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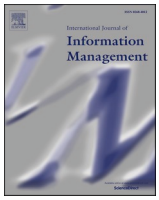

Research article

Creatability, achievability, and immersibility: New game design elements that increase online game usage

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ABSTRACT

Online games are popular technology-enabled applications designed to satisfy a wide range of player needs. Self-determination theory (SDT) has been used in past online game studies to explain player satisfaction, but it is rarely used to examine game design as a trigger for player satisfaction, which reveals a research gap. This gap keeps game makers in the dark about the design of games that effectively satisfy players, throwing gamers' ongoing game usage into doubt. Aiming to fill this gap, we proposed three new game design elements and examined their impacts on player satisfaction, continuance, and usage. We followed 546 participants who responded to our online survey and permitted us to collect their system-captured game usage data, generating two-wave and two-source data. We found that game achievability and game immersibility are game design elements that satisfy players. Competence satisfaction and autonomy satisfaction—but not relatedness satisfaction—are characteristics that secure players' continuance and actual usage. Two replication studies were conducted to further verify these findings. Our study extends SDT backward to examine the game-contextualized triggers of satisfaction. These theorized triggers showcase game system design, theoretically clarifying the means of using SDT to design games, and providing practical insights to guide game makers in securing player continuance and actual usage.

1. Introduction

Online games fulfill many human needs (Formosa et al., 2022; Teng et al., 2022a; Xi & Hamari, 2019), which explains why more than three billion people around the world play them (Dataprot, 2023). For instance, DOTA 2, a strategy game, boasted million active players every month (Statista, 2022). Online games have created a market projected to reach more than 26 billion USD in 2023 (Statista, 2023). More than 10,000 new games were released on a single platform in a single year (Prodanoff, 2023). This intense competition shows the importance of sustaining players' behavioral engagement, e.g., game continuance and usage. To best achieve this, games should be designed to comprehensively satisfy players' needs, which have been theoretically characterized by the well-known self-determination theory (SDT) (Ryan & Deci,

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2000).

Past online game research that has applied SDT has found that in-game need satisfaction elevates gameplay (Formosa et al., 2022). Regarding players' comprehensive need satisfaction, frequent interaction with the game content is associated with both autonomy satisfaction and relatedness satisfaction (de Henestrosa et al., 2023). All satisfaction types strengthen the intention to play (Kim et al., 2018; Teng et al., 2022a). However, past online game research using SDT has generally ignored the game design elements that comprehensively satisfy players' needs, thus resulting in a research gap.

Focusing on game design elements is a reasonable approach as they may offer players satisfying gaming experiences and can be adjusted by game providers. Previous gamification research has identified design elements, including trophies (Whittaker et al., 2021), the quantified self (Hassan et al., 2019), badges, rewards (Hollebeek et al., 2021; Simonofski et al., 2022), points, and levels (Toda et al., 2019). However, such research has not examined the game design elements that can comprehensively satisfy players' needs, particularly those needs theorized by SDT. That is, past research has not filled our research gap, leaving it open.

Conducting research to fill this gap is important both academically and practically. Academically, such research can extend SDT backward to the design elements. These newly examined elements can then be applied to research this theory in other contexts, thus increasing the impact of game research that applies the theory. Moreover, investigating the effects of need satisfaction can test and may shift our theoretical understanding that all satisfaction elements can effectively escalate behavior engagement. Practically, new design elements offer novel insights for game providers to comprehensively satisfy players, thus securing players' behavioral engagement and establishing game providers' competitive advantage. Furthermore, investigating the effects of need satisfaction can guide game providers to focus investment on game elements that bolster satisfaction (e.g. autonomy satisfaction), rather than diluting their resources across all satisfaction elements, including those that may not be as effective. Therefore, this gap needs to be addressed.

