

## **The Dark Side of Gamification: An Experimental Study on Digital Fitness Apps**

### **Structured Abstract:**

#### **Purpose**

This study, anchored in Self-Determination Theory, explores the paradoxical effects of gamification on digital health promotion, focusing on user engagement, physical activity adherence, stress levels, and social dynamics.

#### **Design/methodology/approach**

In a preregistered experimental design, participants interacted with one of three fitness apps: a non-gamified control app, a competition-based gamified app (GameFit), or a self-exploration-based gamified app (ExploreFit). Quantitative data were collected through scales measuring key variables, and qualitative insights were gathered from structured diaries.

#### **Findings**

Gamification significantly enhanced user engagement and physical activity adherence. However, competition-based gamification also increased stress and negative social dynamics, with gender-specific effects: females experienced higher stress, and males encountered more negative social dynamics. These adverse effects were mitigated in the ExploreFit group, suggesting that self-exploration elements in gamification can reduce negative outcomes.

#### **Originality**

This research offers a comprehensive analysis of the complex interplay between gamification, competition, self-exploration, and health outcomes. It provides valuable insights for the design of persuasive technologies, highlighting the need for a balanced approach to gamification that considers both its benefits and potential pitfalls.

**Keywords:** Gamification, Fitness Applications, Health Promotion, User Engagement, Negative Effects of Gamification

## **1. INTRODUCTION**

Gamification, which involves the integration of game design elements into non-game contexts, has been identified as a powerful strategy for enhancing user engagement and motivation across various domains, including digital health promotion such as fitness applications (apps) (Deterding et al., 2011a; Carcioppolo et al., 2022; Mørch et al., 2019). The existing literature has highlighted the potential benefits of gamification in digital health promotion and its widespread adoption (Cheng et al., 2019; Patel et al., 2017; Wen & Guo, 2023). It has been shown to foster user engagement and enjoyment, thereby encouraging greater participation in health activities (George & George, 2022). Notably, the impact of gamification on digital health promotion is complex and multifaceted. For instance, Yang & Li (2021) found that the use of gamification in fitness apps was positively associated with privacy invasion and social overload, potentially leading to gamification exhaustion. Similarly, Sun & Jiang (2022) discovered that the social comparison elements of gamification might decrease users' exercise intentions. Further, Li et al. (2023) documented a U-shaped relationship between competition in gamification and technological exhaustion. These findings underscore the need for a nuanced understanding of the effects of gamification in digital

health promotion.

Despite the insights provided by the existing literature (e.g. see Zhang, Jiang, Lowry, and Li, 2018), it does not yet offer a comprehensive understanding of how gamification impacts digital health promotion across all dimensions of health. These dimensions include physical health, which pertains to the body's ability to perform physical activities and resist diseases; mental health, which encompasses emotional and psychological well-being, affecting how we think, feel, and act; and social health, which involves the ability to form satisfying interpersonal relationships, adapt to social situations, and perform social roles (Arora & Razavian, 2021; Esmaeilzadeh, 2021). Furthermore, while the majority of existing studies primarily rely on survey methods, which certainly provide valuable empirical evidence, they may not be able to establish the causal effects of gamification on digital health promotion with the same level of rigor as experimental designs. This study employs an experimental design, utilizing scale feedback from participants and conducting regression analyses to examine the relationships between gamification, user engagement, physical activity adherence, stress levels, and social dynamics. The mechanisms through which gamification can lead to negative consequences are also not clearly identified. As Johnson et al. (2016) argued, more rigorous identification strategies, such as randomized controlled trials and double-blind experiments, are necessary to isolate the effects of individual game design elements on mediators like user experience or motivation and health and wellbeing outcomes.

In response to these gaps in the literature, our study aims to explore the paradox of gamification, where it can both enhance and potentially undermine health outcomes. We employ Self-Determination Theory (SDT) (Deci & Ryan, 2013) as our guiding framework, providing a theoretical basis for our investigation. This study embarks on an in-depth exploration of the intricate relationship between gamification in fitness apps

and the aforementioned dimensions of health, grounded in the principles of SDT. By doing so, our research aims to fill the existing void in the literature, offering a more nuanced understanding of the effects of gamification in digital health promotion.

Informed by SDT, we propose three main research questions:

1. How does gamification in fitness apps influence the different dimensions of health - physical, mental, and social?
2. What are the mechanisms through which gamification can lead to negative effects on these health dimensions?
3. What factors moderate the effects of gamification on these health dimensions, and how do these factors interact with the design elements of the fitness apps?

SDT posits that individuals have three basic psychological needs - autonomy, competence, and relatedness - that when satisfied, lead to optimal function and growth. In the context of our study, these needs translate into the desire for control over one's actions (autonomy), the desire to effectively interact with the environment (competence), and the desire to feel connected with others (relatedness) (Wang et al., 2021). We hypothesize that gamification elements in fitness apps can support these needs, thereby enhancing user engagement and adherence to physical activity (physical health), reducing stress levels (mental health), and fostering positive social interactions (social health). However, if gamification elements overemphasize competition or fail to support these needs, they could potentially lead to negative effects, such as increased stress and negative social dynamics (Brownlow, 2022; Chen & Zhao, 2022).

In our preregistered experiment, users were divided into three groups: one using a fitness app without any gamification elements (control), one using a competition-based gamified app (GameFit) characterized by leaderboards, points, and challenges, and one using a self-exploration-based gamified app (ExploreFit) which highlighted personal

progress tracking, exploration tasks, and self-set goals. These designs allowed us to examine the impacts of different gamification strategies in fitness apps. The experiment involved tracking a range of variables, including user engagement, physical activity adherence, stress levels, and social dynamics among users. In addition to the experimental design, we also incorporated diary research into our methodology. Participants were asked to keep structured diaries throughout the experiment, documenting their experiences with the fitness apps. This provided us with rich qualitative data that complemented the quantitative findings from the experiment. The diary entries allowed us to delve deeper into the users' experiences with the gamified systems and uncover the underlying mechanisms through which gamification impacts users' health outcomes.

Our findings reveal a paradox in the role of gamification in fitness apps. While it significantly boosted user engagement and adherence to physical activity, competition-based gamification also introduced unintended consequences. It led to an overemphasis on extrinsic motivation, potentially overshadowing intrinsic motivation for fitness, aligning with the Self-Determination Theory's caution against overemphasizing external rewards (Eikey, 2021). We observed increased stress levels among users, particularly females, in the competition-based gamification group. This could be due to the competitive nature of the game elements, aligning with the “Tend & Befriend” theory's suggestion that women may respond to stress differently than men (Taylor, 2006). We also noticed an increase in negative social dynamics, particularly among male users, in the competition-based gamification group, suggesting that gamification may inadvertently foster unhealthy competition or comparison among users (Zhang et al., 2021). However, these adverse effects were mitigated in the self-exploration-based gamified app group, highlighting the potential of self-exploration in gamification design.

This study contributes to the HCI literature on gamification, particularly focusing on its impacts within fitness apps. While user engagement and physical activity adherence have been well-documented benefits of gamification (Cotton & Patel, 2019; Edwards et al., 2016a; Esmailzadeh, 2021; W. Feng et al., 2020a; Y. Feng et al., 2022; Tu et al., 2019; Wu et al., 2015; Yin et al., 2022), our research extends this understanding by exploring the potential negative effects on stress levels and social dynamics. Our findings suggest that an overemphasis on competition, a frequent feature in gamified systems, could undermine intrinsic motivation, elevate stress, and foster negative social dynamics (Alahäivälä & Oinas-Kukkonen, 2016; Johnson et al., 2016; King et al., 2013; Pereira et al., 2014; Sardi et al., 2017). By offering a balanced perspective on the role of gamification, our study fills a critical gap in the literature, informing the design of more effective, user-friendly gamified systems (Yang & Li, 2021).

A unique contribution of our study is the revelation of gender-specific effects of competition-based gamification. Our findings indicate that females experience increased stress, while males encounter more negative social dynamics in the competition-based gamification group. This highlights the importance of considering user demographics in the design and implementation of gamified systems, a factor often overlooked in current HCI research (Breslin & Wadhwa, 2018; Posard, 2014).

