Tricky Multi-Player Multi-Planar Puzzle

WATH-P

We Are Team Hot-Potatoes

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Physical Computing & Interaction Design Studio Proposal

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Contents

1 Introduction

Teamwork and communication are considered to be some of the most sought after skills that employers are looking for in prospective employees [6]. However the ability to communicate and work in a team effectively have been found lacking among graduates [4]. A number of educational websites [5],[3] have dedicated posts about the importance of teaching these necessary life skills to children in early schooling. If children participate in team-building exercises early on, skills such as communication, and self-confidence can develop and aid in the child's personal growth [3]. A common theme these sites share is that enforcing teamwork through engaging and interactive activities is the "way to go".

Interactive spaces in conjunction with supporting interactive technologies have been attributed as a tool to 'orchestrate' teamwork [1](Anslow et al., 2016). A prime example of this idea is the physical installation *The Pool* [2]. This installation invites collaborative interaction through circular pads which change light and colour as users walk on them, enabling users to "paint and splash light collaboratively [2]" to create interesting colour patterns. Video games such as *Leedmees* and *Fru* which rely on Kinect features encourage participants to use their bodies as the main form of reaching the goal in these cooperative games.

An interactive space is the perfect medium to deliver a practical hands on teamwork experience to younger students. Having an area where participants are able to interact with each other in different ways is an ideal environment to teach teamwork and collaboration skills. The physical "hands on" interactions also helps keep the attention of students.

2 Intended Experience

This project aims to deliver an engaging team-building experience through providing meaningful challenges to be solved within an interactive space. Participants will work through a series of cooperative puzzles towards a shared goal. The puzzles are designed to force members of a team to work together and communicate to complete stages. In order to keep users engaged and active, one of the main interactions is with physical objects. For example, the participants need to navigate their objects through the puzzle without hitting any virtual walls. The object's position is reflected digitally on two screens, the floor and the wall. Moreover users can also interact with pressure pads which are arranged on the floor to trigger different events within the puzzle.

Cooperative elements that can be added over the top of the core user experience to improve the projects team-building experience. For example, there could be an element where all members must stay standing on pressure pads and to get their object to the goal, they must throw it or pass it to each other.

The overall interactive space is bounded by two two dimensional (2D) screens. Figure 1 illustrates how the overall space will be laid out. The *x-z plane* only reflects changes made by the object moving up and down. The *x-y plane* only reflects changes on the floor as the object is moved towards and away from the wall. The two screens share the same x-axis (the width of the floor and wall space).

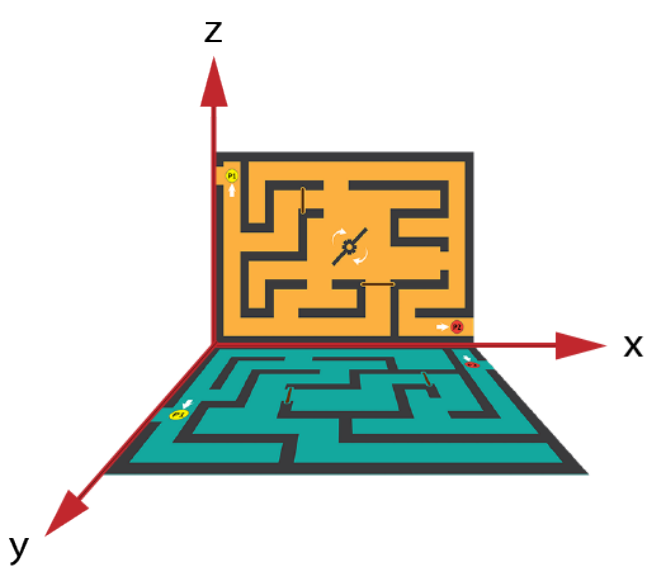

Figure 1: Representation of the two screens

2.1 Use Case Scenario: Two Participants, General Puzzle

The puzzle shown in Figure 1 is designed for two users. The starting player positions are shown with the coloured dots on the left and right sides of the interactive areas. This scenario requires that both users navigate their cube to the other side of the maze. The main challenge is that they should not let the cube-that they are holding-“touch” other objects within the puzzle and most importantly the maze walls. The fact the maze walls are not visible with the space the users are moving in, makes this puzzle a real challenge.

Each participant will have to work together in order to successfully finish the level. In this situation, they are required to stand on pressure pads in order to open up doors blocking the other user. Once the users reach the spinner in the middle of the maze, they must coordinate themselves in such a manner that results in their objects and themselves successfully avoiding the spinner and each other.