To fill this research gap, we identified three game elements by starting with the widely accepted gameplay motivation typology (Xi & Hamari, 2019; Yee, 2006), which comprises achievement, immersion, and socialization. First, players have strong motivations to attain goals and obtain achievements that boost their behavioral engagement (Lin et al., 2015; Teng et al., 2022b), indicating that the game elements that fulfill such motivations can be highly satisfying to players. Hence, we proposed *game achievability* (a game's ability to enable players to reach goals and attain achievements in the game) as a suitable game design element. Second, immersion is a major gameplay motivation (Xi & Hamari, 2019; Yee, 2006), which effectively limits users to interact with other in the real world (Mogaji et al., 2023) and encourages continued gameplay (Billieux et al., 2015; Teng, 2010), thus motivating us to propose *game immersibility* (a game's ability to generate a feeling of being surrounded by the game world) as another suitable game design element. Third, we chose *not* to include socialization as a game element, because the effects of socialization may be mixed, i.e., possibly positive when a player builds social connection (Türkay et al., 2023) or negative when they cheat and annoy others merely to enhance their own enjoyment (Chou et al., 2014). Such mixed evidence explains why increased socialization may not always evoke players' positive emotions (Lee et al., 2021). The mixed evidence on socialization likely signals that gameplay enables players to do what they cannot do in the real world, e.g., easily and unlimitedly assemble items to create new ones with whole new functions. This fits a recent game development, i.e., enabling players to create items that are not known to other players (Verlisify, 2023). Creating items offers individuals enjoyment and likely encourages further engagement. Thus, we proposed *game creatability* (a game's ability to allow players to mobilize their creativity in the game) as the third game design element.

Overall, the purpose of this study was to examine whether and how the three new game design elements—game achievability, game immersibility, and game creatability—comprehensively satisfy players' needs as defined by SDT (i.e., autonomy satisfaction, competence satisfaction, and relatedness satisfaction), thus further securing their behavioral engagement (game continuance and game usage). To achieve this, we conducted three studies. The first was our main study, which used two-wave and two-sourced data collected from 546 players. The second was a quantitative replication study to verify the findings of the first study and address its potential issues. The third was a qualitative study, which offers an in-depth explanation of why design elements would work well. These studies offer multiple contributions. First, they provide new game design elements and examine how these comprehensively satisfy players' needs as defined by SDT. Intuitively, the first study offers an academic contribution. Second, these studies collectively form multi-method research, offering replicable results and triangularized insights. Collectively, these studies offer a methodological contribution. Third, our findings uniquely indicate that the game achievability and game immersibility elements can be applied to comprehensively satisfy players' needs, thus effectively ensuring players' behavioral engagement. The findings can help build game providers' competitiveness. In other words, these studies offer a practical contribution.

2. Theory and prior research

Online games have been widely used in information research due to their usefulness in examining various issues, including social influence (Mäntymäki & Riemer, 2014), purchase behavior (Mäntymäki & Salo, 2013), and gifting behavior (Sharma et al., 2021). Online games have garnered substantial scholarly attention, indicating their academic usefulness and impacts. We position our study in the online game context.

Online game research has identified a number of means to enhance game continuance and increase game usage. The verified means include enjoyment, satisfaction (Aydınlıyurt et al., 2021), social value, economic value (Hamari et al., 2020), and the fear of missing out (Laato et al., 2020). These means primarily assess players' psychological states, without offering highly specific insights into game design. We address this by identifying three potential game design features—namely game creatability, game achievability, and game immersibility—which can provide novel insights for game makers seeking to satisfy players' needs to ensure their game continuance and usage.

Game research has examined various user psychological states as antecedents to game usage. However, few game studies have provided direct game design elements or perceptions that can be applied to game design decisions. There are a few notable exceptions: Li et al. (2014) found that game complexity and game familiarity are related to players' cognitive processing and further game engagement. Lee et al. (2021) found that massively multiplayer online role-playing games (MMORPGs) have three affordances: competition affordance, social affordance, and immersion affordance. Two of three can increase positive moods, decrease negative moods, and subsequently increase game engagement. Teng (2021) found that the customizability of avatar items can increase players' identification with their avatars, thus strengthening their game loyalty. While these studies have considered a number of game design elements, none has addressed the mechanisms behind the satisfaction of players' comprehensive needs (for autonomy, competence, and relatedness) through game elements, revealing a research gap.