## **2. THEORY AND HYPOTHESES DEVELOPMENT**

Our research, grounded in the Self-Determination Theory (SDT), aims to explore the multifaceted impacts of gamification on user engagement, physical activity adherence, and potential negative effects on psychological and social dimensions of health in the context of fitness apps. SDT, a robust theory of motivation, posits that individuals are driven to grow and change by three innate and universal psychological needs: competence, relatedness, and autonomy (Deci & Ryan, 2000).

Competence is about feeling effective in one's interactions with the environment. In the context of fitness apps, gamification elements like points, badges, and levels can enhance this sense of competence by providing tangible indicators of progress and achievements (Lister et al., 2014). This could lead to increased user engagement and physical activity adherence.

Relatedness is the desire to connect with others and to feel part of a community. Fitness apps can potentially enhance this sense of relatedness through social features like leaderboards, achievement sharing, and social challenges (Edwards et al., 2016). However, while these features can foster a sense of community, they can also lead to negative social dynamics. For instance, the competitive nature of some gamified systems can foster hostility or unsportsmanlike behavior among users. This could potentially undermine the user's sense of relatedness and lead to decreased engagement with the app.

Autonomy refers to the need to be the origin of one's own behavior and to act in harmony with oneself. In the context of fitness apps, this need could be undermined if the rewards system overshadows the inherent enjoyment or satisfaction derived from the activity itself. This phenomenon, known as the overjustification effect, suggests that an overemphasis on rewards could undermine intrinsic motivation, potentially leading to decreased long-term engagement (Deci et al., 1999).

In our literature review, we identified the key variables for our study from both past literature and qualitative methods. User engagement and physical activity adherence were identified through extensive quantitative research studies. For instance, George & George (2022) and Patel et al. (2017) provided important data on user engagement and

physical activity adherence through large-scale surveys and empirical analysis.

Stress levels and social dynamics have also been well-documented in existing quantitative literature. Studies by Yang & Li (2021) and Sun & Jiang (2022) used surveys to demonstrate the effects of competitive gamification on stress levels and social dynamics. Li et al. (2023) further explored this relationship through quantitative methods, using regression analysis to highlight the U-shaped relationship between competition and technological exhaustion.

To supplement the insights from quantitative literature, we conducted qualitative interviews with users of fitness apps. This approach allowed us to capture a broader range of variables and ensured that our study addresses real-world concerns and behaviors. The qualitative insights helped refine our understanding of how gamification affects different health dimensions, which were not fully explored in previous quantitative studies (Arora & Razavian, 2021; Esmaeilzadeh, 2021).

By combining insights from both past quantitative literature and qualitative methods, we have ensured that our study variables are comprehensive and relevant to the research objectives.

## **2.1 Gamification, Engagement, and Physical Activity Adherence**

Informed by the Self-Determination Theory (SDT), our research explores how gamification, defined as the use of game design elements in non-game contexts (Deterding et al., 2011), enhances user engagement and adherence to physical activity in fitness apps. These apps often employ gamification mechanisms like narrative design to motivate users towards their real-world fitness goals, leading to higher persistent usage of the app (Hsu et al., 2017).

Engagement here refers to the degree of interaction with the app, its frequency of use, and the user's commitment to long-term usage. Although there is evidence suggesting that not all users maintain long-term engagement with fitness apps, gamification is generally known to increase initial engagement and promote app use in the short to medium term (Conroy et al., 2014).

SDT suggests that the three basic psychological needs—competence, autonomy, and relatedness—are essential for fostering intrinsic motivation and promoting user engagement (Ryan & Deci, 2000). Gamification can enhance these needs in unique ways. For instance, elements like points, badges, and levels provide tangible indicators of progress and achievements, enhancing the user's sense of competence (Villalobos-Zúñiga et al., 2021).

Autonomy can be supported by providing users with choices and options within the fitness app, such as selecting different challenges or setting personal goals (Wang et al., 2021a). Furthermore, many fitness apps incorporate social features, such as leaderboards or achievement sharing, fostering a sense of community among users and enhancing their feelings of relatedness (Brownlow, 2022).

While these gamified elements can boost user engagement, they also play a pivotal role in promoting adherence to physical activity. Evidence suggests that enhancing users' feelings of competence through achievement and progress can increase their motivation to stick with physical activity routines (Hanus & Fox, 2015). Empirical findings from various studies, such as Lyons (2015), Lister et al., (2014), and Alahäivälä & Oinas-Kukkonen (2016), support these theoretical considerations and highlight the effectiveness of gamified elements in increasing physical activity adherence.

Given this understanding, we propose Hypothesis 1 (H1) and Hypothesis 2 (H2):

**H1:** Gamification in fitness apps will increase user engagement.

**H2:** Gamification in fitness apps will improve adherence to physical activity

### **2.3 Negative Effects of Gamification**

The Self-Determination Theory (SDT) provides a useful framework for understanding the potential negative effects of gamification in fitness apps. According to SDT, the psychological needs of competence, autonomy, and relatedness are crucial for fostering intrinsic motivation. However, certain aspects of gamification could potentially undermine these psychological needs, leading to negative outcomes.

The overemphasis on extrinsic motivation in gamification is one such potential issue. This is derived from the SDT's emphasis on intrinsic motivation, which is closely linked to the psychological need for autonomy. If gamification elements in fitness apps overemphasize external rewards, such as points or badges, they may overshadow the inherent enjoyment and satisfaction derived from the physical activity itself, potentially leading to exacerbated symptoms of eating disorders (Eikey, 2021).

Besides the risk of overemphasizing extrinsic motivation, gamification may also inadvertently contribute to increased stress levels among users due to the competitive elements. This is based on the SDT's concept of competence. Leaderboards and other competitive elements could induce stress among users, particularly those who may not be performing as well as others. This could undermine their feelings of competence and efficacy, and raise ethical challenges (Arora & Razavian, 2021). This concern is further

nanced by the Tend and Befriend theory (TB), which suggests that women may respond to stress with activities of mutual care (“tend”) and social connectivity (“befriend”) to increase odds of evolutionary survival and self-regulation.

Moreover, gamification could potentially give rise to negative social dynamics, which is linked to the SDT's concept of relatedness. Pressure to keep up with peers or hostility among users could undermine users' feelings of connectedness and belonging. These social dynamics, such as social comparison and competition, can impact users' participation in group physical activities (Zhang et al., 2021).

In the context of competition-based gamification, these negative social dynamics could be exacerbated. For instance, leaderboards, which rank users based on their performance, could foster a competitive environment that might lead to hostility or unsportsmanlike behavior among users. This could potentially undermine the user's sense of relatedness and lead to decreased engagement with the app.

Furthermore, research suggests that gender may play a role in how individuals respond to competition. For instance, studies have shown that men tend to be more competitive than women (Gneezy & Niederle, 2003). This could potentially mean that men are more likely to engage in negative social dynamics in a competitive environment. On the other hand, women, who are generally more cooperative and less competitive than men (Eagly & Wood, 1999), might be more negatively affected by the competitive environment, leading to increased stress levels.

Lastly, we consider the potential role of self-exploration-based gamification. This design approach emphasizes self-discovery and personal growth, offering users the opportunity to explore different challenges or goals based on their preferences. The aim

is to foster a sense of autonomy, one of the key psychological needs according to the SDT, and to enhance intrinsic motivation by making the fitness experience more personally relevant and meaningful. This approach could potentially avoid the pitfalls of competition-based gamification, such as stress and negative social dynamics.

Therefore, based on the theoretical underpinnings of SDT and empirical research, we can formally propose the following hypotheses.

**H3:** Competition-based gamification in fitness apps will lead to an overemphasis on extrinsic motivation.

**H4a:** Competition-based gamification in fitness apps will increase stress levels among users.

**H4b:** The positive effect between competition-based gamification in fitness apps and stress level is more pronounced for female participants.

