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Article

Exploring Educational Exergames in Well-being Education: A Study in a Finnish Primary School

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Abstract

Integrating exergames into well-being education has garnered substantial attention for promoting physical wellness. This study focused on assessing student preferences in exergames, particularly examining variables such as game selection, difficulty level, and collaborative mode. Furthermore, we scrutinized play duration across these variables to gain an in-depth understanding. Our exploration was guided by self-determination theory, centering on autonomy, competence, and relatedness concepts. Conducted within a primary school in Jyväskylä, Finland, our study utilized iWall, an Interactive Gaming Wall, to capture data on these variables, amassing 1707 data points from student frequency log data. Analysis of game frequency delineates game preferences emphasizing physical endurance, rhythmic coordination, and multiplayer engagement. Correlation analyses illuminate the dynamic interaction between game types and difficulty levels, elucidating the connection between gaming challenges and student choices. Moreover, examining play duration underscores how game genres significantly impact gameplay duration, emphasizing the need for diversified cognitive and physical challenges in exergame design. These findings are anticipated to offer insights into future exergame development for well-being education, drawing from a detailed understanding of student preferences established in this study. In addition, the findings in this study suggest that exergames offer well-being education that can be adapted to educational activities globally, which provides insight into balancing cognitive and physical activities in the classroom.

1. Introduction

The burgeoning field of well-being education has garnered substantial attention from scholars and practitioners over the past few decades [1], [2], [3], [4]. This educational approach emphasizes academic excellence and prioritizes students' holistic development, encompassing physical, emotional, social, and mental well-being [5]. A noteworthy trend within well-being education involves the integration of exergames, which are video games designed to promote physical activities, as a means to support students across these dimensions [6], [7]. The concept gained prominence with the introduction of *Nintendo's Wii* console [8]. Although it has only recently become widely known due to the emergence of the Nintendo Wii console, exergames have a long history from the conventional era of exergames, such as Atari "The Joyboard" in 1980 [9]. Until the last few years, the latest studies have discussed exergames that can be combined with artificial intelligence to read user movement patterns and produce further training recommendations [10], [11], [12]. In well-being education, exergames are are most often employed outside of the formal learning activities, such as icebreaking or extracurricular activities [13], [14].

In the sphere of education, research predominantly centers on behavioral aspects during student gameplay [15], [16] and the consequent influence of games on academic performance [17]. Remarkably, there remains to be more investigation into game preferences within educational realms despite the extensive exploration of user preferences in the broader video game research landscape [18]. Within entertainment games and other digital platforms, understanding user preferences has been pivotal for enhancing game (or platform) quality, increasing innovation, broadening market reach, and fostering player (or user) engagement [19], [20].

The use of exergames in education has gained attention in recent years, but research remains limited in scope, with a predominant focus on mental and emotional health outcomes over the past five years. For example, in their systematic review, Marques et al. [21] highlighted exergame studies examining emotional experiences. Their findings indicated that exergames positively influence happiness, self-esteem, and intrinsic motivation. Similarly, Quintas and Bustamante [22] demonstrated through their research on gamified exergames that these games enhance enjoyment and attitudes. Another study by Coacci et al. [23] explored students' self-perceptions and revealed that exergames foster experiences of motivation, engagement, and a positive impact on academic learning. Collectively, these studies illustrate the positive potential of exergames for learning processes and outcomes, suggesting their value as interventions in educational contexts.

Thus, a similar focus on analyzing student preferences within exergames, specifically within the domain of well-being education, becomes imperative. This analysis aims to expand game choices, tailor learning experiences to suit individual capacities, foster collaborative opportunities, and fundamentally foster a holistic health and fitness paradigm in physical well-being. To answer this gap related to observing student preference for exergames, our study analyzes student preferences based on multiple observed variables: game selection, difficulty levels, collaborative modes, and play duration. Game selection analysis illuminates the preferred gaming choices among students. Examining difficulty levels seeks to decipher students' inclinations toward diverse challenge levels within games. Collaborative modes illuminate how students prefer interacting within the exergaming context, while play duration offers insights into preferences for shorter, intensive sessions versus prolonged engagements.

This paper utilizes data sourced from iWall, an interactive gaming wall developed by CSE Entertainment in Finland, designed specifically for educational and sports-centric exergaming [24]. The study focuses on the use of iWall outside formal learning environments. By analyzing this dataset and deriving conclusions regarding student preferences, we aim to delineate an overview of students' preferences within exergames . Such insights promise to guide future exergame development endeavors aligned with supporting well-being education.

This study addresses three key research questions related to game selection, difficulty level, collaborative mode, and play duration:

1. What are students' preferences based on the frequency of game selection, difficulty level, and collaborative mode?
2. Is there a correlation between game selection, difficulty level, and collaborative mode?
3. Does play duration vary depending on game type, difficulty level, and collaborative mode?

2. Theoretical Framework: Self-Determination Theory

This study is anchored in Self-Determination Theory (SDT), a theoretical framework proposed by Deci and Ryan [25], [26], emphasizing the psychological requisites of autonomy, competence, and relatedness as pivotal motivators driving human behavior. These needs significantly influence intrinsic motivation and holistic well-being. In the context of this research, we apply SDT to interpret the findings gleaned from the analysis of student preferences. The outcomes of this analysis are interconnected with the psychological needs outlined in SDT, encompassing autonomy, competence, and relatedness, providing a contextual lens through which to comprehend students' preferences within the framework of this theory.