Throughout this puzzle, the participants will need to communicate and coordinate with each other. The structure of each level relies on the fact that it cannot be completed without everyone playing their part. In doing so the intended experience will result in participants leaving with better teamwork skills and newfound friendships.

3 Target Audience

There are two kinds of users that will be considered for this project. The primary users are students who will be directly participating in the puzzle activity, and the secondary users are presenters who will be running the activity but not directly participating. The primary users should come away from the experience with improved teamwork and communication skills.

The project is intended to be presented in educational environments such as school workshops or libraries.

3.1 Primary Users

The students can range from early years of primary school up to secondary and even tertiary years. A minimum year level appropriate for the difficulty of the experience would be around year 5. The intended experience can be catered to suit a broad range of ages and year levels depending on aptitude (i.e. cognitive skills). Students may not be familiar with some fundamental concepts of teamwork, and may need direction. They may find some challenges too difficult and become impatient. The puzzles are designed to be scalable, in order to suit these considered scenarios.

It is likely that the students participating in the workshop could have a short attention span and may not be enthusiastic to learn about teamwork. This is where the physical interaction elements will help improve the experience. Younger children may be shy and would have a difficult time communicating with their team. The puzzle designs may have to take this in to consideration for the easier challenges.

3.2 Secondary Users

Presenters run the activity by creating teams, setting challenges and leading discussions to reflect on the experience the users had completing the puzzle. In order to make the most of the primary user's experience, presenters will need to also be fluent with advanced concepts of teamwork and experience in working with children. For example, a curriculum which includes suggested starting points for challenges or reflective discussion points for the users post-activity.

4 Project Plan

4.1 Milestones and Deliverables

Figure 2 is the overall project plan of core milestone components the team has identified. Given this report is a proposal, the tasks and dates are liable to change.

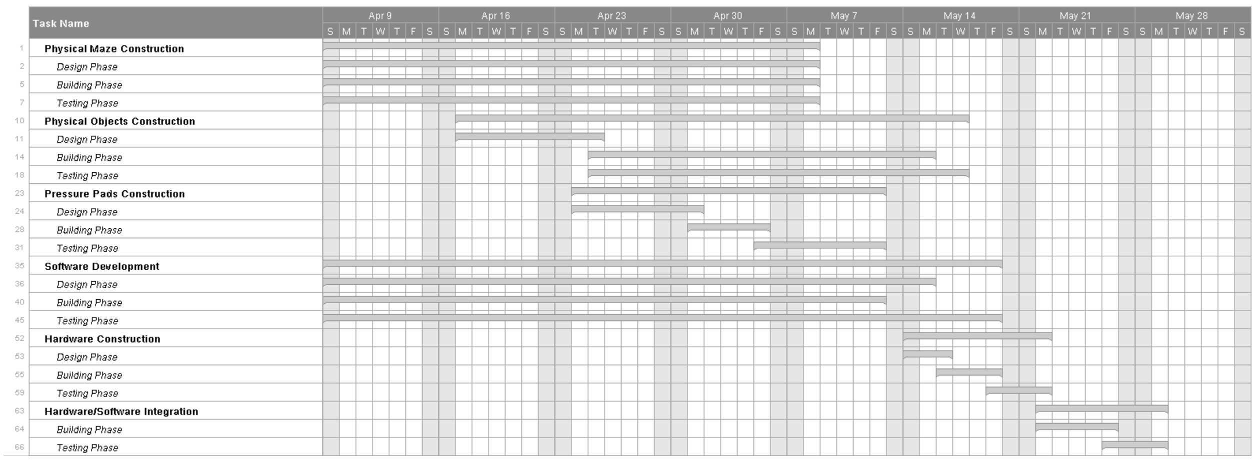

Figure 2: Core Component Breakdown

The overall project has been split up into general milestones that can be broken down, developed and tested individually. Each of these broken down components fit into a *design*, *development* or *testing* phase. In order to stay on track and help dictate task relegation, appropriately suited members are assigned to tasks and receive a time frame in which to complete their given deliverable. The full Gantt chart, outlined in Figure 3 in Appendix, details the broken down components and assigned team members.

4.1.1 Physical Maze Prototypes

Physical maze prototypes will be used as a means to benchmark the design of each puzzle. In order to ensure challenge feasibility, target audience will be taken into consideration as part of the design process. The maze designs need to encourage cooperation and teamwork and avoid a reliance on individual skill.

Sketches of the wall and floor planes should be completed simultaneously to ensure that they can be completed together. Extra puzzle elements need to be introduced in an intuitive way so that users can learn how to handle these elements without too much direction.

