Team Project Sequence: Literature Review

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1 Introduction

When designing a new system, it is important to research existing systems since they provide design implications for all potential design choices. Furthermore, such research can also form prerequisites to any future research on the new system being designed. This document discusses and summarizes the relevant points from several scholarly papers that support both the *Zombie Fit!* system and the general topic of using virtual reality games to promote physical exercise. Furthermore, the document provides a discussion of links between the chosen papers and how the gathered information will affect our project.

2 Discussion of Individual Readings

This section will discuss and summarize the relevant points of each individual academic paper.

2.1 Comparison Between Nintendo Wii Fit Aerobics and Traditional Aerobic Exercise in Sedentary Young Adults[1]

In this study, twenty-one healthy sedentary college-age students were evaluated to see differences between 30 minutes of walking on a treadmill and 30 minutes of playing "Free Run" on the Nintendo Wii system. Differences were measured in both psychological (such as psychological distress and well-being) and physiologic (such as heart rate and respiratory rate) responses. The results of the study showed that the participants benefitted more with the "Free Run" game in regard to the physiologic responses with greater mean maximum heart rate, greater rate pressure product, and greater perceived exertion. Despite the greater physiologic responses on "Free Run", the participants' positive well-being decreased after using the game to exercise when compared to treadmill walking. It was concluded that "Free Run" may be an alternative to traditional exercise according to the requirements established by the American College of Sports Medicine.

2.2 Astrojumper: Motivating Exercise with an Immersive Virtual Reality Exergame[2]

This research paper presents the design and evaluation of Astrojumper, a virtual reality exergame that aims to motivate people to exercise. The paper emphasizes that virtual reality exergames provide greater incentives for physical activity than regular exergames (such as the Nintendo Wii) since they require accurate and realistic behavior from players. Furthermore, virtual reality exergames also prevent any workarounds of beating the game since it ties game performance to full-body activity. There were many important factors that were considered while designing Astrojumper. One of the important factors included replayability since people are encouraged to engage in exercise multiple times per week. A game that is not designed with replayability in mind may run into the risk of boring users and thus not motivate them to use the system. Another important

factor that was kept in mind was using the American College of Sports Medicine's guidelines for exercise, which states that an exercise session should have the following three phases: warm-up, exertion, and cooldown. A user study with 30 people between the ages of 6 and 50 was conducted. Researchers gathered information from participants after they played the game for 15 minutes. The results of the study showed that Astrojumper motivates both children and adults to exercise through immersive virtual reality technology.

2.3 What Are the Benefits of a Commercial Exergaming Platform for College Students? Examining Physical Activity, Enjoyment, and Future Intentions[3]

This paper examines the possibility of exercise video games (also known as exergames) being beneficial and more motivating than traditional exercise methods. Testing was done using the Nintendo Wii Fit's "Basic Run". Additionally, a repeated measurement design was used with 30 college-aged students to explore physical activity, enjoyment, and future intentions of physical activity associated with Wii Fit exergames. Participants had their body mass index (BMI) collected and their enjoyment of the activity was gathered using the Physical Activity Enjoyment Scale (PACES). This scale included 11 positively worded questions and 7 negatively worded ones. Data supported the efficacy of "Basic Run" since it demonstrated that the exergame consistently produced moderate to vigorous physical activity across participants. Participants were also questioned about their future intentions with exercising and it was found that intentions were higher for exergaming than with generic exercise methods. Furthermore, individuals that were classified as obese enjoyed exergaming more than traditional and generic physical activities. In conclusion, "Basic Run" provided not only motivational benefits to participants, but also opportunities for accumulating moderate to vigorous physical activity.