**H5a:** Competition-based gamification in fitness apps will increase negative social dynamics.

**H5b:** The positive effect between competition-based gamification in fitness apps and negative social dynamics is more pronounced for male participants.

## **2.4 Self-Exploration-Based Gamification: A User-Centric Approach to Health Promotion**

Lastly, we delve into the potential role of self-exploration-based gamification, a design approach that diverges notably from the conventional competition-focused models. This strategy emphasizes self-discovery and personal growth, resonating with the principles of Self-Determination Theory (SDT) which emphasize autonomy, competence, and relatedness as core psychological needs.

Specifically, self-exploration-based gamification is grounded in fostering a sense of autonomy, a crucial psychological need according to SDT. By offering users the opportunity to explore different challenges or goals based on their personal preferences and interests, this approach aims to enhance intrinsic motivation (Wang et al., 2021; Oliveira & Carvalho, 2020). This is in stark contrast to extrinsically driven gamification methods that rely heavily on external rewards like points or leaderboards. By making the fitness experience more personally relevant and meaningful, self-exploration-based gamification aligns more closely with intrinsic motivational factors, which are key to long-term engagement and well-being (Bitrián, Buil, & Catalán, 2021; Garrido et al., 2022).

Further, a significant advantage of this approach is its potential to circumvent the negative consequences commonly associated with competition-based gamification. Our research indicates that competitive elements in gamification can exacerbate stress and foster negative social dynamics (Mamede et al., 2021; Litvin et al., 2020). In contrast, a self-exploration approach can mitigate these issues by removing the competitive element and focusing on personal progress and fulfillment (Kubota et al., 2022; Polo-Peña et al., 2020).

Finally, recent psychological research has highlighted the benefits of self-determination and personal agency in various domains, including health and wellness (Ntoumanis et al., 2020; Xu et al., 2022). These studies suggest that when individuals engage in activities that are aligned with their personal values and interests, they experience higher levels of satisfaction and psychological well-being. Self-exploration-based gamification taps into this principle by allowing users to engage in a manner that feels personally enriching rather than externally imposed (Gómez-del-Río et al., 2020; Ma et

al., 2022). Furthermore, the flexibility inherent in self-exploration gamification accommodates diverse user profiles, acknowledging that users have varied motivations, goals, and preferences. This approach is particularly advantageous in digital health promotion, where one-size-fits-all models often fail to address the individualized nature of health and fitness journeys (Mitchell et al., 2021).

In light of these considerations, self-exploration-based gamification represents a more holistic and user-centric approach to digital health promotion. It aligns with contemporary psychological understanding, offers a solution to the limitations of competition-focused methods, and caters to the diverse needs and motivations of users. Consequently, we propose this approach as a viable alternative to traditional gamification strategies in health apps, hypothesizing that it will lead to more sustainable engagement and positive health outcomes without the negative repercussions associated with competitive gamification.

Thus, we formally provide H6:

**H6:** Self-exploration-based gamified apps do not produce significant effects on participants' extrinsic motivation, stress levels, and social dynamics compared with non-gamified apps.

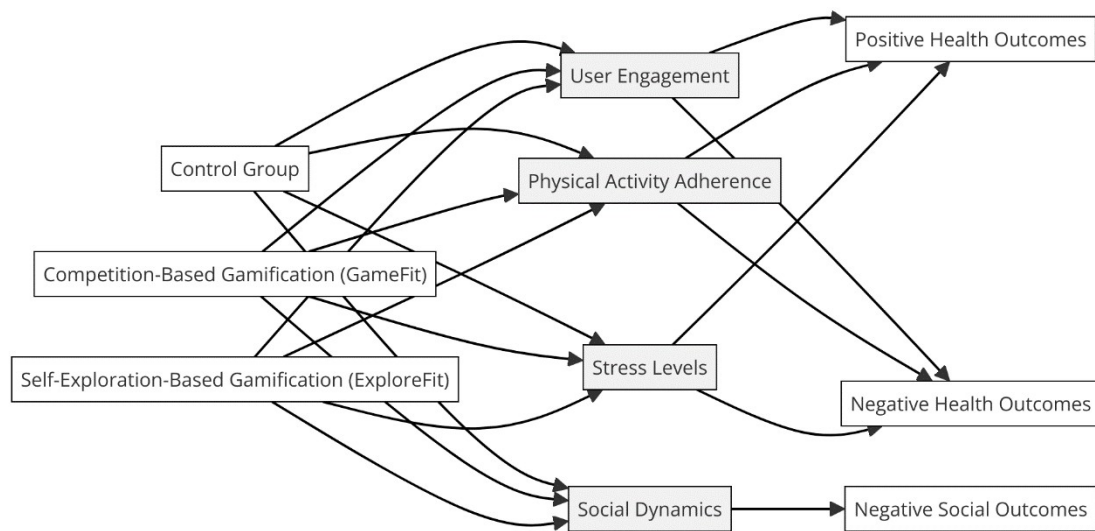
### **3. METHOD**

The method employed in this study was an experimental design, chosen for its ability to establish causal relationships between variables. This design allowed us to directly

observe the effects of gamification on user engagement and adherence to physical activity, as well as its potential negative effects.

The research model explores the impact of different gamification strategies on various mediating variables, which in turn affect health outcomes. The independent variables include the control group, competition-based gamification (GameFit), and self-exploration-based gamification (ExploreFit). The mediating variables are user engagement, physical activity adherence, stress levels, and social dynamics. These mediators influence the dependent variables: positive health outcomes, negative health outcomes, and negative social outcomes. The research model is visualized in Figure 1:

**Figure 1: Impact of Gamification Strategies on Health Outcomes**



The figure above illustrates the relationships between the gamification strategies, mediating variables, and health outcomes. It demonstrates how different strategies impact user engagement, physical activity adherence, stress levels, and social dynamics, leading to various health outcomes.

### 3.1 Rationale for Using Experiment

The experimental design was chosen because it allows for a high level of control over

the variables in the study (Bärnighausen et al., 2017; Cook et al., 2002). This control makes it possible to isolate the effects of gamification from other factors that might influence the outcomes. Furthermore, an experimental design allows for the manipulation of one variable (in this case, the presence or absence of gamification) to observe its effect on other variables (user engagement, adherence to physical activity, stress levels, social dynamics, and autonomy).

### **3.2 Participants**

The participants in this study were adult users of fitness apps, who were recruited through a diverse range of online platforms, including social media, fitness forums, and health-related websites. This recruitment strategy was designed to ensure a broad and representative sample of the general population. Participants ranged in age, gender, fitness levels, and geographical locations, reflecting the wide variety of individuals who use fitness apps.

Before conducting the experiment, we utilized power analysis, a method essential for determining the minimum sample size required to detect an effect of a given size (Collins & Watt, 2021; Uttley, 2019). Our objective was to discern a medium effect size (Cohen's  $d = 0.5$ ) at an 80% power level, a benchmark in psychological and behavioral research (Schäfer & Schwarz, 2019).

We conducted this power analysis using G\*Power (Erdfelder et al., 1996), a precise program for statistical tests in behavioral research. The analysis indicated that a sample size of 300 (100 per group) would suffice to detect a medium effect size with 80% power at the 0.05 significance level. This was calculated using a two-tailed test, ensuring a more conservative and robust estimation.

With an actual sample size of 330 (110 per group), exceeding the recommended number, we bolster our confidence in the study's ability to reliably detect medium-sized effects, underpinning the validity of our findings. This larger-than-required sample size addresses potential concerns about the adequacy of our participant pool and reinforces the strength of our conclusions.

Participants were randomly assigned to one of three groups: a control group using a fitness app without gamification, an experimental group using a fitness app with traditional gamification (competition-based), and another experimental group using a fitness app with self-exploration gamification. This random assignment was crucial to ensure that any differences observed between the groups could be attributed to the treatment (type of gamification) rather than pre-existing differences among participants. This methodological approach enhances the external validity of the study, supporting the generalizability of the findings to the broader population of fitness app users.