SDT is widely recognized as a macro theory in psychology that addresses human motivation and personality [25], [26], [27]. Central to SDT is the assertion that individuals possess an innate inclination toward developing and fulfilling psychological needs. The theory delves into the motivations guiding individual decisions, focusing on self-motivation and self-determination. Originating in the early 1970s, initial discussions around SDT revolved extensively around intrinsic and extrinsic motivation. It was in the mid-1980s that SDT gained empirical acceptance through the seminal work of Edward L. Deci and Richard Ryan. During this period, Deci and Ryan delineated three intrinsic needs—autonomy, competence, and relatedness—as pivotal to understanding individual motivation [25], [26], [27]. These needs, integral to psychological health and well-being, form the core tenets of SDT [25], [26], [27].

While the trio of psychological needs—autonomy, competence, and relatedness—are generally considered universal, their salience may vary based on temporal factors, cultural nuances, or individual experiences [25]. Consequently, it becomes imperative to comprehend the contextual intricacies and acknowledge the necessity of fulfilling these fundamental psychological needs to facilitate optimal personal growth and fulfillment [25]. As one of these innate needs, autonomy enables optimal functioning and development when satisfied. It is characterized by the desire to be the causal agent of one's life, acting in harmony with one's integrated self [25]. Autonomy, however, does not imply independence from others; it entails a sense of psychological liberty and internal will freedom. Individuals exhibiting autonomous motivation tend to manifest higher performance, wellness, and engagement levels than those directed by external instructions [25]. Thus, providing individuals with autonomy is pivotal in enhancing intrinsic motivation, ultimately contributing to optimal well-being [25], [26], [27].

Competence, another intrinsic need delineated by SDT, refers to the desire for control over outcomes and the pursuit of mastery [25]. The fulfillment of this need significantly influences meaning-making, well-being, and the discovery of value within internal growth and motivation. Offering positive feedback on tasks is crucial to bolstering intrinsic motivation and diminishing extrinsic motivation [25]. Conversely, negative feedback undermines individuals' need for competence, reducing intrinsic motivation [25]. Therefore, recognizing the impact of feedback on an individual's competence is vital for fostering intrinsic motivation [25], [26], [27].

The third identified innate need in SDT is relatedness, encompassing the inclination to interact with, connect to, and care for others [25]. The fulfillment of this need is instrumental in promoting psychological functioning, and conversely, deprivation can impede developmental growth. Providing individuals with nurturing from a social environment, extending beyond superficial interactions, is essential for realizing their inherent potential [25]. SDT underscores humans' natural trajectory toward positive motivation, development, and personal fulfillment, underscoring the significance of preventing the compromise of basic needs to safeguard well-being [25]. Hence, a nuanced understanding of the context and a concerted effort to satisfy these basic psychological needs is essential for optimal growth and personal fulfillment [25], [26], [27].

In Self-Determination Theory (SDT), the three psychological needs—autonomy, competence, and relatedness—are intricately linked to student preferences within exergames, playing specific roles in shaping the educational landscape. *Autonomy*, a fundamental aspect of SDT, is pivotal in understanding these preferences. Tailoring game selection to align with students' inclinations fosters a sense of control over their learning experiences. This customization supports autonomy, allowing individuals to feel empowered within their educational journey. Moreover, aligning difficulty levels in exergames with student preferences assists in crafting learning experiences attuned to their *competence* levels. As students engage with games they enjoy and feel capable of mastering, their sense of competence is bolstered, aligning with another core element of SDT. Additionally, utilizing student preferences within exergames creates opportunities for collaborative and social interactions, elucidating the concept of *relatedness*. Shared preferences among students can strengthen their sense of connectedness, fostering a supportive environment aligned with the relatedness component of SDT.

3. Literature Review

The intersection of SDT and research on physical activity interventions, particularly in exergames, has been a focal point of scholarly inquiry [28]. Exergames amalgamate physical activity with interactive video games and exhibit substantial potential to enhance motivation and engagement across diverse age groups [29]. This potential is closely tied to SDT's foundational psychological needs of autonomy, competence, and relatedness.

Numerous studies have illustrated the alignment between game activities, and the three psychological needs posited by SDT [30], [31]. Autonomy, the first need, manifests in the selection of game types, as evidenced in several investigations [32]. Competence is fulfilled by receiving feedback and acknowledging progress within the gaming environment [33]. The social interactions inherent in multiplayer gaming activities represent a crucial relatedness component [32]. In essence, the activities within exergames intricately address the three fundamental psychological needs outlined by SDT.

The application of SDT theory in research about exergames has been pervasive. For instance, Huang et al. [30] conducted a study examining enthusiasm in the context of exergames, while Zhang et al. [34] focused on exploring unsatisfactory experiences and unmet psychological needs associated with implementing exergames. Moreover, research endeavors such as that by Ijaz et al. [35] have delved into the impact of VR Exergaming on health and well-being.

Drawing from the insights garnered in these studies; there emerges a compelling impetus to investigate students' preferences concerning the types of games within the exergaming domain. This study is motivated by the recognition that, despite its exclusive focus on quantitative data in this initial stage, it serves as a foundational benchmark. Future research can subsequently build upon this quantitative foundation, delving qualitatively into why students make particular choices in exergames. This iterative approach is essential for developing a comprehensive understanding of the intricate dynamics between students' preferences, game types, and the underlying psychological principles delineated by SDT within the context of well-being education.

4. Method

4.1 Study Context

This study employs a single case study methodology [36] as part of a broader, extensive case study endeavor. Explicitly focused on gathering quantitative data from students' engagements with games on iWall, the data collection involves tracking their interactions with the iWall gaming system. Each student possesses a printed QR-code card granting access and enabling the identification of individual participants. The research was conducted within a primary school in Jyväskylä, Finland, encompassing a total student population of 285 across grades 1-9. Each student gets the opportunity to access iWall 5-6 times. This educational setting allowed students to engage with iWall, an interactive gaming wall serving as a novel learning environment, see Figure 1 for the implementation iWall in the classroom. The gaming sessions occurred exclusively during students' free time and outside regular class hours.

