boy	8	4
Control	407	1	1	12	14:41:50	03/03/16	Girl	8	4
Control	407	2	1	14	14:42:07	03/03/16	Girl	8	4
Control	407	3	1	22	14:43:13	03/03/16	Girl	8	4
Control	407	4	1	25	14:43:43	03/03/16	Girl	8	4
Control	407	5	1	27	14:44:20	03/03/16	Girl	8	4
Control	407	6	1	63	14:45:32	03/03/16	Girl	8	4
Control	407	7	1	33	14:46:11	03/03/16	Girl	8	4
Control	407	8	1	45	14:47:00	03/03/16	Girl	8	4
Control	407	9	1	28	14:47:31	03/03/16	Girl	8	4
Test	408	1	1	9	10:06:59	03/03/16	Boy	9	4
Test	408	2	2	25	10:07:35	03/03/16	Boy	9	4
Test	408	3	1	43	10:08:22	03/03/16	Boy	9	4
Test	408	4	1	49	10:09:13	03/03/16	Boy	9	4
Test	408	5	1	30	10:09:52	03/03/16	Boy	9	4
Test	408	6	1	80	10:11:15	03/03/16	Boy	9	4
Test	408	7	1	28	10:11:47	03/03/16	Boy	9	4
Test	408	8	1	43	10:12:33	03/03/16	Boy	9	4
Test	408	9	1	34	10:13:13	03/03/16	Boy	9	4
Test	408	10	1	312	10:18:29	03/03/16	Boy	9	4
Test	501	1	1	5	09:05:04	23/03/16	Girl	9	5
Test	501	2	1	14	09:05:24	23/03/16	Girl	9	5
Test	501	3	1	23	09:05:51	23/03/16	Girl	9	5
Test	501	4	2	40	09:06:37	23/03/16	Girl	9	5
Test	501	5	1	26	09:07:15	23/03/16	Girl	9	5
Test	501	6	2	90	09:08:53	23/03/16	Girl	9	5
Test	501	7	1	85	09:10:22	23/03/16	Girl	9	5
Test	501	8	1	39	09:11:04	23/03/16	Girl	9	5
Test	501	9	1	24	09:11:31	23/03/16	Girl	9	5
Test	501	10	5	206	09:15:09	23/03/16	Girl	9	5
Test	501	11	2	412	09:22:12	23/03/16	Girl	9	5
Control	502	1	1	7	13:27:45	23/03/16	Boy	10	5
Control	502	2	1	9	13:28:01	23/03/16	Boy	10	5
Control	502	3	1	22	13:28:27	23/03/16	Boy	10	5
Control	502	4	5	69	13:29:49	23/03/16	Boy	10	5
Control	502	5	1	36	13:30:28	23/03/16	Boy	10	5
Control	502	6	1	76	13:31:47	23/03/16	Boy	10	5
Control	502	7	1	35	13:32:24	23/03/16	Boy	10	5
Control	502	8	3	165	13:35:18	23/03/16	Boy	10	5
Control	502	9	1	21	13:35:42	23/03/16	Boy	10	5
Control	502	10	2	92	13:37:19	23/03/16	Boy	10	5