### **3.3 Treatment**

The treatment in this study was the use of different types of gamification in a fitness app. Participants in the control group used a fitness app without gamification elements, while participants in the two experimental groups used similar apps that incorporated different types of gamification features. These features included earning points for workouts, unlocking achievements, competing with friends, and progressing through levels as users meet their fitness goals. We have designed three apps for this study: the control app, which we've named 'FitnessFirst', the competition-based gamified app, which we've dubbed 'GameFit', and the self-exploration gamified app, which we've named 'ExploreFit'.

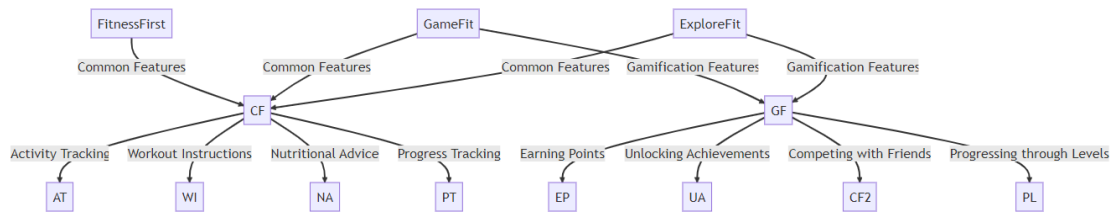
FitnessFirst is a comprehensive fitness app designed to assist users in their pursuit of health and wellness. It offers a multitude of features such as activity tracking, workout instructions, and nutritional advice to guide users towards their personal health goals. The app is designed with a clean and intuitive interface, making it easy for users to navigate and access its features. It also includes a progress tracking feature that allows users to monitor their fitness journey and set personal goals.

GameFit, on the other hand, incorporates all the features of FitnessFirst but with an added layer of traditional gamification. It uses game design elements in a non-game context to enhance user engagement and motivation. Features include earning points for workouts, unlocking achievements, competing with friends, and progressing through levels as users meet their fitness goals. The aim is to make the fitness journey more enjoyable and motivating, thereby increasing the likelihood of users sticking to their physical activity routines.

ExploreFit also includes all the features of FitnessFirst, but with a different type of gamification. It emphasizes self-exploration and personal growth, encouraging users to set and achieve their own fitness goals. Features include earning points for personal achievements, unlocking new levels of workouts, and tracking personal progress. The aim is to make the fitness journey more intrinsically rewarding, thereby increasing the likelihood of users sticking to their physical activity routines.

The differences between FitnessFirst, GameFit, and ExploreFit are visualized by Figure 2:

**Figure 2:** Comparative Features of FitnessFirst, GameFit, and ExploreFit



In the above diagram, as can be seen, all three apps share common features such as Activity Tracking, Workout Instructions, Nutritional Advice, and Progress Tracking. However, GameFit and ExploreFit have additional features of Gamification, which include Earning Points, Unlocking Achievements, Competing with Friends, and Progressing through Levels. The type of gamification layer is what differentiates GameFit and ExploreFit from FitnessFirst, making the fitness journey more enjoyable and motivating for users.

### 3.4 Procedures of the Experiment

The experiment was conducted over a period of four weeks, from March to April 2023. At the start of the experiment, all participants were given a brief tutorial on how to use their assigned fitness app. They were then asked to use the app regularly throughout the experiment period (see Supplementary Files A for participation consent sheet).

During this period, data was collected on various metrics, including user engagement (measured by the frequency and duration of app usage), adherence to physical activity (measured by the consistency in meeting workout goals), social dynamics (observed through user interactions within the app).

For participants assigned to the FitnessFirst app, their journey began at the Home Screen, where they were greeted with a snapshot of their current fitness statistics. As the days progressed, they regularly visited the Workout Section, where they followed a variety of workout plans and exercises tailored to their fitness goals. The Nutrition

Section became a daily guide, providing nutritional advice and tracking their diet to ensure balanced nutrition. The Profile Section served as a personal space where participants could view and edit their personal information, fitness goals, and preferences, adjusting them as needed throughout the month. Lastly, the Settings section allowed them to customize the app settings to their liking, ensuring a comfortable and personalized user experience.

Participants in the GameFit and ExploreFit groups embarked on a month-long gamified fitness journey. The Home Screen, displaying their current level, points, and achievements, became a daily reminder of their progress. The Workout Section, offering points for each completed workout, motivated them to stay active regularly. The Leaderboard in GameFit added a layer of competition, showing a ranking of users based on their points, and kept them engaged throughout the month. The Achievements Section provided a sense of accomplishment, showcasing the badges or trophies they had earned. The Profile Section allowed participants to view their game stats, such as their total points, rank on the leaderboard, and earned achievements, providing a sense of progression. Similar to FitnessFirst, they could adjust the app settings in the Settings section to suit their preferences.

Throughout the month, participants in all three groups were encouraged to use the app as part of their daily routines, fully engaging with the features of their respective apps. This consistent interaction provided a comprehensive user experience and allowed for a thorough evaluation of the impact of different types of gamification in fitness apps.

At the end of the four weeks, participants were asked to complete a survey to gather their feedback on their experience using the app. This survey included questions about their motivation (intrinsic and extrinsic) and stress levels, and their feeling about

competition. The data collected from the app usage and the surveys were then analyzed to test the hypotheses.

### **3.5 Variables**

The variables in this study were user engagement, adherence to physical activity, extrinsic motivation, in-app rewards or achievements, leaderboard rankings, user interactions with rewards and leaderboard, stress levels, and social dynamics. User engagement was evaluated based on three key metrics: session length, frequency of use, and retention rate. Adherence to physical activity was evaluated based on the user's progress towards their fitness goals over time. Stress levels were measured **based upon** the development of this 10-item scale, which is grounded in extensive literature and aims to measure the level of stress experienced by participants during the use of fitness apps (Caplan; 2007; Dhir et al., 2018; Fardouly et al., 2015; Vogel et al., 2014; Chen, 2017; Hamari & Keronen, 2017; Koivisto & Hamari, 2019; Lee, 2014; Whitton, 2014). Social dynamics were evaluated by analyzing user interactions within the social features of the app (Schäfer & Schwarz, 2019; Denovan et al., 2019). See Supplementary Files B for detailed explanations of variable definitions and measurements, as well as sample of calculation process of these variables.

In addition to the experimental design, we incorporated diary research into our methodology. Participants kept structured diaries throughout the experiment, documenting their experiences with the fitness apps. This qualitative data complemented the quantitative findings from the experiment. See Supplementary Files C for the template of the structured diary.

**Table 1:** Variable names and definitions

Variable Name	Definition	Measurement
User Engagement	Evaluation based on session length, frequency of use, and retention rate	Composite score ranging from 0 to 100
Adherence to Physical Activity	Evaluation based on the user's progress towards their fitness goals over time	Composite score ranging from 0 to 100
Extrinsic Motivation	Evaluation based on how much a user's activity was driven by the desire to earn	Composite score ranging from 0 to 100

Variable Name	Definition	Measurement
	in-app rewards or achievements	
Stress Levels	Users' self-reported stress levels	Stress level on a scale ranging from 0 to 100
	Evaluation by analyzing user interactions within the social features of the app	Frequency and nature of interactions quantified to create a composite score ranging from 0 to 100

### 3.6 Manipulation Check

To ensure the validity of our experimental manipulation - the introduction of different types of gamification features in the fitness app - we conducted a manipulation check. We asked participants in the control group and both experimental groups to rate the extent to which they perceived their assigned app as "game-like" on a scale of 1 (not at all) to 7 (very much).

As expected, participants in the GameFit group ( $M = 5.8$ ,  $SD = 0.9$ ) perceived their app as significantly more game-like compared to participants in the control group ( $M = 2.1$ ,  $SD = 1.2$ ),  $t(218) = 21.47$ ,  $p < .001$ . Similarly, participants in the ExploreFit group ( $M = 5.6$ ,  $SD = 1.0$ ) also perceived their app as significantly more game-like compared to participants in the control group,  $t(218) = 20.32$ ,  $p < .001$ .