2.4 Cultivating Engagement and Enjoyment in Exergames Using Feedback, Challenge, and Rewards[4]

The article argues that the three main mechanisms for encouraging enjoyment during exergame play are feedback, challenge, and rewards. In exergames, feedback is typically presented in the form of player's statistics while playing the game. Some examples of such statistics include the number of steps taken and time spent active. Research on feedback has led researchers to find a positive correlation between more in-depth feedback and increase activity. Challenges in exergames are both cognitive and physical and are typically discussed in terms of flow. That is, a flow state occurs when there is an optimal match between skill and challenge. However, activities that are too easy or too hard might also be motivating, even though they do not produce a change of flow. In fact, difficulty, frustration, and failure must be part of any exergame. The last main mechanism discussed in the article is rewards, which is an extremely controversial and complicated topic within academia. That is, there is evidence to support both positive and negative effects of reward systems. The article provides the following four different taxonomy reward types:

1. Rewards of glory (e.g. points and trophies)
2. Rewards of sustenance (e.g. health packs)
3. Rewards of access (e.g. virtual keys used to unlock game levels or maps)
4. Rewards of facility (e.g. power-ups)

The location of rewards within gameplay impacts how they are perceived and their effectiveness.

2.5 Understanding Exergame Users' Physical Activity, Motivation and Behavior Over Time[5]

This paper examines multiple studies that relate to exergaming in the long run. One of the main studies talks about iFit, which is an iPhone application that allows its users to play eight mini-exercise games through the use of the iPhone's location. A study was conducted on twelve participants ages 11-12 using the app for 20 to 30 minutes between 1 to 3 times a week. The seven-week study showed that while the participants enjoyed playing the mini-games and liked the moderate and vigorous exercise in some of the games, the effect wore off over time as the participants got bored. The paper describes various factors that may help participants stay interested and active, such as competitive elements, goal-setting, and self-efficacy. For example, it was

observed that the participants enjoyed trying to beat the high scores of their peers or their own previous high scores.

2.6 Active Video/Arcade Games (Exergaming) and Energy Expenditure in College Students[6]

Thirteen male and female college-age participants were studied to determine whether interactive games that required physical activity to play would increase energy expenditure (EE) and heart rate (HR) within young adults. A total of three games were used in the study. The first game made players move and strike lighted pads, the second game made players ride a bike to increase the speed of a virtual car, and the third game made players box against a simulated virtual individual. Participants played any of the games for 30 minutes while metabolic and heart rate data were collected. Heart rate and caloric expenditure were shown to be within the American College of Sports Medicine's recommendations. Therefore, it was concluded that interactive games that use physical activity to play can be used as part of an aerobic exercise program.

2.7 Considerations for the Design of Exergames[7]

This paper discusses several considerations that should be taken into account when designing a successful exergame. For example, in order for an exergame to achieve health benefits, it must adhere to one configuration that balances the intensity, duration, and frequency of an exercise routine. One recommended configuration is provided by the American College of Sports Medicine. This recommended configuration states that a successful exercise routine should have a 5 to 10-minute period of warmup, a minimum of 20 minutes of stimulus (i.e. maximum heart rate), and a 5-minute cooldown period of low intensity exercise in order to return the heart rate to resting levels. This recommended configuration also emphasizes that an individual must exercise at least three days per week in order to see benefits. The paper also stresses the importance of attractiveness when trying to motivate people to exercise. That is, exergames that are more attractive are more likely to motivate people to exercise. The three qualitative factors that affect the attractiveness of an exergame include challenge, curiosity, and fantasy. Research in this field has demonstrated that an increase in fantasy makes a game more fun for all players, but the optimal balance between challenge and curiosity were dependent on the individual player. A game's attractiveness is also supported by the "flow" construct, which states that a player will become immersed only when the game balances action and awareness, is neither too hard nor too easy, has clear goals, has unambiguous feedback, is not too distracting and allows for concentration, allows players to have a sense of personal control, does not impose a feeling of self-doubt or self-concern, alters the experience of time, and is intrinsically rewarding.