Appendix 9 (vi): Raw Data – App Results

Test	503	1	1	7	09:05:10	23/03/16	Girl	9	5
Test	503	2	1	9	09:05:23	23/03/16	Girl	9	5
Test	503	3	3	105	09:07:23	23/03/16	Girl	9	5
Test	503	4	2	38	09:08:08	23/03/16	Girl	9	5
Test	503	5	1	24	09:08:44	23/03/16	Girl	9	5
Test	503	6	2	84	09:10:19	23/03/16	Girl	9	5
Test	503	7	1	35	09:10:59	23/03/16	Girl	9	5
Test	503	8	1	186	09:14:09	23/03/16	Girl	9	5
Test	503	9	1	31	09:14:43	23/03/16	Girl	9	5
Test	503	10	2	54	09:15:48	23/03/16	Girl	9	5
Test	504	1	1	7	09:25:51	23/03/16	Boy	10	5
Test	504	2	1	8	09:26:04	23/03/16	Boy	10	5
Test	504	3	2	37	09:26:48	23/03/16	Boy	10	5
Test	504	4	1	15	09:27:07	23/03/16	Boy	10	5
Test	504	5	1	19	09:27:29	23/03/16	Boy	10	5
Test	504	6	3	94	09:29:14	23/03/16	Boy	10	5
Test	504	7	1	29	09:29:46	23/03/16	Boy	10	5
Test	504	8	2	68	09:31:00	23/03/16	Boy	10	5
Test	504	9	3	63	09:32:16	23/03/16	Boy	10	5
Test	504	10	1	23	09:32:42	23/03/16	Boy	10	5
Test	504	11	6	412	09:39:58	23/03/16	Boy	10	5
Test	504	12	1	43	09:40:45	23/03/16	Boy	10	5
Test	505	1	1	6	09:25:58	23/03/16	Girl	9	5
Test	505	2	2	26	09:26:38	23/03/16	Girl	9	5
Test	505	3	2	66	09:27:53	23/03/16	Girl	9	5
Test	505	4	1	41	09:28:39	23/03/16	Girl	9	5
Test	505	5	2	78	09:30:11	23/03/16	Girl	9	5
Test	505	6	1	87	09:31:43	23/03/16	Girl	9	5
Test	505	7	1	31	09:32:27	23/03/16	Girl	9	5
Test	505	8	1	39	09:33:11	23/03/16	Girl	9	5
Test	505	9	1	28	09:33:43	23/03/16	Girl	9	5
Test	505	10	2	104	09:35:37	23/03/16	Girl	9	5
Test	505	11	2	265	09:40:07	23/03/16	Girl	9	5
Test	505	12	2	80	09:41:40	23/03/16	Girl	9	5
Test	506	1	1	5	09:46:42	23/03/16	Girl	9	5
Test	506	2	1	15	09:47:01	23/03/16	Girl	9	5
Test	506	3	2	44	09:47:53	23/03/16	Girl	9	5
Test	506	4	1	25	09:48:21	23/03/16	Girl	9	5
Test	506	5	1	20	09:48:46	23/03/16	Girl	9	5
Test	506	6	1	34	09:49:25	23/03/16	Girl	9	5
Test	506	7	1	28	09:50:03	23/03/16	Girl	9	5
Test	506	8	1	36	09:50:42	23/03/16	Girl	9	5
Test	506	9	1	22	09:51:08	23/03/16	Girl	9	5
Test	506	10	4	136	09:53:45	23/03/16	Girl	9	5
Test	506	11	4	175	09:56:58	23/03/16	Girl	9	5
Test	506	12	1	31	09:57:34	23/03/16	Girl	9	5
Test	506	13	2	97	09:59:24	23/03/16	Girl	9	5
Test	506	14	1	163	10:02:13	23/03/16	Girl	9	5
Control	507	1	1	7	14:27:04	23/03/16	Girl	9	5
Control	507	2	1	10	14:27:23	23/03/16	Girl	9	5
Control	507	3	2	79	14:28:52	23/03/16	Girl	9	5
Control	507	4	1	62	14:30:01	23/03/16	Girl	9	5
Control	507	5	1	28	14:30:35	23/03/16	Girl	9	5
Control	507	6	1	180	14:33:41	23/03/16	Girl	9	5
Control	507	7	1	84	14:35:11	23/03/16	Girl	9	5
Control	507	8	1	58	14:36:13	23/03/16	Girl	9	5
Control	507	9	1	53	14:37:11	23/03/16	Girl	9	5
Control	507	10	1	62	14:38:17	23/03/16	Girl	9	5