Broadly speaking, gamification research should be related to game research. Gamification has been widely applied in various disciplines, such as marketing (Singh et al., 2021) and information systems (Koivisto & Hamari, 2019). Gamification provides value to individuals (Huotari & Hamari, 2017) and therefore exhibits strong influences on various user behaviors, e.g., consumer citizenship behavior (Xu et al., 2022) and repeated use (Hamari & Koivisto, 2015; Whittaker et al., 2021), showing

the relevance of gamification research to contemporary management practice.

Gamified systems include many design features that influence users. Specifically, medals and levels (e.g., silver or bronze) have been shown to provide affective feedback, thus encouraging continued use (Hassan et al., 2019). Points and levels can serve as feedback related to both competition and cooperation among users (Toda et al., 2019). The use of points, badges, and trophies likely forms flow experience and increases player engagement (Whittaker et al., 2021). Badges show a particularly strong influence in the use of open government data portals (Simonofski et al., 2022). Overall, these elements (badges, points, levels, and trophies) form a positive reinforcement system, or rewarding mechanism, which is a key driver of users' further engagement (Hollebeek et al., 2021). Collectively, this research stream has focused on *gamified* systems, while our research focuses on *game* systems. Moreover, in this research stream, the existence (Whittaker et al., 2021), importance (Hassan et al., 2019), and usefulness (Simonofski et al., 2022) of the *gamified* design elements have been examined. Comparatively, our study uniquely provides *game* design elements and their impacts on players' comprehensive needs, addressing the aforementioned research gap, which had not been filled by gamification research.

To address this gap, we found that comprehensive needs have been theorized by the SDT. SDT starts with intrinsic motivation, which can effectively trigger behavioral responses (Sultana et al., 2023). SDT posits that needs satisfaction can increase individuals' engagement in specific activities (Ryan & Deci, 2000)—which is consistent with the link between satisfaction and continuance that has been demonstrated in the online environment (Alalwan, 2020)—and prompt them toward actual adoption (Alalwan et al., 2017), usage (Sun et al., 2020), and loyalty (Ryu & Suh, 2021). Hence, SDT should be applicable in the online game context.

SDT posits that individuals have three basic human needs: the autonomy need (the desire to make choices freely) (Xi & Hamari, 2019), the competence need (the desire to feel capable) (Tsai & Pai, 2014), and the relatedness need (the desire to perceive closeness with others) (Suh et al., 2018). The needs defined by SDT and their satisfaction have been widely applied in various contexts. For example, job autonomy leads to job engagement (Hou et al., 2023); autonomy offers value and sustains participation (Wu et al., 2023); autonomy and competence affect online transaction experience and retention (Zhang et al., 2023); and autonomy satisfaction (the perception of freely making choices) and relatedness satisfaction (the perception of being close and connected to others) can strengthen continuance and increase contribution to online communities (Kuem et al., 2020). The reason for this may be that autonomy satisfaction and relatedness satisfaction, as well as competence satisfaction (the perception of being capable of attaining achievements), can facilitate the formation of social identity (Tsai & Pai, 2014), which further prompts users' desire to contribute and thereby stimulates actual contribution (Tsai & Bagozzi, 2014). Moreover, SDT can be used to explain how the three needs motivate the use of social media in workplaces and in users' social lives (Wei et al., 2022). Furthermore, SDT has been used to build a larger framework to explain online users' digital identities (Turel et al., 2020). These past studies indicate that SDT is suitable for explaining the perceptions and responses of online users, which include online game players.

The needs defined by SDT have been used in the gaming context. Specifically, these three needs can be used to predict players' enjoyment and future play intention (Ryan et al., 2006). Achievement and social game features can satisfy all three of these needs (Xi & Hamari, 2019). Rewarding game features can satisfy the competence and autonomy needs, while competition game features can satisfy the competence and relatedness needs (Suh et al., 2018). In online game teams, both strategic and offensive engagement can satisfy players' competence needs, thus increasing their loyalty and usage (Teng et al., 2022a). These findings indicate that SDT is a valid theory for explaining the mechanism underlying online gameplay. Table 1 displays the definitions of our research concepts.