However, when comparing the two experimental groups, there was no significant difference in their perception of the app as game-like,  $t(218) = 1.25$ ,  $p = .213$ . This suggests that both types of gamifications were perceived as equally game-like by the participants.

This confirms that our manipulation of different types of gamifications was successful

and perceived as intended by the participants.

## 4. RESULTS

### 4.1 Quantitative Results

#### 4.1.1 Descriptive statistics

Table 2 presents the descriptive statistics of the participants of the experiment:

**Table 2:** Descriptive statistics for participants

Variable	No Gamification Fitness		Competition-Based Fitness		Self-Exploration-Based Fitness	
	Mean	SE	Mean	SE	Mean	SE
Age	27.92	0.66	28.13	0.81	28.66	0.78
Education Level	0.84	0.04	0.83	0.04	0.85	0.03
Gender	0.5	0.05	0.5	0.05	0.55	0.05
Income (RMB)	96545.45	3034.13	96807.21	2670.41	93554.98	2743.77

**Notes:** This table provides a comprehensive comparison of key demographic characteristics across the three groups: No Gamification Fitness, Competition-Based Fitness, and Self-Exploration-Based Fitness. It presents the mean and standard error (SE) for each demographic variable in the respective groups.

The average age of participants in the No Gamification Fitness, Competition-Based Fitness, and Self-Exploration-Based Fitness groups is approximately 27.92, 28.13, and 28.66 years, respectively. The standard errors for these means are 0.66, 0.81, and 0.78,

indicating a small dispersion in the age data within each group.

In terms of gender, the proportion of female participants is 50% in both the No Gamification Fitness and Competition-Based Fitness groups, whereas it is slightly higher in the Self-Exploration-Based Fitness group at 55%.

Regarding education level, the proportion of participants with a bachelor's degree or above is similar across all groups, at approximately 84% for the No Gamification Fitness group, 83% for the Competition-Based Fitness group, and 85% for the Self-Exploration-Based Fitness group.

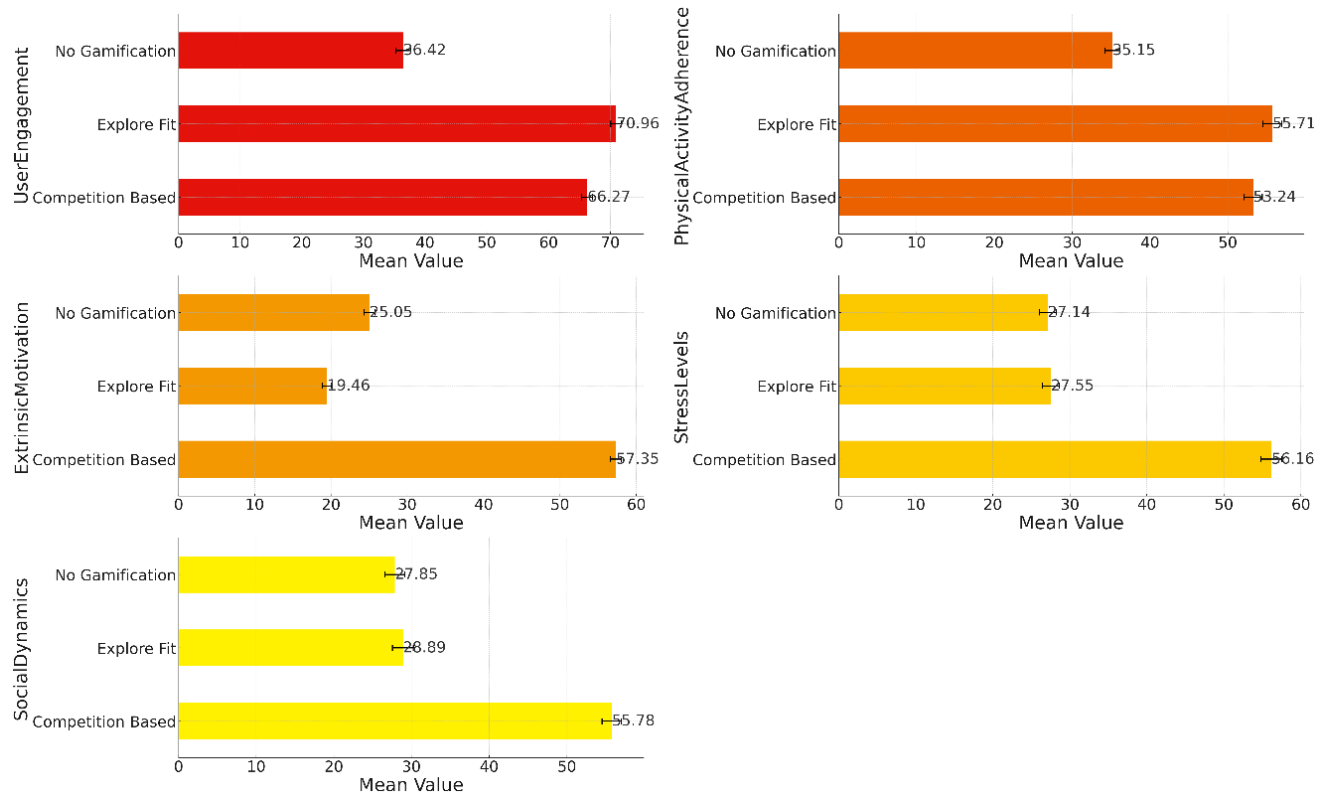
The average annual income (in RMB) is similar across the groups, at approximately 96545.45 for the No Gamification Fitness group, 96807.21 for the Competition-Based Fitness group, and 93554.98 for the Self-Exploration-Based Fitness group. The standard errors for these means are 3034.13, 2670.41, and 2743.77, respectively, showing a small dispersion in the income data within each group.

Furthermore, the t-test results confirm that the differences in these demographic characteristics across the three groups are not statistically significant, reinforcing the notion that any differences in outcomes can be attributed to the effects of the interventions (gamification features) rather than to differences in participant demographics (see Supplementary Files D for t-test results).

#### 4.1.2 Influence of Gamification on Health Dimensions and Underlying Mechanisms (RQ1 and RQ2)

Figure 3 presents the comparison results of key variables of our study:

#### **Figure 3: Comparison of key variables**



Our results reveal that the use of gamification in fitness apps significantly improves user engagement, adherence to physical activity, and extrinsic motivation, while also increasing stress levels and negative social dynamics.

For User Engagement, the mean values are approximately 36.42 for No Gamification, 66.27 for Competition-based, and 70.96 for Exploration-based apps. This suggests that users of Exploration-based apps are most engaged. The one-way ANOVA test shows that the difference in user engagement across the different types of fitness apps is statistically significant ( $F = 356.16, p < 0.01$ ).

Regarding Physical Activity Adherence, the mean values are roughly 35.15 for No Gamification, 53.24 for Competition-based, and 55.71 for Exploration-based apps. This indicates that gamification might lead to better adherence to physical activities, with

Exploration-based apps showing the highest adherence levels. The one-way ANOVA test shows that the difference in physical activity adherence across the different types of fitness apps is statistically significant ( $F = 101.83, p < 0.01$ ).

In terms of Extrinsic Motivation, the mean values are around 25.05 for No Gamification, 57.35 for Competition-based, and 19.46 for Exploration-based apps. The Competition-based apps have the highest mean value, suggesting that their nature of providing external rewards or incentives enhances extrinsic motivation. The one-way ANOVA test shows that the difference in extrinsic motivation across the different types of fitness apps is statistically significant ( $F = 871.57, p < 0.01$ ).

However, for Stress Levels, the mean values are approximately 27.14 for No Gamification, 56.16 for Competition-based, and 27.55 for Exploration-based apps. This shows that Competition-based apps also lead to the highest stress levels among users. The one-way ANOVA test shows that the difference in stress levels across the different types of fitness apps is statistically significant ( $F = 193.78, p < 0.01$ ).