Appendix 9 (vi): Raw Data – App Results

Control	508	1	1	4	14:27:00	23/03/16	Girl	9	5
Control	508	2	2	16	14:27:31	23/03/16	Girl	9	5
Control	508	3	1	20	14:27:57	23/03/16	Girl	9	5
Control	508	4	1	23	14:28:25	23/03/16	Girl	9	5
Control	508	5	1	21	14:28:48	23/03/16	Girl	9	5
Control	508	6	1	53	14:29:44	23/03/16	Girl	9	5
Control	508	7	3	164	14:32:43	23/03/16	Girl	9	5
Control	508	8	1	44	14:33:30	23/03/16	Girl	9	5
Control	508	9	2	71	14:34:46	23/03/16	Girl	9	5
Control	508	10	2	67	14:36:01	23/03/16	Girl	9	5
Control	508	11	1	85	14:37:28	23/03/16	Girl	9	5
Control	508	12	2	54	14:38:28	23/03/16	Girl	9	5
Test	509	1	1	7	09:46:45	23/03/16	Girl	10	5
Test	509	2	2	16	09:47:10	23/03/16	Girl	10	5
Test	509	3	1	20	09:47:33	23/03/16	Girl	10	5
Test	509	4	2	53	09:48:35	23/03/16	Girl	10	5
Test	509	5	3	86	09:50:12	23/03/16	Girl	10	5
Test	509	6	1	50	09:51:07	23/03/16	Girl	10	5
Test	509	7	1	25	09:53:17	23/03/16	Girl	10	5
Test	509	8	2	74	09:54:40	23/03/16	Girl	10	5
Test	509	9	2	63	09:55:51	23/03/16	Girl	10	5
Test	509	10	4	164	09:58:51	23/03/16	Girl	10	5
Test	509	11	2	188	10:02:12	23/03/16	Girl	10	5
Test	509	12	1	42	10:02:57	23/03/16	Girl	10	5
Test	510	1	1	6	10:08:57	23/03/16	Boy	10	5
Test	510	2	1	11	10:09:12	23/03/16	Boy	10	5
Test	510	3	2	39	10:09:58	23/03/16	Boy	10	5
Test	510	4	2	28	10:10:30	23/03/16	Boy	10	5
Test	510	5	1	22	10:10:59	23/03/16	Boy	10	5
Test	510	6	3	91	10:12:42	23/03/16	Boy	10	5
Test	510	7	1	29	10:13:15	23/03/16	Boy	10	5
Test	510	8	1	36	10:13:55	23/03/16	Boy	10	5
Test	510	9	3	53	10:15:07	23/03/16	Boy	10	5
Test	510	10	3	77	10:16:42	23/03/16	Boy	10	5
Test	510	11	3	240	10:21:00	23/03/16	Boy	10	5
Test	510	12	1	36	10:21:39	23/03/16	Boy	10	5
Test	510	13	5	238	10:25:57	23/03/16	Boy	10	5
Control	511	1	1	4	14:05:49	23/03/16	Girl	10	5
Control	511	2	1	8	14:06:03	23/03/16	Girl	10	5
Control	511	3	1	12	14:06:19	23/03/16	Girl	10	5
Control	511	4	1	18	14:07:10	23/03/16	Girl	10	5
Control	511	5	2	42	14:08:00	23/03/16	Girl	10	5
Control	511	6	4	136	14:10:34	23/03/16	Girl	10	5
Control	511	7	1	38	14:11:16	23/03/16	Girl	10	5
Control	511	8	1	49	14:12:10	23/03/16	Girl	10	5
Control	511	9	1	41	14:12:54	23/03/16	Girl	10	5
Control	511	10	3	53	14:14:01	23/03/16	Girl	10	5
Control	511	11	7	230	14:18:19	23/03/16	Girl	10	5
Control	511	12	5	113	14:20:33	23/03/16	Girl	10	5
Control	512	1	1	5	14:05:54	23/03/16	Girl	10	5
Control	512	2	1	6	14:06:05	23/03/16	Girl	10	5
Control	512	3	1	19	14:06:28	23/03/16	Girl	10	5
Control	512	4	1	20	14:06:51	23/03/16	Girl	10	5
Control	512	5	1	17	14:07:13	23/03/16	Girl	10	5
Control	512	6	1	54	14:08:11	23/03/16	Girl	10	5
Control	512	7	2	74	14:10:20	23/03/16	Girl	10	5
Control	512	8	1	49	14:11:14	23/03/16	Girl	10	5
Control	512	9	1	43	14:12:01	23/03/16	Girl	10	5
Control	512	10	1	61	14:13:06	23/03/16	Girl	10	5
Control	512	11	4	304	14:18:26	23/03/16	Girl	10	5
Control	512	12	1	39	14:19:09	23/03/16	Girl	10	5
Control	512	13	1	96	14:20:51	23/03/16	Girl	10	5
Control	512	14	1	46	14:21:41	23/03/16	Girl	10	5