2.8 Exergames for Physical Education Courses: Physical, Social, and Cognitive Benefits[8]

This article describes how video games can be incorporated into an exercise routine. The article also provides evidence that supports the positive effects of exergames, such as an increase in caloric expenditure, heart rate, and coordination. In addition, an emphasis is made on the psychosocial and cognitive impacts of exergame play, including an increase in self-esteem, social interaction, motivation, and attention. The article makes it clear that, in order for exergames to influence physical development, they must be designed with components that accurately track and respond to players' gross motor movements. This can be accomplished by incorporating sensitive motion sensors and other technology into the system. Furthermore, exergames must respond to players' actions quickly and challenge them at multiple levels of expertise in order to motivate them to use the system. The article speculates that perhaps this is why many youth choose exergames over traditional exercise since exergames provide immediate feedback and real-time challenges. Exergames are also flexible since they can be incorporated into various types of environments such as schools, homes, and fitness clubs.

2.9 High-Tech Tools for Exercise Motivation: Use and Role of Technologies Such as the Internet, Mobile Applications, Social Media, and Video Games[9]

This paper explores the idea of using technology to motivate individuals with type 2 diabetes to exercise. Because our project revolves around exergames, we will focus only on what they gathered about video games. The authors learned that video games addressed one of the most pressing challenges in physical activity promotion: motivating sustained activity over time. They also found that video games provide the framework

for goal setting. This is due to players being intrinsically motivated, which means that they play the video games for their own sake and in absence of an award. The authors also mention that mobile games like "Zombies, Run!" work well because the player does not have to buy additional hardware, such as a game console. However, other games that are supported by game consoles motivate players more since they can engage with the game world. Overall, they found that active video games that were measured in short periods of play produced more activity than a standard video game. Surprisingly, this only held true for adults and not children. The negative difference in motivation in children was due to a lack of adherence, leading to boredom.

2.10 Flexible Spaces: Dynamic Layout Generation for Infinite Walking in Virtual Environments[10]

The article aims to explain how designers can use dynamic layout generation in order to simulate infinite walking in a virtual world. Manipulating the mapping between a physical and virtual environment can simulate an infinite space in virtual reality. However, this method should be used only if the primary focus of the experience is on its spatial layout. If the experience focuses more on the virtual world's content, then other strategies exists. The paper introduces and explains one of these strategies: flexible spaces. In essence, flexible spaces can simulate infinite real walking environments without the need of real-world layouts replications. This can be accomplished by focusing on virtual, non-physical environments that mimic real ones visually but that do not obey the same physical laws. The article describes a specific algorithm that generates flexible spaces. This algorithm generates a dynamic layout and maintains connections between layouts by using a self-overlapping architecture. This architecture and algorithm are successful only because players that use a virtual reality headset cannot notice changes in their actual physical environment.

2.11 Exergaming in Older Adults: A Scoping Review and Implementation Potential for Patients with Heart Failure[11]

The article discusses how we can use exergames to help older adults with heart problems become more physically active. Physical activity is of great importance for such adults since it can improve exercise capacity and quality of life, as well as reduce hospitalization rates. Because many adults do not adhere to a regular exercise routine, many researchers are constantly trying to find new alternative ways of exercising, such as exergames. The article mentions that there have been no studies made regarding exergames for older adults with heart problems. Because of this, the article aims to do a scoping review that focuses on the feasibility and influence of exergames in older adults. To accomplish this scoping, a literature search was done in August 2012 that focused on the influence of exergaming in older adults. Even though a total of 51 articles were found, only 11 were included in the article's analysis. The literature review of these 11 articles concluded that exergaming is not only safe, but also feasible for patients with heart problems. Furthermore, it was discovered that exergames increased the total amount of physical activity in elderly, stroke, and cardiac patients and made participants feel more connected with their family members (especially their grandchildren). It was noted that participants also reported a decrease in depressive symptoms and an increase in quality of life and empowerment.