Figure 1. Implementation of iWall

4.2 iWall

The interactive gaming wall employed in this research, as previously detailed in the introduction, is the iWall. Developed by CSE Entertainment, the iWall is designed for exergaming applications in educational, well-being, and sports contexts, with a global presence spanning over 55 countries [24]. While the iWall features numerous game options, our investigation concentrates on a select set of 10 games, chosen based on specific criteria. These criteria encompass the games' distinct difficulty levels, categorized as easy, medium, and hard. Additionally, our focus is directed towards games that facilitate multiplayer engagement. A description of each game, along with the skills that can be developed through gameplay, is provided in Table 1. All relevant data have been sourced from the official website http://cse.is/education.

Table 1. Game Types, Descriptions, and Developed Skills

No	Games	Description	Developed skills
1	Ski Jumping	Ski Jumping game provides an excellent opportunity to get a taste of the well-known winter sport in Finland. In order to excel at the game, one must possess particular abilities such as explosive takeoff power, quick reaction time, and good mobility.	Mobility, reaction speed and timing, explosive takeoff power, body balance
2	Flow Master	Flow Master is a game set in the Himalayas that draws inspiration from Tai Chi. It requires players to mimic the movements of a moving statue as precisely as possible to earn points.	Mobility, coordination, balance
3	Step Up!	Step Up! is a game that features dance moves suitable for people with varying levels of proficiency in dancing. This game allows everyone to participate and enjoy dancing according to their skill level.	Rhythm Coordination, Timing
4	KayaKing	KayaKing is an exergame that simulates the experience of kayaking down a river and maneuvering through checkpoints. This game offers an intuitive control scheme requiring players to move their upper body and arms as if paddling a kayak.	Upper Body, Core , Coordination, Endurance
5	Space shooter	Space Shooter is an interactive video game in a fictitious galaxy that requires the player to maneuver a spacecraft while avoiding incoming obstacles, such as meteorites and floating space debris.	Upper body, spatial awareness , core, reaction speed
6	Shadow master	Shadow Master is a comprehensive game that enhances physical fitness by promoting mobility, balance, and muscular endurance. This immersive game offers various difficulty modes that cater to individuals of different fitness levels. The fitness routines featured in this game have been curated by certified fitness professionals and target major muscle groups, in addition to improving muscular endurance and mobility.	Mobility, balance, acrobatics, muscular endurance

7	JumpOn	JumpOn is an engaging game that requires a combination of dexterity, focus, and strategy to succeed. Player control a robot that jumps from platform to platform on a skyscraper to clean windows. To accumulate points, the player must perform a series of tasks, including gathering items, cleaning windows, and reaching the top of the building within a specific time frame.	Cardio, upper body, spatial awareness
8	Parkour	Parkour is a game that embarks on a firsthand exploration of the world of parkour, where navigating obstacles with speed and agility is the key. Scale rooftops and glide beneath rails, each attempt fueling the desire to surpass your previous record. Engage in this thrilling activity to enhance cognitive skills and memory as participants strategize to recall the swiftest routes.	Cardio, coordination, muscular endurance, mobility
9	Parkour Extreme	Parkour extreme is the next version of the Parkour game. The routes in this version are notably more challenging, demanding players to move swiftly in their quest to discover the quickest path to the finish line.	Interval, cardio, muscular endurance
10	Deepsea Dash	In Deepsea Dash, the gold goes to the speediest and most nimble participant who successfully navigates narrow paths and bridges to reach the finish line.	Spatial awareness, timing, balance, strategy

4.3 Data Collection

The dataset utilized for this study encompasses 1707 records collected from iWall spanning April 6, 2021, to June 3, 2021. Each record corresponds to a student initiating a new game session on the *iWall* platform. This comprehensive dataset encompasses information, including game selection, difficulty level, collaborative mode, and play duration. Game selection refers to the games chosen on *iWall*, detailed in Table 1. Difficulty level is an ordinal representation indicating the game's level of difficulty, categorized into easy, medium, and hard. Collaborative mode denotes the students' choice between single-player or multiplayer formats when playing games. Lastly, play duration records the elapsed time from a student initiating a new game session to each log, recorded in minutes.

The selection of these four variables aligns with the primary aim of this paper, which seeks to connect students' preferences to Self-Determination Theory (SDT), focusing on autonomy, competence, and relatedness. Game selection signifies students' independent control over their exergaming experience, representing their autonomy. Competence pertains to the mastery level of the exergame, closely linked to the game's difficulty level. Relatedness is associated with the game's collaborative mode, reflecting students' preferences for single-player or multiplayer formats and delineating their social attachment. Meanwhile, play duration offers an overarching perspective on how students engage with the game, providing insights into the duration based on the three variables above (game selection, difficulty levels and collaborative mode).

4.4 Data Anonymousness and processing data

To maintain user confidentiality, all in-game data that we collect in this study is anonymized, especially related to personal data such as names, age, etc. Processing personal data in this study refers to Article 6 (1) of the EU General Data Protection Regulation, which requires consent from students and guardians/parents. The research is carried out in accordance with the guidelines of good scientific practice of *tutkimuseettisen neuvottelukunnan* (TENK) of the Finnish Ministry of Education and Culture. The data subject has the right to complain to the Office of the Data Protection Commissioner if the data subject considers that the processing of personal data concerns has violated the applicable data protection legislation. (read more: http://www.tietosuoja.fi).