For the building and testing phases, a miniature model of the maze will be constructed as a means to help test puzzle feasibility. This will allow for any necessary corrections if the puzzle is too difficult. This physical prototype will also help act as a reference for the software programmers when they recreate it digitally.

The physical maze prototypes will be continuously developed in parallel to the rest of the project. Since multiple puzzles are required there need to be as many tested designs as possible. This process will occur until there are enough levels to provide enough variation and a sense of growth in the overall experience.

4.1.2 Physical Objects

There are many design concerns surrounding the construction of the physical objects. The shape, size, weight and material will all affect the comfort levels of the object and should be carefully selected. This is to minimise any unbalanced experiences i.e. the cube is too heavy. Durability, safety and the ability to accurately track the object also need to be considered to ensure a pleasant and consistent experience. The potential to include light and vibration to the objects should also be explored and incorporated in the design so it is possible to implement later on in the project if there is time. Sketches of each potential object will be drawn and reviewed before building. This is to ensure minimum time is wasted on the construction of the objects.

During the building phase, the tracking pucks will need to be integrated with the selected materials. The design may need to change in order to form the desired shape and feel. After the core components of the project are completed, lighting and vibration functions of the physical objects may be added.

Each physical object will need to be user tested. This is to ensure that users find the shape comfortable and pleasant to hold. It also will help the team to redesign the object if it is easily damaged.

4.1.3 Pressure Pads

The pressure pads are crucial elements to provide forced cooperative elements within the project's puzzle design. Their design needs to take into consideration their placement and quantity. A floor mat layout plan with the pressure pads will be constructed to optimise their use. For example, pressure pads must be implemented in such a way which makes seem random and not repetitive. Seeing as the pressure pads will be part of the floor arrangement, the floor mat will need to be tested. The floor pads must be easy to trigger and comfortable to step on. Safety also needs to be considered since there will be electrical components within contact with flammable fabrics.

4.1.4 Software

The software takes input from any hardware components of the project and displays them digitally on the two planes. The Unity game engine will be used as the means control the interactive space behavior and render all puzzle layouts on the screen. Most of the project time will be spent coding the asset behavior and building the levels from the physical maze prototypes. Testing tracking integration will also play a major role in ensuring the physical objects are tracked accurately.

Identified components for the software development milestone are as follows:

- Create example maze in engine
  - Create a simple development level environment for testing
  - Setup 2 cameras for each view
  - Setup collision and some behaviors (i.e. test wall collision)
- Test level as participants would experience
  - Test using any control means (i.e. use keyboard to test physical object tracking)
- Get physical object tracking working with unity
  - Test tracking (see change in x, y, z coords)
  - Map tracking of physical object to virtual object
- Transpose a physical maze designs to 3D 'levels'
- Debug and modify code according to test results

4.1.5 Hardware

The hardware milestone encompasses the construction of all physical elements that are not part of the interactive space. This includes mounts for projectors, mounts for the HTC lighthouses and screens (wall and floor mat) to project onto. The hardware components will need to be designed according to area and safety restrictions. The floor plan must fit within the designated area that will be available during the demonstration.

4.1.6 Integration

The integration milestone is when all the elements are finally combined together. While each component can be built and tested individually, it is crucial to ensure that everything works together as intended. Integration tests are completed at different stages throughout the project whenever two components that work together are completed. These tests will provide an accurate indicator on progress.

Final user testing can begin when all the components of the project have been integrated together. The final user tests will serve as an accurate indicator of the intended experience users will get out of the project. Any data that is gathered from these 'user tests' will serve as last minute modifications of the installation.

4.2 Resource Breakdown

The following Table(A) outlines identified resources the major components of the project require. As with the identified milestones and deliverables, the identified resources are liable to change.

Table A: Resource Breakdown

Component	*Resources*
Maze Design	A3 Paper
	A3 Board
	Adobe Photoshop and Illustrator
	Blue-tac
Physical Objects	At least 2 x htc tracking pucks
	At least 2 x htc lighthouses
	Materials for the cube(s) (i.e. foam/3d printed cover)
	Access to workshop (78-207)
Floormat	At least 5 x pressure sensors
	Makey Makey hardware controller
	Non-slip material for backing
	Floormat edging (i.e. for zip concealment/neatness)
	Material for interior padding
	Durable material suitable to be projected upon and walked upon
	Sewing Machine
	Thread & Heavy duty needles
Software	PC/laptop capable of running the software on 2 x displays at 60fps
	Unity Game Engine
	Access to VR room to use tracking tools
Physical Setup	2 x projectors
	Wood frames for the wall screen
	Material for the wall screen
	Mounts for projectors
	Mounts / tripods for lighthouses
	Access to workshop (78-207)

5 Constraints

The team has identified two major constraint types, user and technical. These constraint types are further broken down in order to understand how to work around these identified conflicts and deliver the proposed experience.