Lastly, for Social Dynamics, the mean values are about 27.85 for No Gamification, 55.78 for Competition-based, and 28.89 for Exploration-based apps. This indicates that Competition-based apps promote the most positive social dynamics among users. The one-way ANOVA test shows that the difference in social dynamics across the different types of fitness apps is statistically significant ( $F = 151.36, p < 0.01$ ).

In conclusion, while our findings confirm that gamification can effectively enhance user engagement and adherence to physical activity in fitness apps, they also highlight potential drawbacks, such as increased stress levels and negative social dynamics. These findings underscore the need for a balanced approach to the design and

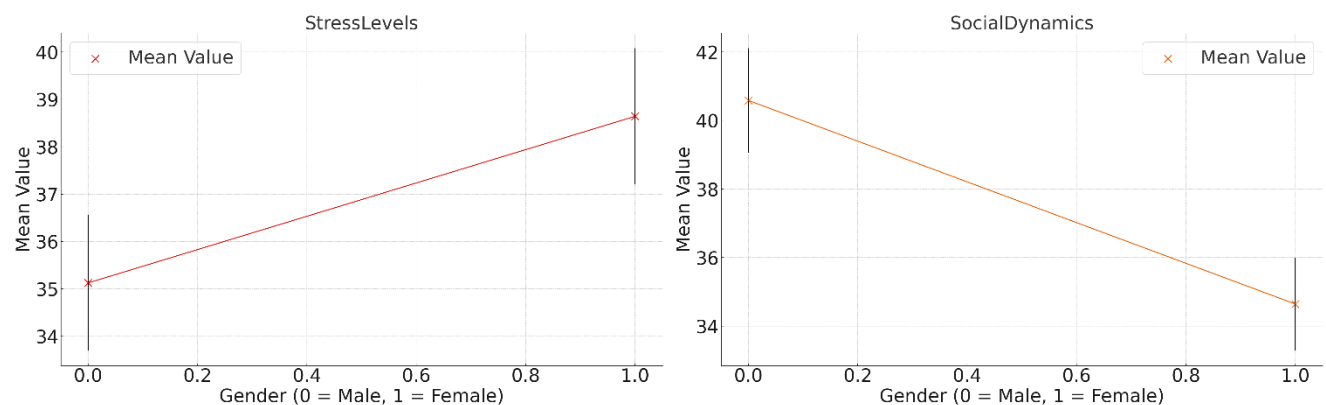
implementation of gamification in fitness apps.

### 4.1.3 Moderating Factors (RQ3)

To investigate gender differences in the effects of competition-based gamification on stress levels and social dynamics, we conducted a subset analysis within the competition-based app group of our dataset. This group was chosen for analysis because of the unique implications of competitive environments, which can elicit distinct responses from different genders due to evolutionary and sociocultural factors.

The primary variables of interest were stress levels and social dynamics, which were compared between male and female participants. Stress levels represent the psychological strain experienced by the participants, while social dynamics refer to the quality of their interactions with others in the context of the fitness app. The results are visualized by Figure 4:

**Figure 4: Gender-specific effects**



The line graph above represents the comparison of stress levels and social dynamics between male and female participants using fitness apps, irrespective of the type of

gamification used. Our t-test results reveal that while there is a trend towards higher stress levels in females, the difference is not statistically significant at the conventional 5% level (p-value approximately 0.084). However, the difference in social dynamics between males and females is statistically significant at the 1% level (p-value approximately 0.0037), suggesting a more pronounced effect for males.

Drawing from the Tend and Befriend Theory (Taylor et al., 2000), we can interpret these findings in the context of evolutionary adaptive challenges. Men, historically responsible for hunting and protecting families, tend to adopt a "fight or flight" strategy in response to stress, which often manifests as competitiveness and dominance over others. This can potentially contribute to more negative social dynamics within the context of fitness apps.

On the other hand, women, who have traditionally been caretakers, tend to adopt a "tend and befriend" strategy when faced with stress. This involves seeking social support and working collaboratively, which can mitigate the adverse effects of competition on their social dynamics.

This is supported by empirical studies, such as the meta-analysis by Jordan and Revenson (1999), which found that women typically seek more social support when facing stress than men do. Similarly, research in developmental psychology and experimental economics has shown that women tend to be more cooperative than men (Barnett et al., 1987; Engel, 2011). The interconnected nature of stress and social dynamics should be considered when interpreting these findings. Even though women are generally more sensitive to stress, the adverse social dynamics induced by competition might also cause stress in men. Thus, the gender difference in stress response to competition in fitness apps warrants further investigation.

In conclusion, our findings highlight the importance of considering gender differences in response to gamification in fitness apps. This has implications for the design of such apps, suggesting that a one-size-fits-all approach may not be optimal. Instead, app designers might consider incorporating gender-sensitive features to cater to the different ways in which men and women respond to competition and stress.

#### 4.1.4 Regression Analysis

In addition to our primary analysis, we conducted a series of regression analyses to provide robustness checks for our findings. The results are presented in Table 3:

**Table 3:** Impact of Gamification on User Engagement: A Regression Analysis

	<b>User Engagement</b>	<b>Physical Activity Adherence</b>	<b>Extrinsic Motivation</b>	<b>Stress Levels</b>	<b>Social Dynamics</b>
Age	-0.007 (0.087)	-0.012 (0.087)	0.045 (0.087)	-0.102 (0.087)	-0.002 (0.087)
Female	-0.710 (1.452)	0.385 (1.452)	-0.367 (1.452)	4.137 * (1.452)	-5.241 * (1.452)
Bachelor	-1.458 (2.246)	-2.738 (2.246)	1.325 (2.246)	-1.715 (2.246)	0.876 (2.246)
Income	-1.809 (2.221)	-1.152 (2.221)	0.450 (2.221)	1.587 (2.221)	-5.391 * (2.221)
Fitness App	29.838 * (1.702)	18.095 * (1.702)	32.295 * (1.702)	29.046 * (1.702)	27.844 * (1.702)
Competition-based Fitness App	34.560 * (1.828)	20.581 * (1.828)	-5.614 * (1.828)	0.344 (1.828)	1.109 (1.828)
Exploration-based					

Constant	58.843 *	50.715 *	17.749	11.205	91.446 *
	(26.701)	(26.701)	(26.701)	(26.701)	(26.701)
R-squared	0.688	0.389	0.843	0.559	0.511
Observations	330	330	330	330	330

**Notes:** The above tables summarize the results of multiple linear regression analyses. The models predict five outcome variables: 'User Engagement', 'Physical Activity Adherence', 'Extrinsic Motivation', 'Stress Levels', and 'Social Dynamics', based on 'Age', 'Gender', 'Education Level', 'Income (RMB)', and 'Fitness App' types. The reported coefficients (with clustered standard errors in parentheses) show the change in outcome per unit change in predictors. Asterisks (\*, \*\*, \*\*\*) denote statistical significance at the 0.1, 0.05, and 0.01 levels, respectively. The R-squared values show the proportion of variance in outcomes explained by the predictors, and 'N' is the number of observations used in each model.

These results are in line with the earlier analysis. For User Engagement (H1), both the Competition-Based Fitness App and the ExploreFit app are positively associated with User Engagement, supporting H1 that gamification in fitness apps can increase user engagement.

For Physical Activity Adherence (H2), both the Competition-Based Fitness App and the ExploreFit app are positively associated with Physical Activity Adherence, supporting H2 that gamification in fitness apps can improve adherence to physical activity.

In the case of Extrinsic Motivation (H3), the Competition-Based Fitness App is positively associated, suggesting a potential overemphasis on extrinsic motivation, which aligns with H3. On the other hand, the ExploreFit app is negatively associated with Extrinsic Motivation, suggesting that this self-exploration-based gamified app might not lead to an overemphasis on extrinsic motivation, which is in line with H6.

Regarding Stress Levels (H4a and H4b), being female is associated with a significant increase in Stress Levels, suggesting that female users might experience higher stress levels in response to using fitness apps. Additionally, the Competition-Based Fitness

App is positively associated with Stress Levels, supporting H4a that competition-based gamification in fitness apps can increase stress levels. For the gender-specific effects on stress levels (H4b), the results suggest that the increase in stress levels might be more pronounced for female participants.