4.5 Data Analysis

In our study, the data analysis involved several approaches aligning with Self-Determination

Theory (SDT) as the theoretical foundation of well-being education. We initiated a descriptive analysis [37] encompassing frequency counts to outline student preferences across games. This exploration mirrors SDT's autonomy aspect, revealing students' autonomy in game selection and dissecting game preferences concerning different difficulty levels and collaborative modes.

Subsequently, a correlation test using Chi-square [38] scrutinized associations between game variables, difficulty levels, and collaboration modes. This approach, emphasizing autonomy, gauged how game selection correlates with difficulty levels and collaborative modes, indicating how students fulfill their autonomy needs based on their preferred game settings. Concerning competence, the focus lies on difficulty levels and their relationship with games and collaborative modes, presenting insights into students' sense of competence amidst varied gaming challenges and interactions. Finally, exploring relatedness through collaborative modes delved into the link between games and social engagement, illuminating the games with frequent collaborations and the level of student interaction.

Moreover, differential tests employing ANOVA (Analysis of variance) [39] or independent sample t-tests [40] were conducted to assess play duration based on game selection, difficulty levels, and collaborative modes. Subsequently, to identify significant differences among game types or difficulty levels after ANOVA, Duncan's test was implemented [41]. This evaluation aimed to discern whether students' play duration fluctuated based on their preferences for games, difficulty levels, and collaborative modes. This comprehensive analysis aimed to elucidate how each aspect of psychological needs in SDT influences the duration of exergame participation.

The outcomes across these analyses offer an extensive portrayal of students' overarching preferences for exergames, delineated by game choices, difficulty types, and collaborative modes. Additionally, the influence of these variables on play duration was observed, shedding light on how these preferences potentially impact the duration of gameplay.

5. Result

From our preceding explanation, this study undertook three primary analyses encompassing frequency (game selection, difficulty level, collaborative mode), correlation (among these variables), and differences (in play duration based on game selection, difficulty level, and collaborative mode). In this section, we delineate these subsections, accompanied by insights into student frequencies derived from each of these analyses.

5.1 Student preferences based on the frequency of game selection, difficulty level, and collaborative mode

In this segment, our emphasis is directed toward examining the frequency at which games are selected, the difficulty levels, and the collaborative mode. In Figure 2, the depiction showcases the percentages reflecting the frequency of game selections made by students. Parkour Extreme is the most frequently played game, accessed 577 times, constituting 34% of the total accesses. Remarkably, this is double the access frequency of the second most chosen game, StepUp!, which was accessed 278 times, comprising 16%. Conversely, games like Flow Master, accessed merely 24 times (2%), Space Shooter, with 89 accesses (5%), and KayaKing, with 69 accesses (4%), demonstrate lower frequencies. Reviewing the skill sets of each exergame in Table 1, it is evident that students prefer exergames centered around intense physical endurance and rhythmic coordination. For instance, Parkour Extreme enhances interval, cardio, and muscular endurance skills. Similarly, StepUp! centers on dance-based gameplay, focusing on rhythm coordination and timing. Conversely, games like Flow Master and KayaKing, despite having coordination elements, witness lower play frequencies due to their absence of rhythmic features. It highlights the impact of game-based skill development on the frequency of student engagement with these exergames.

Moreover, students opt for the hard difficulty level across various exergames. However, a breakdown of specific game preferences concerning different difficulty levels reveals intriguing patterns, see Figure 3. For instance, most students favor the medium difficulty level in Parkour Extreme, the most frequently played game. Conversely, games like StepUp! and Ski Jump witness a preference for the hard level among students. This distinction indicates that for games emphasizing physical endurance, students lean towards the medium difficulty, while those emphasizing timing aspects, like StepUp! and SkiJump, prompt students to opt for the hard level. These three games were chosen as representative examples due to their high play frequency among students.