Appendix 9 (vi): Raw Data – App Results

Test	513	1	1	5	10:08:47	23/03/16	Boy	10	5
Test	513	2	1	8	10:08:57	23/03/16	Boy	10	5
Test	513	3	1	57	10:09:56	23/03/16	Boy	10	5
Test	513	4	1	18	10:10:17	23/03/16	Boy	10	5
Test	513	5	1	15	10:10:35	23/03/16	Boy	10	5
Test	513	6	4	140	10:13:08	23/03/16	Boy	10	5
Test	513	7	1	25	10:13:36	23/03/16	Boy	10	5
Test	513	8	2	55	10:14:36	23/03/16	Boy	10	5
Test	513	9	2	26	10:15:06	23/03/16	Boy	10	5
Test	513	10	1	28	10:15:37	23/03/16	Boy	10	5
Test	513	11	5	223	10:19:35	23/03/16	Boy	10	5
Test	513	12	4	56	10:20:42	23/03/16	Boy	10	5
Test	513	13	3	53	10:21:42	23/03/16	Boy	10	5
Test	513	14	1	19	10:22:04	23/03/16	Boy	10	5
Control	514	1	1	7	14:46:22	23/03/16	Boy	10	5
Control	514	2	1	9	14:46:35	23/03/16	Boy	10	5
Control	514	3	2	26	14:47:09	23/03/16	Boy	10	5
Control	514	4	2	65	14:48:21	23/03/16	Boy	10	5
Control	514	5	1	60	14:49:26	23/03/16	Boy	10	5
Control	514	6	1	43	14:50:12	23/03/16	Boy	10	5
Control	514	7	1	33	14:50:50	23/03/16	Boy	10	5
Control	514	8	2	51	14:51:48	23/03/16	Boy	10	5
Control	514	9	1	25	14:52:21	23/03/16	Boy	10	5
Control	514	10	3	201	14:55:50	23/03/16	Boy	10	5
Control	514	11	4	223	14:59:43	23/03/16	Boy	10	5
Control	514	12	1	25	15:00:15	23/03/16	Boy	10	5
Control	515	1	1	7	13:27:45	23/03/16	Boy	9	5
Control	515	2	1	7	13:28:01	23/03/16	Boy	9	5
Control	515	3	1	25	13:28:30	23/03/16	Boy	9	5
Control	515	4	1	44	13:29:16	23/03/16	Boy	9	5
Control	515	5	1	20	13:29:42	23/03/16	Boy	9	5
Control	515	6	3	73	13:31:08	23/03/16	Boy	9	5
Control	515	7	2	77	13:32:39	23/03/16	Boy	9	5
Control	515	8	2	93	13:34:20	23/03/16	Boy	9	5
Control	515	9	1	96	13:36:00	23/03/16	Boy	9	5
Control	515	10	1	44	13:36:54	23/03/16	Boy	9	5
Control	515	11	1	159	13:39:39	23/03/16	Boy	9	5
Control	515	12	1	62	13:40:49	23/03/16	Boy	9	5
Test	516	1	1	5	10:48:45	23/03/16	Boy	10	5
Test	516	2	2	14	10:49:07	23/03/16	Boy	10	5
Test	516	3	1	15	10:49:26	23/03/16	Boy	10	5
Test	516	4	2	39	10:50:12	23/03/16	Boy	10	5
Test	516	5	1	31	10:50:49	23/03/16	Boy	10	5
Test	516	6	4	125	10:53:06	23/03/16	Boy	10	5
Test	516	7	1	41	10:53:49	23/03/16	Boy	10	5
Test	516	8	1	51	10:54:43	23/03/16	Boy	10	5
Test	516	9	1	25	10:55:10	23/03/16	Boy	10	5
Test	516	10	1	33	10:55:47	23/03/16	Boy	10	5
Test	516	11	6	282	11:00:50	23/03/16	Boy	10	5
Test	516	12	2	70	11:04:16	23/03/16	Boy	10	5
Test	516	13	5	199	11:07:56	23/03/16	Boy	10	5
Test	516	14	1	70	11:09:14	23/03/16	Boy	10	5
Test	517	1	1	4	10:48:43	23/03/16	Boy	10	5
Test	517	2	2	18	10:49:07	23/03/16	Boy	10	5
Test	517	3	2	35	10:49:50	23/03/16	Boy	10	5
Test	517	4	1	52	10:50:46	23/03/16	Boy	10	5
Test	517	5	2	45	10:51:40	23/03/16	Boy	10	5
Test	517	6	1	48	10:52:31	23/03/16	Boy	10	5
Test	517	7	1	39	10:53:12	23/03/16	Boy	10	5
Test	517	8	1	108	10:55:02	23/03/16	Boy	10	5
Test	517	9	2	54	10:56:04	23/03/16	Boy	10	5
Test	517	10	2	34	10:57:43	23/03/16	Boy	10	5
Test	517	11	3	46	11:01:35	23/03/16	Boy	10	5
Test	517	12	2	124	11:03:45	23/03/16	Boy	10	5
Test	517	13	1	67	11:04:55	23/03/16	Boy	10	5
Test	517	14	4	217	11:08:50	23/03/16	Boy	10	5