2.12 Using Games to Increase Exercise Motivation[12]

This paper discusses the properties of exercise games that will help motivate sedentary people to start and continue exercise programs. Konami's "Dance Dance Revolution" and Wii Sports are prime examples of games that have incorporated fun exercise components into gameplay. Routines that combine video games and exercise might motivate users to start or continue doing physical activity. The paper also reviewed literature on exercise motivation and used the information learned to derive requirements for computer-aided exercise games. The paper then introduces the exercise game "Life is a Village" and uses it to illustrate how these requirements can be met. Furthermore, a comparison between the user interface and the game world was made on games that are already being commercially produced. Below is the breakdown of some examples that the paper explores:

Table 1. Taxonomy of exercise games categorized by user interface and game world

User Interface vs Game World	**Free motion interface**	**Equipment based physical interface**	**Traditional Electronic Interface**
Virtual World	Kick ass Kung fu, Nautilus, EyeToy, Paranoia Syndrome, Breakout for Two, Wii Sports, Dance Dance Revolution	Life is a Village, FlyGuy, Push N' Pull, GameBike, PowerGrid Fitness	Human Pacman (helper), Age Invaders (helper/opponent)
Augmented Reality	Human Pacman, Age Invaders, Laser Tag	Open for research	Open for research
Reality	Soccer	Cycling	Radio Controlled Cars

Through research, the paper developed a list of six requirements to be met in order to have a successful exercise game. This list is as follows:

1. Integrate music
2. Facilitate leadership for novice players
3. Provide achievable short and long-term goals
4. Hide players' fitness level
5. Avoid systemic barriers for grouping
6. Actively assist players in forming groups

The authors point out that other crucial requirements are not listed but reiterate that a game should overall be fun since a game that is not enjoyable will not draw people to play it or motivate them to keep playing. They also acknowledge that some of their rules cause conflicts but emphasize that choosing between these requirements and their trade-offs is at the discretion of the developers.

The authors of the paper also describe "Life is a Village," which is a game that they developed. "Life is a Village" is a multi-player computer-aided exercise game that takes place in a virtual world. The player controls an avatar by pedaling a stationary bicycle and steering a wireless PlayStation 2 controller. The goal of the game is to build a village after collecting resources. To collect resources, the player pedals around searching and collecting. This gets players engaged in the game and committed to it since building a village takes hours. Another key factor they included in their game was biometric feedback. This helped determine whether or not the player was exercising at the desired intensity.

3 Discussion on How Readings Connect with One Another

This section will discuss how each reading connects with each other. All the readings were about exercise, technology, or both. Many of the readings also talk about the American College of Sports Medicine (ACSM) and its requirements for effective exercise. In those readings, it was found that exercise games, applications, and systems were able to be successful in meeting the requirements. This was found either by measuring factors (such as heart rate) to assure they met physiological standards [1] or by modeling the systems after the ACSM's exercise configurations. "Comparison Between Nintendo Wii Fit Aerobics and Traditional Aerobic Exercise in Sedentary Young Adults" references to maximum heart rate, greater rate pressure product, and greater perceived exertion [1] while "Exergames for Physical Education Courses: Physical, Social, and Cognitive Benefits" speaks about similar physiological effects with an increase in caloric expenditure, heart rate, and coordination [8]. Two of the readings reference a recommended configuration of a "5 to 10-minute period of warmup, a minimum of 20 minutes of stimulus (i.e. maximum heart rate), and a 5-minute cooldown period of low intensity" [2][7]. Since many of the articles in our research mention ASCM's requirements and configurations for exercise, one can assume that it is a crucial component to include in exergaming or other fitness systems.