Table 1
Definitions of the Study Concepts.

Construct	Definition	Relevant References
Game Creatability	A game's ability to allow players to mobilize their creativity in the game	Verlisify (2023)
Game Achievability	A game's ability to enable players to reach goals and attain achievements in the game	Xi and Hamari (2019);Yee (2006)
Game Immersibility	A game's ability to generate a feeling of being surrounded by the game world	Billieux et al. (2015);Teng (2010)
Competence Satisfaction	The perception of feeling capable to attain achievements in a game	Liao et al. (2020)
Autonomy Satisfaction	The perception of feeling free to make choices in a game	Liao et al. (2020)
Relatedness Satisfaction	The perception of feeling close to and connecting with other players in a game	Liao et al. (2020)
Game Continuance	The intention to frequently play a game	Liao and Teng (2017)
Game Usage	The number of times a game has been played in a specific time period	Teng et al. (2022a); Teng et al. (2022b)

3. Model and hypotheses

Fig. 1 shows our research framework. Our study used SDT as the main theory with which to develop a research framework and formulate hypotheses. Past online game research has used SDT to explain player satisfaction (Sepehr & Head, 2018) and loyalty (Teng et al., 2022a). Our study is novel because no previous studies have examined the impacts of our three proposed game design elements. Our study is valuable because our findings can guide game makers to effectively boost player satisfaction by selecting the best elements to improve.

Game creatability represents a game's ability to give players the power to create. The possession of power instills a perception of competence (Yee, 2006). According to the gameplay motivation literature, perceived competence can meet the gameplay motivation for achievements (Yee, 2006). Creating new crafts offers a sense of achievement (Mochon et al., 2012). Moreover, creating implies completing artifacts (e.g., in-game avatars) on one's own, which increases the evaluation of the created crafts (Norton et al., 2012). Furthermore, successfully creating in-game artifacts can be seen as an achievement, and achievements satisfy players' competence needs (Xi & Hamari, 2019). For instance, in League of Legends, players can create their avatars by crafting avatar appearances, outer frames, and titles (Riot Games, 2022). Players need to complete tasks to obtain the materials needed to create artifacts. Creating highly evaluated artifacts can be a symbol of high competence. All these results indicate that game creatability can generate perceptions of competence in players, thus resulting in their competence satisfaction. Hence, we hypothesize:

H1a. Game creatability is positively related to competence satisfaction.

Game creatability affords players the freedom to create avatars and in-game items, e.g., it allows for the customization of in-game items to fit player preferences, thus meeting players' motivation to role-play avatars (Teng, 2021). Creation can enable humans to lead themselves (Bunjak et al., 2022), thus experiencing achievement, impacting performance, and increasing engagement (Junglas et al., 2022). During their creation, games offer various options that players can choose or change. For example, Animal Crossing allows players to design their avatars' outfits based on their own ideas (Gamerjoob, 2020). These options free the players from using presumed and standardized avatars or in-game items. Hence, by crafting their avatars' items, players feel that they are expressing their free will, by leveraging item customizability (Teng, 2021), which increases the level of player engagement (Cheung et al., 2015) by allowing for subtle differences in avatars and