Appendix 9 (vi): Raw Data – App Results

Control	518	1	1	5	14:46:24	23/03/16	Girl	10	5
Control	518	2	1	6	14:46:36	23/03/16	Girl	10	5
Control	518	3	4	75	14:48:03	23/03/16	Girl	10	5
Control	518	4	1	26	14:48:32	23/03/16	Girl	10	5
Control	518	5	1	19	14:48:53	23/03/16	Girl	10	5
Control	518	6	3	78	14:50:20	23/03/16	Girl	10	5
Control	518	7	2	54	14:51:18	23/03/16	Girl	10	5
Control	518	8	1	47	14:52:08	23/03/16	Girl	10	5
Control	518	9	1	34	14:52:48	23/03/16	Girl	10	5
Control	518	10	1	99	14:54:31	23/03/16	Girl	10	5
Control	518	11	3	260	14:58:59	23/03/16	Girl	10	5
Control	518	12	1	22	14:59:23	23/03/16	Girl	10	5
Control	518	13	1	36	15:00:04	23/03/16	Girl	10	5
Control	519	1	1	5	13:45:14	23/03/16	Girl	10	5
Control	519	2	1	29	13:45:47	23/03/16	Girl	10	5
Control	519	3	3	81	13:47:25	23/03/16	Girl	10	5
Control	519	4	1	62	13:48:30	23/03/16	Girl	10	5
Control	519	5	1	51	13:49:24	23/03/16	Girl	10	5
Control	519	6	2	84	13:50:54	23/03/16	Girl	10	5
Control	519	7	1	107	13:52:43	23/03/16	Girl	10	5
Control	519	8	1	74	13:54:00	23/03/16	Girl	10	5
Control	519	9	1	176	13:56:59	23/03/16	Girl	10	5
Control	519	10	3	158	13:59:54	23/03/16	Girl	10	5
Control	520	1	1	5	13:45:20	23/03/16	Boy	10	5
Control	520	2	1	8	13:45:32	23/03/16	Boy	10	5
Control	520	3	1	19	13:45:54	23/03/16	Boy	10	5
Control	520	4	1	29	13:46:26	23/03/16	Boy	10	5
Control	520	5	1	26	13:46:55	23/03/16	Boy	10	5
Control	520	6	1	56	13:47:56	23/03/16	Boy	10	5
Control	520	7	1	28	13:48:27	23/03/16	Boy	10	5
Control	520	8	2	85	13:50:01	23/03/16	Boy	10	5
Control	520	9	2	71	13:51:21	23/03/16	Boy	10	5
Control	520	10	2	116	13:53:22	23/03/16	Boy	10	5
Control	520	11	2	179	13:56:28	23/03/16	Boy	10	5
Control	520	12	1	24	13:56:56	23/03/16	Boy	10	5
Control	520	13	2	170	13:59:54	23/03/16	Boy	10	5
Control	520	14	1	37	14:00:36	23/03/16	Boy	10	5

Level	Played	Avg Attempts	Avg Time Sec	Girl	Boy
1	39	1	7	25	14
2	39	1	13	25	14
3	39	2	44	25	14
4	39	2	46	25	14
5	39	1	42	25	14
6	38	2	96	24	14
7	38	1	69	24	14
8	37	1	76	23	14
9	35	1	50	22	13
10	23	2	107	13	10
11	16	3	230	8	8
12	15	2	55	7	8
13	8	3	120	3	5
14	6	2	92	2	4