5.1 User Constraints

A major problem area identified within user constraints is participant behaviour. As the primary target audience are school students, the difference in ages and cognitive abilities impact on puzzle design. For example, high school students-being older and more knowledgeable-would require a more challenging puzzle than younger primary school students. If the level of difficulty is too high for younger participants, their promised experience would be be invalidated. To combat this, a range of puzzle difficulties will be implemented as a means to decrease ‘too much’ challenge.

Students who exhibit behavioural traits such as bossiness towards their team during activity participation will most likely contribute to the reduced enjoyment of their team-mates. As a result the puzzle levels will be designed to be 100% reliant on cooperation, no one team member is more important than the other. Another issue which may arise are the heights of the participants; all users need to be able to reach the top and bottom of the interactive space.

5.2 Technical Constraints

Issues identified with technical constraints revolve around environment conditions and a potential lack of physical space. For example, the overall participant experience may be affected if they cannot see the projections on the wall and floor due to environment brightness or projector dimness. As this issue is not something the team can control, advising the best place to set up the product (minimal light) is the best we can do. The location of the projectors also need to be setup so that user-shadows cast over the floor and wall are minimised. Rigorous testing and research will be conducted to minimise this issue.

Given that our proposed experience ties in to teamwork, the size of the installation and participant count presents another issue. If the floor space is too small or there are too many participants, navigation of the puzzle areas may be too difficult (i.e. hitting maze walls more easily). A proposed solution is to limit the participants to a maximum team of four, and design the space so that navigation with four people is possible. Testing will occur to determine best puzzle layout.

Another issue which needs to be considered is resource availability. The project is designed to be functional with the integration of hardware elements such as projectors, pressure sensors and tracking pucks. The time it takes to order these in (pucks) as well as their availability (projector) may cause the proposed project to change its execution. Many components of the project will be able to be created in house if necessary. If the htc tracking pucks are not able to be ordered, the standard tracking controllers can be used instead.

6 Individual Contributions

As a team we have set some expectations to ensure that everyone contributes equally, understands their required tasks and meets their project deadlines. The following list of guidelines will be put in place to ensure all members work successfully as a team.

- When members cannot complete a task in the required time, they will notify the rest of the group immediately to reallocate the task or to ask for assistance.
- All members will be expected to regularly check the main communication channel (Slack).
- All members will be expected to participate in weekly meetings.
- If any member is unable to attend, they must inform the rest of the team.
- Individual progress will be reported to the team consistently.

The team consists of three programmers and one designer. Woody will be in charge of firmware and contribute to software programming for the maze environment and 3D asset behaviour. Daya will be primarily in charge of modelling any necessary 3D assets and also contribute to software programming of the environment and asset behaviour. In addition, Daya will be in charge of designing the floormat. Woody and Raul will assist with firmware/hardware integration. Raul will also help Woody and Daya with any necessary programming and firmware tasks. Leo, being the designer, will be focusing on designing the physical mazes, as well as lead the hardware construction. Everyone will be involved with testing, and aid in the construction of any physical aspects of the project.

6.1 Woody HILL

As a software engineer I will be focusing most of my attention on coding the software and firmware components of the project. I am best suited to lead firmware tasks as I have had experience in firmware development from playing with reference boards such as the arduino or the spark photon. While the software language that will be used with the game engine is one I am not completely familiar with, I should be able to learn it quickly because of its similarities with languages I already know. Since the team already has a strong designer, working on design myself would not be an efficient use of time.

6.2 Daya KERN

My primary role within the team is software programmer, as well as providing my seamstress services for the construction of the floor space. These roles tie in with my strengths: programming and design. Being an avid cosplayer, sewing and selecting appropriate materials is a process which I go through regularly; this will be handy when it comes to designing and constructing the floor mat. In addition, as my major relates to software programming, my coding skills are relevant to the software part of the project. I also have previous experience with the game engine our team is considering, which may help when writing code for this program and designing 3D assets. I would consider my main weakness-in the context of the project-to be firmware as I have had limited exposure and experience in this area.

6.3 Xu LIU

As a designer, I will be responsible for the graphical design and physical implementation of the project. I regularly use Adobe Illustrator and Photoshop, which will be used as the platform to design the initial conceptual maze model. As a student of multimedia design, I can use what I have learnt so far to improve the UX/UI of our project. My graphical design skills will contribute to maze creation, which will help the team's programmers in digitising it. Because I am a designer, I lack the necessary programming skills required for creating the digital maze. This will be a good opportunity to learn from other group members programming languages I have not learnt before.