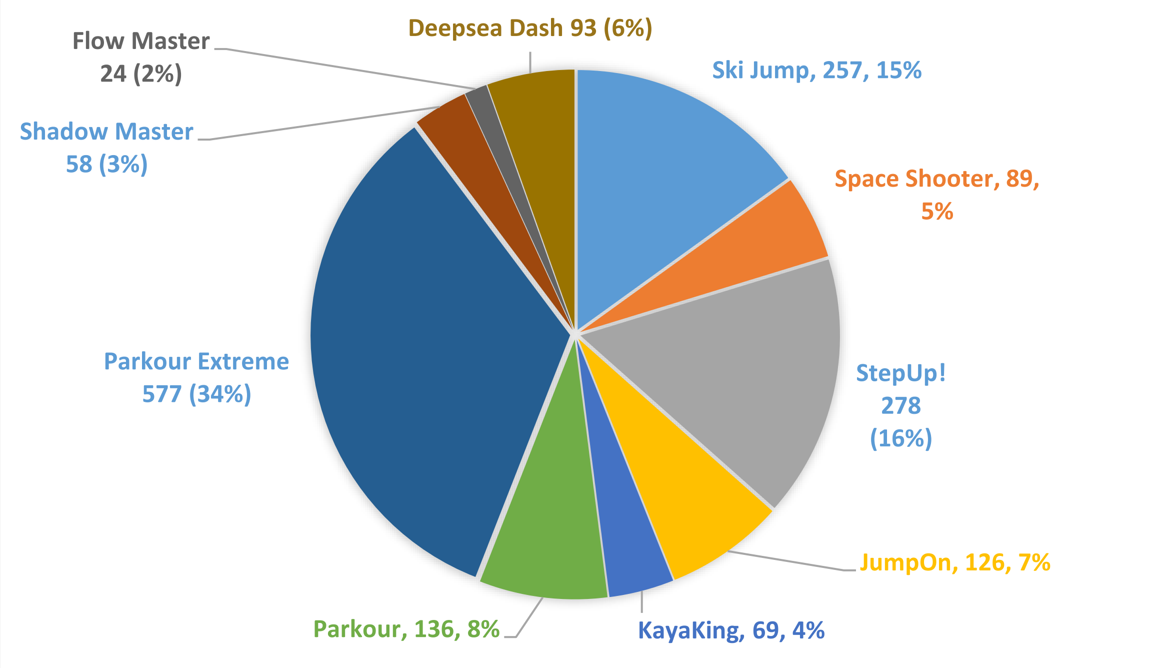

Figure 2. Game Access Frequency

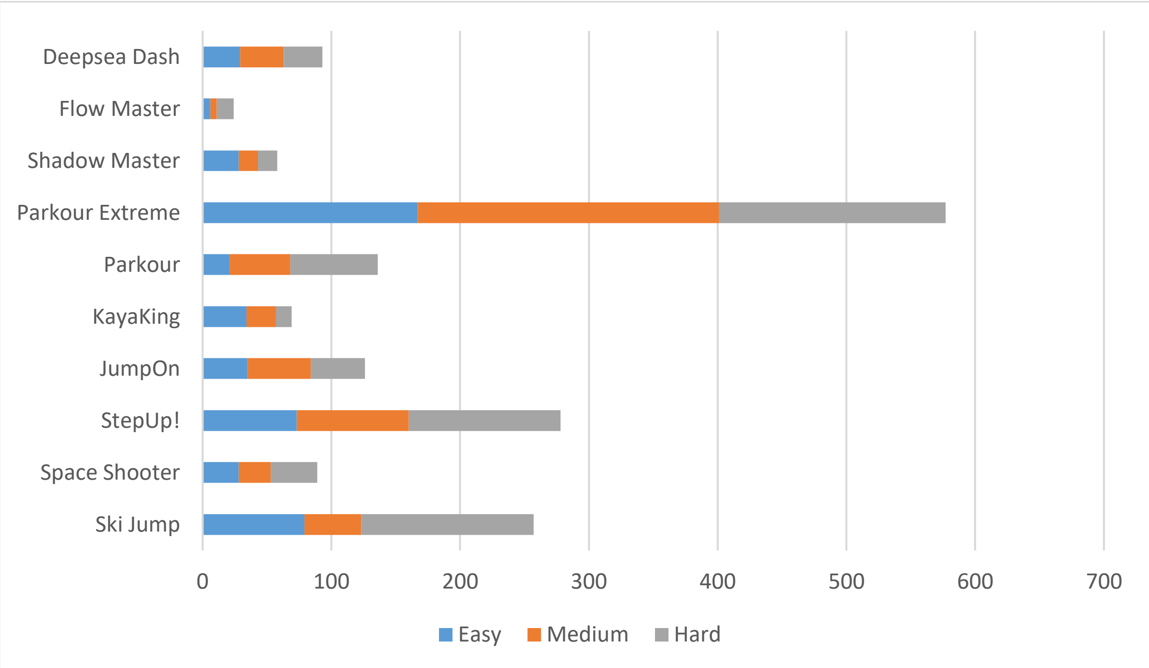

Figure 3. Game-Based Difficulty Levels and Player Frequency Selection (X-axis is the frequency)

Regarding collaborative mode, the dominant preference among students is for multiplayer mode, see Figure 4. This preference emphasizes students' inclination toward engaging with fellow peers during the exergame, fostering interaction and collaboration during gameplay.

In conclusion, this analysis of frequency in iWall usage among students reveals that the required skill sets for each exergame influence their game selection and difficulty level preferences. Games emphasizing physical endurance witness higher play frequencies, with a tendency towards the medium difficulty level. However, students opt for the hard difficulty level in games requiring precise timing. Moreover, while multiplayer mode is favored across most games, the difficulty level and game type choice are notably influenced by the specific skills demanded by each exergame.