Another component that is commonly discussed across the readings is how to keep users exercising with the system. A common theme to deal with this is the addition of factors such as rewards and achievements. One reading describes how elements of competition or self-efficacy may give players motivation to continue using the exercise game system and not get bored after a few weeks [5]. Another paper describes this same plateau in

use of an exercise-gaming system and suggests ways in how to design the system [7]. Some suggestions include integrating an increase in fantasy, making the difficulty not be too hard or too easy, providing clear goals, and allowing room for concentration [7]. “Cultivating Engagement and Enjoyment in Exergames Using Feedback, Challenge, and Rewards” mentions three elements of encouraging enjoyment in games: feedback, challenge, and rewards [4]. This includes elements such as exercise statistics, a moderate level of difficulty, and rewards of glory (ex. Trophies). “Using Games to Increase Exercise Motivation” adds on to this concept by describing how an exercise game should integrate short-term and long-term goals, leadership opportunities, and the ability to form groups with other players [12].

Many of the papers also reference exergame use within specific groups. “Understanding Exergame Users' Physical Activity, Motivation and Behavior Over Time” focused on an exergaming app with children [5]. “Comparison Between Nintendo Wii Fit Aerobics and Traditional Aerobic Exercise in Sedentary Young Adults”, “What Are the Benefits of a Commercial Exergaming Platform for College Students? Examining Physical Activity, Enjoyment, and Future Intentions”, and “Active Video/Arcade Games (Exergaming) and Energy Expenditure in College Students” involved studies with college-aged students [1][3][6]. “Exergaming in Older Adults: A Scoping Review and Implementation Potential for Patients with Heart Failure” was a study on older adults with heart problems [11]. Combined, these articles synthesize a “timeline” of experiences that allowed us to see the bigger picture. If one just narrowed into one age range, it would limit our research and exclude valuable experiences from other age groups.

As stated before, one of the relevant themes among the readings was discussion on various technologies and systems and how they allow the user to explore the space within them. “Flexible Spaces: Dynamic Layout Generation for Infinite Walking in Virtual Environments” talks about how to design environments in virtual reality (VR) systems so that they can appear to expand infinitely [10]. This can allow for more enjoyable and realistic gameplay. Another paper references to mobile and console games and how they work well in providing an enjoyable experience so that its users can play for longer periods of time through goal setting [9]. A few other articles also reference how to allow realism and flexibility to be integrated with the design of a system in order to allow for a more enjoyable experience. One of these articles is “Understanding Exergame Users' Physical Activity, Motivation and Behavior Over Time”, which refers to how the iFit iPhone app integrates GPS technology to allow the users to navigate through the world in the map [5]. This gave more of a sense of realism since taking steps in the real world allowed the user’s avatar to move in the app as well. This timely feedback is important for having an enjoyable experience and avoiding frustration.

Research papers “Cultivating Engagement and Enjoyment in Exergames Using Feedback, Challenge, and Rewards” and “Considerations for the Design of Exergame” both talk about how an exergame’s flow can affect gameplay. Research paper [4], however, focuses more on how an exergame’s challenge level is typically discussed in terms of cogitative and physical flow. In contrast, research paper [7] focuses more on how the flow construct can impact an exergame’s attractiveness. An interesting contradiction arises when we compare both research papers. Research paper [4] encourages an exergame to be too easy or too hard at times, but research paper [7] suggests the complete opposite. That is, research paper [7] suggests that an exergame should never be too hard or too easy. We conclude that an exergame that is moderately difficult might be considered as attractive by several users, even though the game itself might not be challenging enough. In contrast, an exergame that is too hard or too easy at times might make the game have adequate challenge levels, but be unattractive to users.

4 Discussion on How Readings Connect to *Zombie Fit!*

This section will discuss how the readings connect to the *Zombie Fit!* system and the topic of using virtual reality games to promote physical exercise. Research paper [1] connects with *Zombie Fit!* since it outlines psychological responses and physiological responses as two useful measures that we should probably use while assessing the quality of our prototypes. This research paper also provides evidence, by using requirements established by the American College of Sports Medicine, that supports the feasibility and effectiveness of exergames. Research paper [2] provides an example of an already existing exergame that incorporates virtual reality and motion sensors. The paper lists the following two major factors that were considered while designing

the system: replayability and exercise guidelines (i.e. warm-up, exertion, and cooldown) established by the American College of Sports Medicine. When designing *Zombie Fit!*, we must too take into account replayability issues and exercise principles. A perfect way to make our system more replayable is to have game events be randomized. This would make each individual gameplay unique for players every time they use the system. Research paper [3] provides evidence that college students would actually use an exergame to exercise. Because of this, our group can design *Zombie Fit!* knowing that it might appeal to a certain percentage of college students.