6.4 Raul REVELO

My role within the team will be primarily as a software programmer. I have previously developed applications as a UI/UX designer and as a programmer. These skills will help the team in constructing the overall digitised puzzle. I am also able to assist the main designer of the team if needed, but will focus primarily on software programming. I have not had much experience in firmware and hardware but I will do my best to assist where needed.

7 References

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8 Appendix

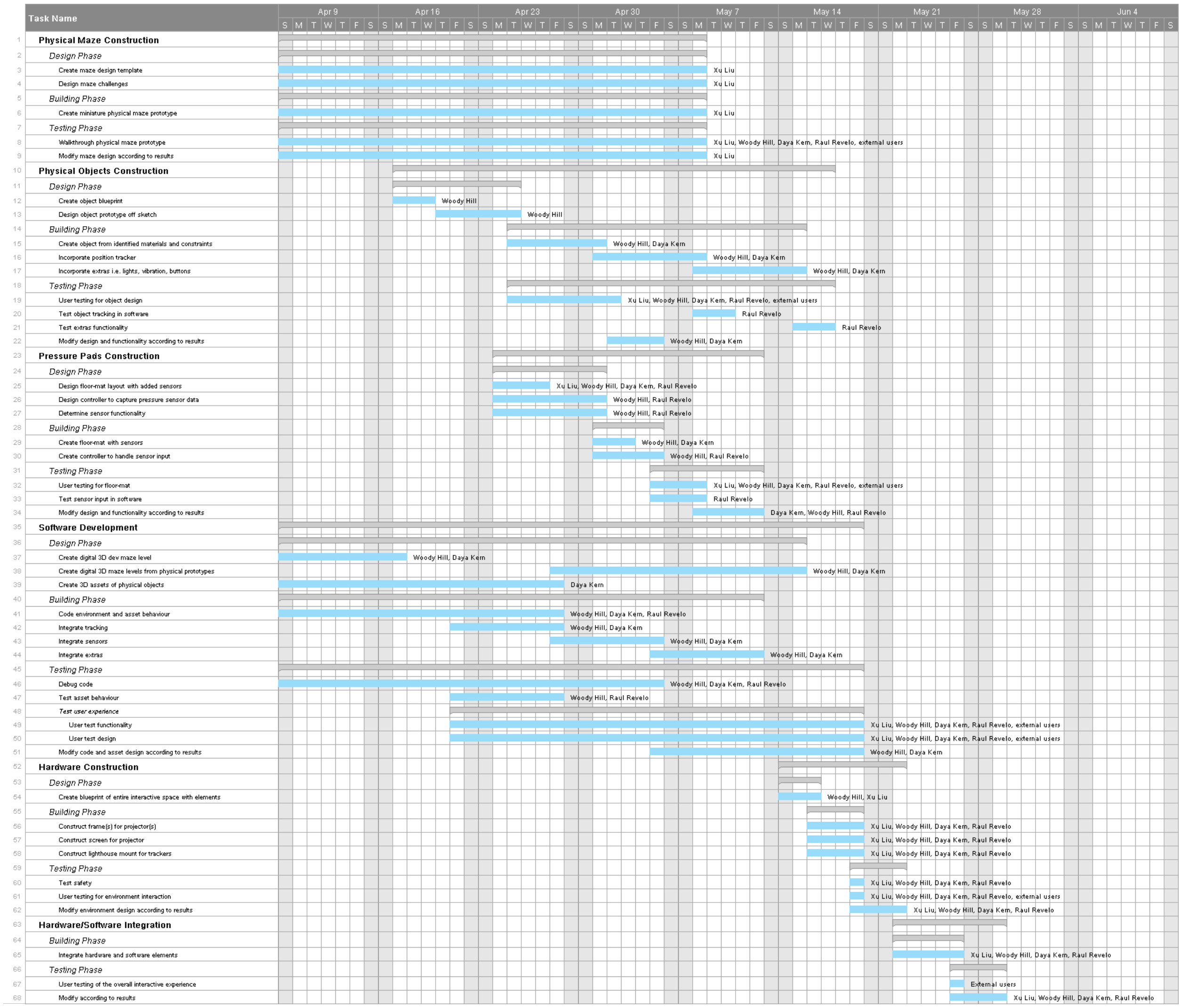

Figure 3: Full Breakdown of Project Plan