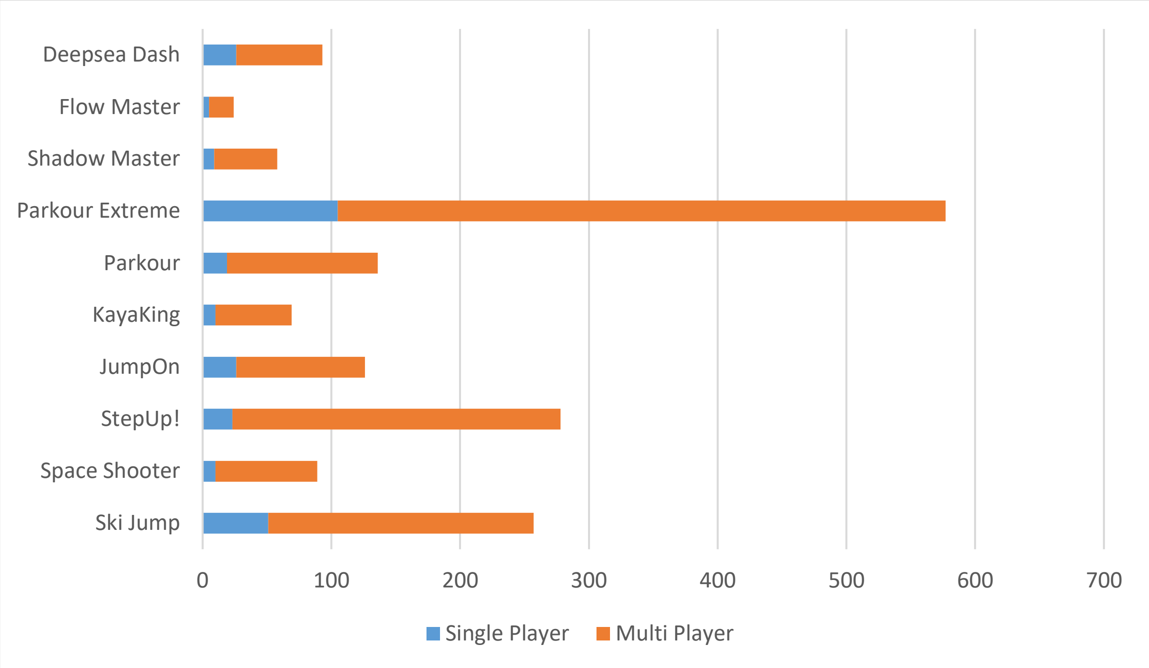

Figure 4. Collaborative mode and player frequency selection (X-axis is the frequency)

5.2 Correlation between game selection, difficulty levels and collaborative mode

This correlation analysis aims to discern the associations between variables and ascertain their interrelations. Pearson chi-square served as the test method, considering the nominal and ordinal nature of the data. The game data is nominal, while the difficulty level data, showcasing three ranks (1: easy, 2: medium, 3: hard), is deemed ordinal. Likewise, collaborative mode data, offering options between single-player and multiplayer, is nominal. The Chi-square test, selected based on the data nature of these three variables, aimed to unveil correlations among them.

The focus in chi-square computations revolved around the Asymp value. Sig. (2-sided), where a value <0.05 indicates a significant correlation. Table 2 displays the calculated outcomes for each variable relationship and their corresponding Asymp value. Sig. (2-sided). The table highlights a significant link between games and difficulty levels and a notable correlation between games and collaborative modes, evident in the Asymp value. Sig. (2-sided) of 0.000, falling below the 0.05 threshold. However, the analysis reveals no significant association between difficulty levels and collaborative modes, reflected in the Asymp value. Sig. of 0.279.

The findings emphasize a relationship between game selection and difficulty levels, signifying that specific games align with difficulty levels. This observation was previously discussed in the section outlining game frequency based on difficulty levels, such as Parkour Extreme, predominantly favored at the medium level, and StepUp! and SkiJump, with a tendency towards the hard level. Additionally, while games and collaborative modes exhibit a relationship, the preference between different collaborative mode games remains unchanged. However, disparities emerge in the proportion of games with a single-player mode, notably in Parkour Extreme and Ski Jump. Ultimately, the difficulty level appears unrelated to the collaborative modes students select, indicating an absence of correlation between difficulty levels and students' collaborative mode preferences.

Table 2. Chi-square analysis depicting the correlation between game types, difficulty levels, and student collaboration.

Pearson Chi-Square	Asymp. Sig. (2-sided)
Game – difficulty levels	0.000
Game – collaborative modes	0.000
Difficulty levels – collaborative modes	0.279

5.3 Differences in duration play based on game type, difficulty levels and collaborative mode

The subsequent phase of our inquiry focuses on analyzing play duration differences across game selection, difficulty levels, and collaborative modes. It entails using one-way analysis of variance (ANOVA) and t-test methods. Table 3 showcases the significance values concerning play duration categorized by game type and difficulty level. ANOVA is used explicitly for examining variations in gameplay duration and difficulty levels due to multiple groups being compared. In contrast, the independent sample t-test is used for collaborative modes considering only two groups (single-player and multiplayer). These tests aim to discern whether specific variables impact the duration of student engagement in exergames. The duration of play is significant in this context as it recruits students' time spent playing based on each variable, whether in short, intense sessions or over extended periods. A significance value below 0.05 implies a statistically significant difference in duration based on either game type or difficulty level. Both one-way ANOVA analyses demonstrate compelling results for duration concerning game types and difficulty levels, yielding a significant value of 0.000, indicating statistical significance as it falls below 0.05. It suggests evident disparities in game duration attributed to variations in game types and difficulty levels. The subsequent step involves continuing with the Duncan Test, elucidated in the subsequent section. Moreover, in the independent sample t-test, visible discrepancies in play duration based on collaborative mode are also apparent.

Table 3. One-way ANOVA and t-test analysis reveals differences in game duration based on game types and difficulty levels.

	Stat. test	**Sig.**
Differences in play duration based on game	Anova	0.000
Differences in play duration based on difficulty levels	Anova	0.000
Difference in play duration based on collaborative modes	t-test	0.000

Subsequently, a more detailed examination of game types and their distinctions and significant differences is elucidated through further testing utilizing the Duncan test, expounded in Table 4. Each game is categorized based on notation, assigned when the average duration falls within the same column. With five columns, we employ notations denoted by the letters a to e. For instance, Sky Jump, exhibiting the lowest average duration, is designated as notation a, distinguishing it from other games. Parkour Extreme and Kayaking share the same average duration and are assigned notation b. The subsequent four games, namely Shadow Master, JumpOn, Parkour, and Flow Master, share a typical average and are designated as notation c. Step Up! and Space Shooter fall under notation d. Lastly, Deepsea Dash, with the highest average duration, is assigned notation e, signaling its divergence from other game types.

Table 4. Duncan test illustrates significant differences in game duration based on game types.