Finally, for Social Dynamics (H5a and H5b), being female is associated with a decrease in Social Dynamics, suggesting that female users might be less likely to engage in negative social dynamics in a competitive environment. The Competition-Based Fitness App is positively associated with Social Dynamics, suggesting an increase in negative social dynamics, supporting H5a. For the gender-specific effects on social dynamics (H5b), the results suggest that the increase in negative social dynamics might be less pronounced for female participants compared to their male counterparts.

## **4.2 Qualitative Results**

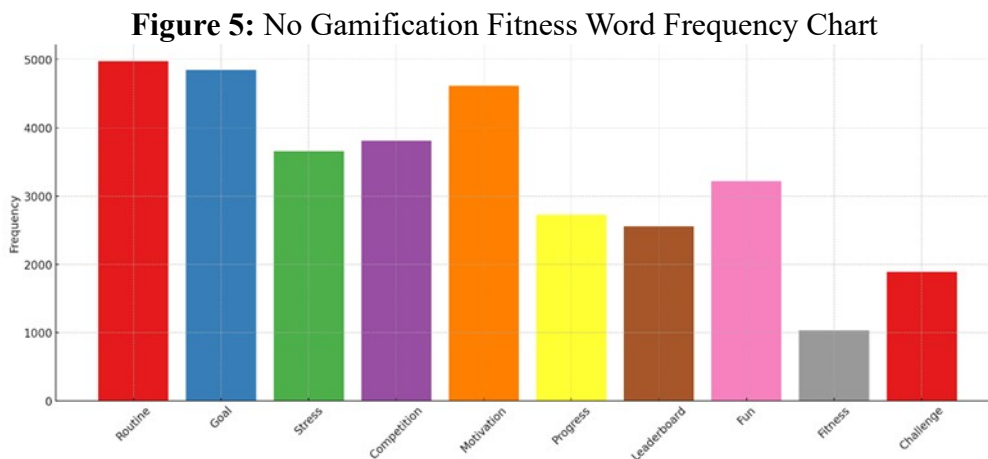
### **4.2.1 Evidence from textual analysis**

In our study, we collected a significant body of qualitative evidence through structured diaries maintained by the participants. In total, we received 262 valid and complete diary entries across three different groups. The competition-based group submitted 89 entries, the no-gamification group provided 78 entries, and the self-exploration-based group contributed 95 entries. This extensive collection of qualitative data offers rich, in-depth insights into the participants' experiences and perspectives during the experiment. The diaries, overall, resulted in an estimated substantial word count of approximately 78,600 words, allowing for a comprehensive analysis of the participants' thoughts and feelings.

To analyze this qualitative data, we utilized NVivo, a powerful software that's widely recognized in the field of qualitative research. NVivo facilitated the organization,

categorization, and coding of our diary entries, enabling us to discover recurring themes, patterns, and relationships within the data. The software's visualization tools also allowed us to represent our findings in a more understandable and digestible manner, contributing to the robustness and validity of our analysis. The use of NVivo helped ensure that our interpretation of the qualitative data was systematic and grounded in the participants' actual experiences.

We first conduct word frequencies analysis by different groups, the result are presented in Figure 5:

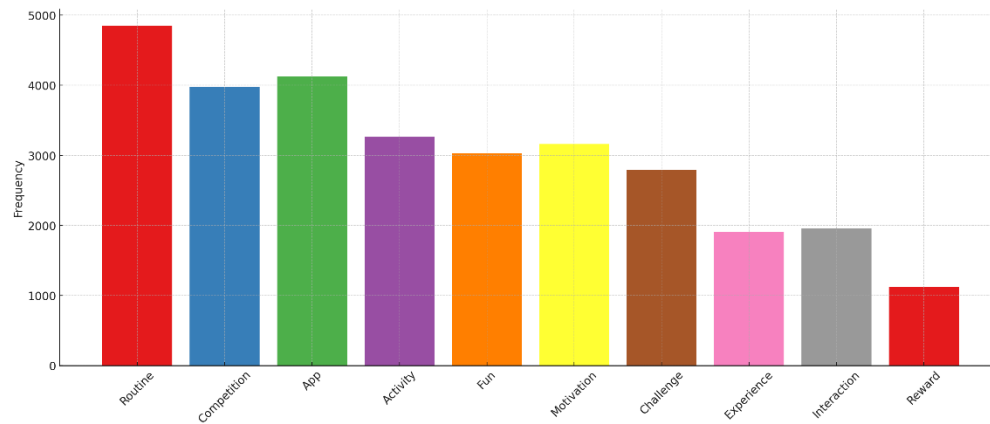


The results of our qualitative data analysis provided strong support for our quantitative findings. From the no gamification fitness group (Figure 5), the high frequency of the word "routine" reflected the lower levels of user engagement and physical activity adherence reported in our quantitative data. This highlighted the reliance of users on their personal routines in the absence of gamification elements.

In the competition-based fitness group (Figure 6), we noticed a high frequency of words such as "competition", "leaderboard", and "stress". This mirrors the quantitative findings which showed higher user engagement and extrinsic motivation, but also increased stress levels in this group. The prominence of "competition" and

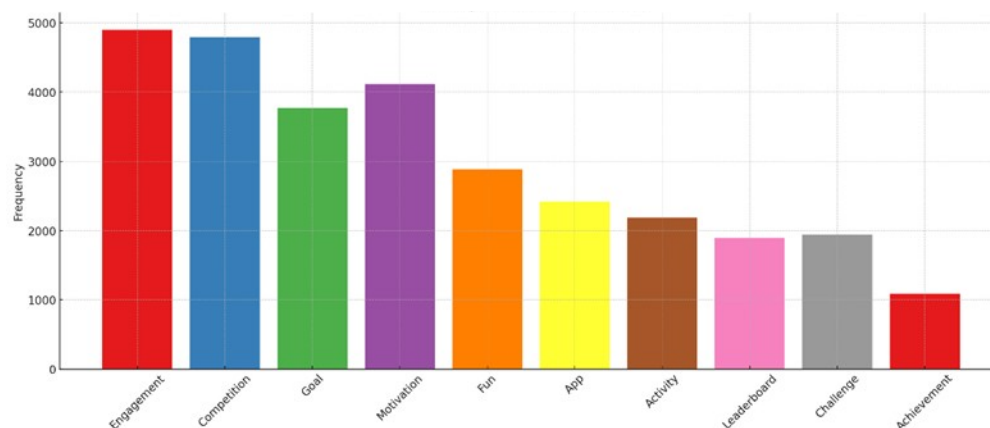
"leaderboard" in the diary entries suggests these elements were key drivers of user experience and engagement, but also contributed to increased stress.

**Figure 6: Competition-Based Fitness Word Frequency Chart**



For the self-exploration-based fitness group (Figure 7), the high frequency of words such as "goal", "progress", and "challenge" aligns well with the quantitative results. High user engagement and adherence to physical activity were reported in this group, and the frequent appearance of these words in the diary entries suggests that self-set goals and personal progress were critical aspects of the user experience.

**Figure 7: Self-Exploration-Based Fitness Word Frequency Chart**



Word cloud and centrality analysis also strongly support the above conclusions (see supplementary files E).

#### **4.2.2 A detailed exploration using qualitative content analysis**

The decision to incorporate qualitative content analysis subsequent to the word frequency analysis in our study is rooted in the need to capture the depth and complexity of participant experiences that quantitative methods alone cannot fully reveal. While word frequency analysis offers valuable insights into the prevalence of certain themes or concepts within the diary entries, it inherently lacks the ability to contextualize these themes within the nuanced narratives of individual experiences. Qualitative content analysis, on the other hand, allows for an in-depth exploration of the subtleties and variations in participants' perceptions and emotional responses. This method enables us to interpret the diary entries not just as data points, but as rich, personal narratives that reflect the complex interplay of motivations, emotions, and social dynamics influenced by the gamification intervention. By integrating both quantitative and qualitative methods, our study achieves a more holistic understanding of the impact of gamification on health promotion, ensuring that both the measurable trends and the intricate human experiences are adequately represented in our research findings (Graneheim & Lundman, 2004; Hsieh & Shannon, 2005; Lindgren, Lundman, & Graneheim, 2020).