Level	Played	Girl	Boy
1	100.00%	100.00%	100.00%
2	100.00%	100.00%	100.00%
3	100.00%	100.00%	100.00%
4	100.00%	100.00%	100.00%
5	100.00%	100.00%	100.00%
6	97.44%	96.00%	100.00%
7	97.44%	96.00%	100.00%
8	94.87%	92.00%	100.00%
9	89.74%	88.00%	92.86%
10	58.97%	52.00%	71.43%
11	41.03%	32.00%	57.14%
12	38.46%	28.00%	57.14%
13	20.51%	12.00%	35.71%
14	15.38%	8.00%	28.57%

Level/Year	*3*	*4*	*5*	
1	11	8	20	39
2	11	8	20	39
3	11	8	20	39
4	11	8	20	39
5	11	8	20	39
6	11	7	20	38
7	11	7	20	38
8	10	7	20	37
9	8	7	20	35
10	1	2	20	23
11	0	0	16	16
12	0	0	15	15
13	0	0	8	8
14	0	0	6	6

Level/Year	*3*	*4*	*5*	
1	100.00%	100.00%	100.00%	100.00%
2	100.00%	100.00%	100.00%	100.00%
3	100.00%	100.00%	100.00%	100.00%
4	100.00%	100.00%	100.00%	100.00%
5	100.00%	100.00%	100.00%	100.00%
6	100.00%	87.50%	100.00%	97.44%
7	100.00%	87.50%	100.00%	97.44%
8	90.91%	87.50%	100.00%	94.87%
9	72.73%	87.50%	100.00%	89.74%
10	9.09%	25.00%	100.00%	58.97%
11	0.00%	0.00%	80.00%	41.03%
12	0.00%	0.00%	75.00%	38.46%
13	0.00%	0.00%	40.00%	20.51%
14	0.00%	0.00%	30.00%	15.38%

Level/Age	7	8	9	10	
1	6	11	9	13	39
2	6	11	9	13	39
3	6	11	9	13	39
4	6	11	9	13	39
5	6	11	9	13	39
6	6	11	8	13	38
7	6	11	8	13	38
8	5	11	8	13	37
9	4	10	8	13	35
10	0	2	8	13	23
11	0	0	5	11	16
12	0	0	4	11	15
13	0	0	1	7	8
14	0	0	1	5	6

Level/Age	7	8	9	10	
1	100.00%	100.00%	100.00%	100.00%	100.00%
2	100.00%	100.00%	100.00%	100.00%	100.00%
3	100.00%	100.00%	100.00%	100.00%	100.00%
4	100.00%	100.00%	100.00%	100.00%	100.00%
5	100.00%	100.00%	100.00%	100.00%	100.00%
6	100.00%	100.00%	88.89%	100.00%	97.44%
7	100.00%	100.00%	88.89%	100.00%	97.44%
8	83.33%	100.00%	88.89%	100.00%	94.87%
9	66.67%	90.91%	88.89%	100.00%	89.74%
10	0.00%	18.18%	88.89%	100.00%	58.97%
11	0.00%	0.00%	55.56%	84.62%	41.03%
12	0.00%	0.00%	44.44%	84.62%	38.46%
13	0.00%	0.00%	11.11%	53.85%	20.51%
14	0.00%	0.00%	11.11%	38.46%	15.38%

Level/Group	Control	Test	
1	19	20	39
2	19	20	39
3	19	20	39
4	19	20	39
5	19	20	39
6	18	20	38
7	18	20	38
8	18	19	37
9	18	17	35
10	11	12	23
11	7	9	16
12	7	8	15
13	3	5	8
14	2	4	6

Level/Group	Control	Test	
1	100.00%	100.00%	100.00%
2	100.00%	100.00%	100.00%
3	100.00%	100.00%	100.00%
4	100.00%	100.00%	100.00%
5	100.00%	100.00%	100.00%
6	94.74%	100.00%	97.44%
7	94.74%	100.00%	97.44%
8	94.74%	95.00%	94.87%
9	94.74%	85.00%	89.74%
10	57.89%	60.00%	58.97%
11	36.84%	45.00%	41.03%
12	36.84%	40.00%	38.46%
13	15.79%	25.00%	20.51%
14	10.53%	20.00%	15.38%