Game types	N	Subset for alpha = 0.05					Notation
		1	2	3	4	5	
Ski Jump	257	21.930					a
Parkour Extreme	577		64.029				b
KayaKing	69		71.971				b
Shadow Master	58			88.121			c
JumpOn	126			90.143			c

Parkour	136			90.904			c
Flow Master	24			94.750			c
StepUp!	278				103.989		d
Space Shooter	89				105.157		d
Deepsea Dash	93					146.699	e
Sig.		1.000	.050	.138	.773	1.000	

Moving to Table 5, we employed the Duncan Test to investigate significant differences in game durations based on difficulty levels. The results, categorized by notation due to the two columns, reveal two notations: a and b. Notably, Easy, with the lowest average duration, is denoted as a, differentiating it from other difficulty levels. In contrast, Hard and Medium share notation b, indicating no significant difference between their average durations. This context highlights that, within the difficulty levels, Easy exhibits the lowest average duration, while Medium stands out as having the highest average duration.

Table 5. Duncan test unveils notable distinctions in game duration based on difficulty levels.

Difficulty Levels	N	Subset for alpha = 0.05		Notation
		1	2	
Easy	500	67.132		a
Hard	644		80.255	b
Medium	563		80.487	b
Sig.		1.000	.923	

Due to the identified differences in play duration based on collaborative mode and the presence of only two groups, the continuation of the Duncan test was unnecessary. However, for illustrative purposes, we have presented the mean and standard deviations between the two groups in Table 6. This depiction aims to offer a comprehensive view of the distinctions between the groups.

Table 6. Mean and standard deviation in collaborative mode

Group	Mean	Std. Deviation
Single player	63.560	44.06
Multiplayer	79.067	39.54

6. Discussion

In well-being education, the prevalent focus often gravitates toward mental well-being in numerous studies, inadvertently sidelining the intrinsic link between mental and physical well-being. The educational emphasis on physical well-being predominantly revolves around sporting activities, which overlooks students who might not resonate with sports. To address this gap, exergames were introduced within the domain of well-being education. However, due to its novelty, previous research primarily delved into student behavior and the impact of exergames on learning outcomes. In our study, we aimed to explore student preferences within exergames, unveiling how these games captivate and foster an enjoyable experience in achieving physical well-being. Thus, in this discussion section, we scrutinize our findings and intertwine them with Self-Determination Theory (SDT), unraveling insights into students' preferences in exergames.

6.1 The frequency of student engagement in exergames sheds light on autonomy, competence, and relatedness within SDT

Examining the results underscores how students exercise autonomy by selecting from ten available games and tailoring their experiences to suit their pursuit of physical well-being. This departure from past studies, which typically constrained participants to one or two predetermined games, represents a novel aspect of our research. Notably, games emphasizing physical endurance and rhythmic coordination are popular among students. This facet still needs to be explored in current literature despite the known benefits of such games, particularly in enhancing physical fitness, muscle strength [42], [43], and rhythm sense [44], [45], as evidenced by studies involving small-sided games. This uncharted terrain underscores an autonomy-driven preference among students for physically enduring and rhythm-coordinated exergames.

Moreover, examining the level of difficulty reveals varied tendencies across games. Generally, more challenging difficulty levels see more frequent student selection, albeit with distinct preferences for each game. For instance, students typically opt for the medium difficulty level in Parkour Extreme, focusing on physical endurance. Conversely, games emphasizing timing features attract more students to the more hard levels. Comparisons with existing studies are limited, as difficulty levels in exergames primarily serve as interventions to improve physical abilities, a trend predominantly observed in health sector research [46], [47]. These findings significantly contribute to understanding competence within SDT, highlighting that students' difficulty level preferences align with their skill proficiency, potentially augmenting their sense of competence.

Finally, collaborative modes reveal a prevalent preference for multiplayer exergames among students. Prior research offers diverse perspectives, suggesting that higher quest complexity prompts students to choose multiplayer modes for collaborative quest completion [48]. Alternatively, other viewpoints highlight psychological motives, reflecting human inclinations for interaction, cooperation, or competition in gaming contexts [49], [50], [51]. This predilection for multiplayer engagement underscores relatedness within SDT, signifying students' proclivity towards interactive engagements with peers.

6.2 Correlation of game, level of difficulty, and collaborative mode and its review for student preferences based on SDT

The correlation analysis investigated the relationship between game selection, difficulty levels, and collaborative modes, elucidating student preferences within SDT's psychological needs. Results unveiled a significant association between games and difficulty levels, indicating a consistent pattern where particular games align with specific difficulty levels. It underscores student autonomy in game selection and in shaping their play experiences, revealing a competence-related aspect. Analogous to health contexts where patients' decisions to elevate difficulty levels during therapy impact physical success, students' success in mastering different exergame levels relates to their learning experience [52], [53].

Moreover, the correlation between games and collaborative modes elucidated a significant relationship. It mirrors the intertwined facets of autonomy and relatedness, unveiling students' inclination toward social connectedness during collaborative gameplay. Studies such as Trespalacios et al. [54] suggest that students' preference for multiplayer engagements in games aligns with their enjoyment derived from interacting with other human-controlled players, highlighting the social aspects of gameplay over computer-controlled interactions.

Conversely, the analysis found no correlation between difficulty levels and collaborative modes. This counters prior studies indicating that higher quest difficulty fosters collaborative gameplay [55], [56]. This divergence might be due to the emphasis in this study on exergames centered on body movement, unlike popular action games that rely less on physical movement. Thus, students' preference for multiplayer engagement appears unrelated to the game's difficulty level.

In summary, while correlations exist within the context of SDT's autonomy, competence, and relatedness, the absence of correlation between competence and relatedness, precisely the collaborative mode's independence from difficulty levels, suggests a predominant link between student competence and their preference for collaborative gameplay, irrespective of the game's difficulty level.