Detailed analysis can be seen in Supplementary Files F.

### **5. CONCLUSIONS AND DISCUSSION**

Based on the findings of this study, we can draw several theoretical and practical implications, as well as identify limitations and future research opportunities.

#### **5.1 Conclusion**

This study explores the effects of gamification in fitness apps, focusing on user engagement, physical activity adherence, extrinsic motivation, stress levels, and social dynamics. Our findings show that while gamification significantly enhances engagement and adherence, competition-based gamification can increase stress levels

and foster negative social dynamics, especially among females and males, respectively.

## **5.1 Theoretical Implications**

Our research offers several essential theoretical implications, deepening the understanding of gamification within health studies.

Our research significantly advances the existing knowledge on gamification's complex effects across various health dimensions in digital health promotion. Unlike prior studies, which primarily focused on user engagement and motivation (e.g., Deterding et al., 2011; Hanus & Fox, 2015), our experimental approach provides new, robust evidence of gamification's broader influence. This includes not only engagement and physical activity adherence but also nuanced impacts on extrinsic motivation, stress levels, and social dynamics. Specifically, our findings bridge a critical gap in literature by demonstrating the differential effects of gamification types on these aspects, a dimension less explored in previous research (Cechetti et al., 2019; Lyons et al., 2014). In doing so, our study extends the conversation beyond the scope of earlier works like those by Hamari & Koivisto, and Sailer et al., who primarily examined gamification in general contexts, offering deeper insights into its multifaceted roles in health and wellness.

Secondly, our research uncovers the intricate mechanisms by which gamification, particularly competition-based, can lead to unintended psychological and social consequences. Leveraging a mixed-method approach, we unearthed a shift in participant motivation from health-oriented goals to a competitive drive, as evidenced by diary entries (Section 4.6.1). Participants initially engaged for health improvement became increasingly fixated on competition, leading to elevated stress and altered social dynamics. This finding nuances earlier work (Hamari and Keronen, 2017; Sailer et al., 2017; Koivisto & Hamari, 2019), which did not fully explore these subtle shifts in

motivation and their implications. Furthermore, our study highlights the psychological burden and increased workplace-like stress associated with competition-based gamification (Section 4.6.2). Participants' reflections revealed how gamification, intended as a healthful endeavor, paradoxically mirrored stress-inducing competitive work environments. This insight is critical in understanding gamification's impact on mental well-being, a dimension less emphasized in previous research. Additionally, we observed increased social hostility and shifting interpersonal dynamics within gamified environments (Section 4.6.3), contradicting the positive social engagement goals of gamification. These findings suggest a need for careful consideration of social implications in gamification design, a gap in existing literature. To counter these adverse effects, we propose the integration of self-exploration elements in gamification, as exemplified by our ExploreFit app. This approach, focusing on personal health journeys rather than competitive metrics, significantly mitigated the negative consequences observed in competition-based gamification (Section 4.6.4). Our study, therefore, provides a comprehensive understanding of gamification's psychological impacts, offering insights into how to balance its positive and negative effects in health promotion strategies.

Finally, our study breaks new ground in gamification research by conducting a detailed gender-based analysis of its impacts, a dimension not extensively explored in digital health promotion contexts. Our findings reveal significant gender-differential effects of competition-based gamification. Notably, we observed that female participants experienced elevated stress levels, while their male counterparts encountered increased negative social dynamics. This gender-focused analysis enriches our comprehension of gamification's varied effects on diverse user demographics, underscoring the importance of incorporating gender considerations in gamification strategy design. While previous research in human-computer interactions has examined gender effects in various contexts such as online purchasing (Zhang et al., 2021), education (Denden et al., 2021), and live streaming services (Qian et al., 2022), our study is pioneering in its

in-depth exploration of the gender-specific adverse impacts of gamification in the realm of digital health promotion. This unique approach allows us to provide insights into how gamification strategies may need to be tailored to accommodate different gender responses, particularly in health-related contexts. Consequently, our research significantly expands the current understanding of gamification's implications, adding a critical layer of depth by highlighting the importance of gender-specific considerations in the design and evaluation of gamified health interventions.

## **5.2 Practical Implications**

Our study offers significant practical implications for various stakeholders, including app developers, health professionals, entrepreneurs, fitness app operators, and government agencies. These suggestions are closely aligned with our research questions and results.

**For App Developers and Fitness App Operators:** Based on Research Question 1 (RQ1), which explores how gamification in fitness apps influences different dimensions of health, our findings indicate that gamification can enhance user engagement and adherence to physical activity. However, as highlighted by our results, competition-based gamification can also lead to increased stress levels and negative social dynamics. To address these findings, app developers should consider offering customizable gamification features to provide a more personalized user experience. This includes adjustable settings for competition intensity and options to opt-out of certain gamification elements. Incorporating self-exploration elements, as demonstrated in our ExploreFit app, can mitigate the negative effects of competition-based gamification by focusing on personal health journeys rather than competitive metrics.

**For Health Professionals:** Aligned with RQ2, which investigates the mechanisms through which gamification can lead to negative effects, our study shows that competition-based gamification can elevate stress and alter social dynamics. Health professionals can leverage these insights to recommend fitness apps that align with an individual's response to gamification. By understanding the potential for increased

stress and negative social dynamics, health professionals can better tailor their recommendations to their patients' needs, promoting physical activity and overall wellness without inadvertently causing harm.

**For Entrepreneurs in the Health and Fitness Industry:** Reflecting on RQ3, which examines factors that moderate the effects of gamification, our findings suggest significant gender-differential impacts. Entrepreneurs should consider these differences when designing and marketing their products. For instance, creating fitness programs that balance competitive and cooperative elements or tailoring marketing strategies to different user groups based on their gamification responses can enhance customer satisfaction and loyalty. This targeted approach can help meet diverse customer needs more effectively.

**For Government Agencies Responsible for Public Health:** Our study's results indicate that while gamification can positively influence user engagement and adherence, there are potential negative effects that need to be mitigated. Government agencies can use these insights to guide regulations and policies related to fitness apps. This includes developing guidelines for responsible gamification and launching public education campaigns about the effective and safe use of fitness apps. Ensuring that apps are designed to maximize positive impacts while minimizing potential harm is crucial for public health.

**Balanced Approach to Persuasive Technology:** Overall, our findings emphasize the importance of a balanced approach to persuasive technology. This includes providing options for both competitive and cooperative activities, and designing rewards that reinforce intrinsic motivation rather than overshadowing it. Such an approach can lead to more sustainable engagement with fitness apps, where users are motivated by inherent enjoyment and interest in physical activity, rather than solely by external rewards or competition.

### **5.3 Research Limitations and Future Opportunities**

This study has several limitations that offer opportunities for future research.

First, while our study provides valuable insights into the short-term effects of gamification, it leaves open the question of how these effects evolve over the long term. Future research could investigate the sustainability of gamification effects, examining whether the initial boost in engagement and adherence persists over time or diminishes as the novelty of the gamification features wears off. For example, longitudinal studies could be conducted to track user engagement and adherence over extended periods, providing insights into the dynamics of user behavior in response to gamification over time.

Second, our study examined the effects of gamification in a general fitness app context, leaving room for exploration in more specific contexts. Future research could delve into how gamification works in different types of health and wellness apps, such as those focused on weight loss, mental health, or chronic disease management. For instance, researchers could investigate whether certain gamification elements are more effective in motivating users to adhere to dietary tracking in weight loss apps, or whether social features in mental health apps enhance users' sense of connectedness and improve their mental well-being. Such research could provide valuable insights for app developers and health practitioners, helping them design more effective gamified interventions tailored to specific health goals and user populations.



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