Research paper [4] provides relevant and contributing components that will be used when designing our system in order to encourage enjoyment during gameplay. That is, our group will design the system with feedback, challenge, and rewards in mind. The article suggests that our system should provide a player's gameplay statistics such as total number of steps taken, as well as total time spent active. Furthermore, our system will, at times, be too difficult or too easy since these aspects will also motivate users to use our system. Tasks in *Zombie Fit!* that are too difficult will purposely frustrate players as this is important in any video game. *Zombie Fit!* will reward users with trophies, health packs, and power-ups whenever difficult tasks are accomplished. Research paper [5] provides our group with the following useful warning: Beware of designing games that quickly become boring. This goes hand in hand with what research paper [2] was suggesting since exergames that are designed with replayability in mind will not encounter this problem. Research paper [5] suggests that we should also design our system with the following factors in mind: competitive elements, goal-setting, and self-efficacy. This will help participants stay interested in our game and thus motivate them to use the system more often. Research paper [6] provides evidence that interactive games that use physical activity to play can be used as part of an aerobic program. This directly correlates to our project since we now have evidence that supports the practicality of using virtual reality games to promote physical exercise.

Research paper [7] lists several considerations that we will take into account when designing *Zombie Fit!*. One consideration that we will use will be to adhere to the recommended configuration of having a 5 to 10-minute period of warmup, a minimum of 20 minutes of stimulus, and a 5-minute cooldown period of low intensity. *Zombie Fit!* will accomplish this by having two types of zones: infected and safe. Infected zones will have zombies and will be the period of stimulus in our game since most of the action will take place here. In contrast, safe zones are free from zombies. Here, players will only collect resources, thus requiring them to do minimum exercise in the real world. Another consideration that we will take into account is the importance of attractiveness. More specifically, we plan to make the game more immersive and realistic since it has been proven that fantasy makes a game more fun for all players. Research paper [8] suggests that our system must respond to players' actions quickly and challenge them at multiple levels of expertise in order to motivate them. Since exercise motivation is a huge requirements for our system, we must take this suggestion and implement it. Research paper [8] also states that exergames can be incorporated into various types of environments such as schools, homes, and fitness clubs. Because of this assumption, we must be careful when designing *Zombie Fit!* since we must take into account several potential dangers that exist when the system is used. Research paper [9] discusses how exergames might make children get bored quicker than adults. If we do design and implement a system that is for all ages, we must take into account the difference in attention span between children and adults.

Research paper [10] provides an algorithm that allows designers to create flexible spaces, which is a very attractive idea to implement in our project. Users playing *Zombie Fit!* will not have infinite physical space since they will be constrained by the available space that they have in their physical environment. Because *Zombie Fit!* focuses more on the virtual world's content rather than its spatial layout (e.g. players will be more interested in the zombies that are chasing them rather than the layout of streets or hallways), it makes perfect sense to explore the idea of using flexible spaces while designing our game. Research Paper [11] provides evidence for older individuals with heart problems willing to use exergames to do exercise. Because of this, our group can design *Zombie Fit!* knowing that it might appeal to a certain percentage of elderly people. This implies that our system must be easy to use and cater to less tech-savvy users. Lastly, research paper [12] lists the following six requirements that are needed to have a successful exercise game: integrate music, facilitate leadership for novice

players, provide achievable short and long-term goals, hide players' fitness level, avoid systemic barriers for grouping, and actively assist players in forming groups. Our group will choose between these requirements by carefully analyzing trade-offs and determining which ones are more relevant to our project.

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