6.3 The influence of game, level of difficulty, and collaborative mode on play duration

The impact of game selection, difficulty levels, and collaborative mode on play duration was scrutinized to discern the influence of autonomy, competence, and relatedness on the duration of gaming sessions. Firstly, analyzing the play duration of games revealed significant differences, indicating varying lengths of student engagement across different games. Interestingly, games with high-frequency access, like Parkour Extreme, exhibited lower average play duration than games with lower access frequencies. Based on previous study, this discrepancy could stem from varying levels of physical demand in different exergames [57]. Parkour Extreme requires high physical endurance, while games like Deepsea Dash or Space Shooter emphasize strategy, spatial awareness, and prolonged play duration despite lower access frequency.

Concerning difficulty levels, distinct differences in play duration were evident, notably in the easy difficulty level, showing the shortest play duration compared to medium and hard levels. Despite hard levels being frequently chosen, the play duration remained relatively shorter, suggesting a potential discrepancy between preference and actual engagement duration. Medium-level challenges appeared more enjoyable, reflecting the longest play duration despite being the second most chosen difficulty level.

Regarding collaborative modes, a significant disparity in play duration emerged between single-player and multiplayer modes, with multiplayer mode manifesting a notably longer play duration. It aligns with previous findings indicating that multiplayer modes foster prolonged engagement [58]. The hypothesis posits that this preference for multiplayer engagements might be attributed to heightened social connectedness among students, aligning with the relatedness aspect, a psychological need in exergames for collaborative or competitive interactions.

The analysis demonstrated that game choice, difficulty levels, and collaborative mode significantly impact play duration. Certain games, specific difficulty levels, and multiplayer modes tend to foster longer play durations, exemplified by Deepsea Dash, medium difficulty, and multiplayer mode being associated with the lengthiest play durations.

6.4 Possible development of exergames for well-being education in the future

The outcomes of this study offer valuable guidance for leveraging exergames within future well-being education research. Examining gameplay frequency suggests the potential for developing exergames focused on physical endurance or rhythmic coordination, emphasizing multiplayer elements to align with students' inclination toward social connections. Rather than game selection, autonomy could be channelled into tailoring difficulty levels, potentially concentrating on medium and hard tiers or employing escalating difficulty across gameplay levels, thereby ensuring autonomy and competence within well-being.

Expanding on correlations, initial emphasis on exergames targeting physical wellness and rhythmic coordination is recommended. Furthermore, regarding game development, the exergame with time feature could be coupled with hard difficulty levels, reflecting students' affinity for more demanding tasks in such game types. It underscores the role of difficulty, a facet of competence, in shaping students' learning experiences within exergame contexts.

The analysis of play duration unveils intriguing insights, revealing that games requiring strategic thinking or spatial awareness tend to extend gameplay compared to those predominantly focused on physical endurance. This suggests integrating elements demanding more cognitive engagement into future exergame designs, possibly combining strategic or spatial aspects with physical activities for a holistic gaming experience.

This study overviews students' preferences concerning exergames in well-being education. An analysis of iWall data illuminates students' distinct preferences in gameplay frequency, correlations among variables, and disparities in play duration. These findings promise to inform the evolution of exercise games tailored for education on well-being. The findings of this study also present a novel contribution with significant potential for advancing the development of exergames tailored to primary school contexts. Previous research has focused on specific age groups or individuals with particular health conditions. For instance, Wang's study [59] explored exergame preferences among senior adults, while Berglund et al. [60] examined design considerations for Augmented Reality mobile exergames aimed at inactive older adults with heart failure. Similarly, Alharbi and Alhalabi [61] focused on exergames for individuals with obesity. These studies predominantly emphasize health-related outcomes.

In contrast, the present study provides new insights for developing exergames within an educational framework, particularly for primary school implementation as part of well-being education outside of the formal learning hours. Despite the increasing interest in this area, students' preferences for exergames remain underexplored. Given the diversity of exergame types, it is essential to evaluate factors such as genre, difficulty level, collaborative modes, and other aspects aligned with student preferences to ensure meaningful and effective integration of exergames in educational settings.

7. Conclusions

This study explores the intricacies of students' preferences within exergames for well-being education. Through examining gaming frequency, interrelations among variables, and gameplay duration, valuable insights emerge, highlighting the pivotal role of autonomy, competence, and social connectivity in students' engagement with exergames.

The analysis unraveled distinctive trends in gaming frequency, showcasing a predilection for exergames focusing on physical stamina, rhythmic coordination, and multiplayer engagement. Moreover, correlation analysis unveiled the intricate interplay between game genres and difficulty levels, elucidating how the challenges embedded in games influence student preferences. Furthermore, an analysis of play duration sheds light on the influence of game genres on the duration of gameplay, emphasizing the necessity for diverse cognitive and physical challenges in exergame design.

Nonetheless, certain constraints warrant careful consideration. This study's reliance on data sourced from a specific exergame platform iWall may constrain the broad applicability of the findings to other gaming environments. Additionally, sample size and demographic characteristics might have influenced observed preferences, prompting prudence in extending these findings to broader student populations. The inability to directly compare the difficulty levels across different iWall game genres is also a limitation in this study.

Moreover, the research primarily hinges on quantitative analysis, potentially overlooking qualitative nuances and individual inclinations that could enrich comprehension of student interactions with exergames. Furthermore, this study primarily explores preferences without delving deeply into specific educational or health outcomes tied to gaming preferences, leaving unexplored potential impacts on well-being or learning outcomes.

Acknowledging these constraints, future investigations should embrace diverse methodological approaches, integrate qualitative perspectives, and encompass broader participant demographics to understand better how exergames can optimize strategies within well-being education.

Conflict of interest

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As part of transparency, we acknowledge that in the final version of this article, we checked the accuracy of grammar and elevated several academic expressions with the help of a large language model, Chat GPT 3.5.

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