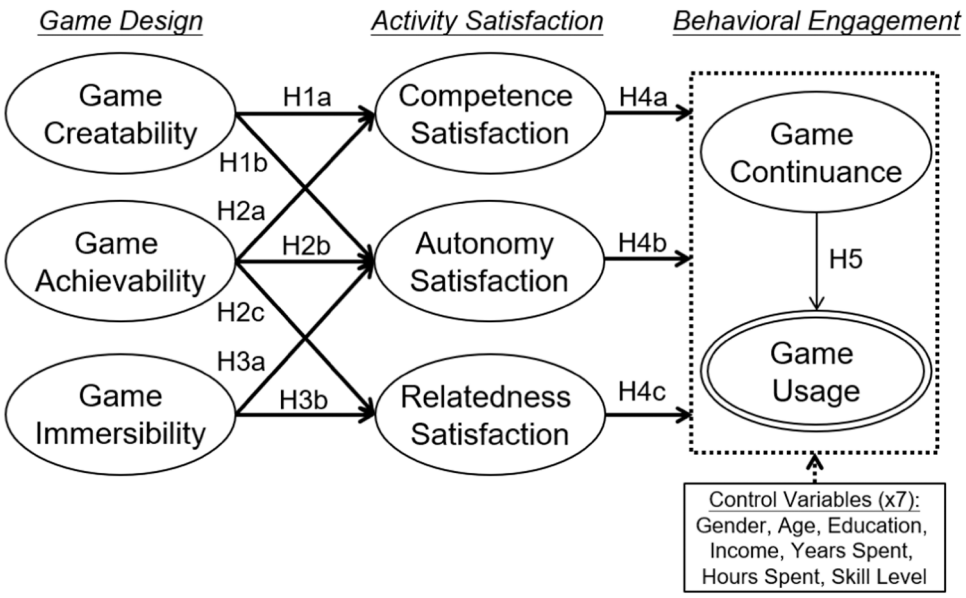

Fig. 1. Research Framework. *Note.* A double circle denotes that the corresponding construct is measured by system-captured behavioral data.

items. Such subtle differences can reflect players' own identities, i.e., allowing players to express themselves. Self-expression enhances autonomy satisfaction (Tseng et al., 2018). In short, game creatability can result in players' autonomy satisfaction. Hence, we hypothesize:

H1b. Game creatability is positively related to autonomy satisfaction.

Game achievability enables players to attain in-game achievements. The gameplay motivation literature indicates that players have a strong motivation to obtain in-game achievements (Lin et al., 2015), which is key to satisfying player competence needs (Xi & Hamari, 2019). In-game achievements comprise various elements, including competition, progress, completion, and accumulation (Yee, 2006). Competing with similarly skilled players can stimulate players, while competing with less-skilled players can increase player enjoyment (Liu et al., 2013). The underlying reason is attaining a sense of competence. To attain in-game progress, players are motivated to pursue game goals (Teng et al., 2022b). Attainment of gaming goals can satisfy the need for closure, which provides a sense of competence. The accumulation of in-game crafts, items, gems, badges, points, or levels is an important element of attaining in-game achievements (Lee et al., 2021; Yee, 2006). All these results indicate that game achievability is vital to player competence satisfaction.

H2a. Game achievability is positively related to competence satisfaction.

Game achievability reflects the level to which players can attain achievements. Therefore, game makers design games to include a series of clearly defined short-term (and thus attainable) goals. For example, the game MapleStory has exploration goals, and players who reach those goals obtain rewards that recognize their achievements (Fandom, 2022). Clear and attainable goals strongly motivate individuals to exert efforts toward achieving those goals (Locke, 1996). That is, game achievability urges players to pursue goal attainment. During in-game goal pursuit, various aspects of in-game goals emerge. For example, players can choose to advance their avatar levels, accumulate in-game artifacts, and beat other players. All these (advancement, accumulation, and dominance) are key components of achievement gameplay motivation (Yee, 2006). Typically, players are free to choose among these in-game goals, combine the goals, change their goals at any time, and set their own goal pursuit schedules. Such freedom greatly enhances the sense of autonomy, thus resulting in player autonomy satisfaction. Hence, we hypothesize:

H2b. Game achievability is positively related to autonomy satisfaction.

Game achievability affords players the possibility of attaining in-game achievements. Achievement is the natural result of overcoming challenges (Xi & Hamari, 2019). Also, cooperation helps players overcome in-game challenges (Riar et al., 2022), thus helping them attain achievements, which is one of the major gameplay motivations (Yee, 2006). In online games, gaming challenges frequently require players' cooperation or teamwork. For example, League of Legends (LoL) requires players to establish a gaming team with which to combat rival teams and destroy enemy bases, thus winning the game (League of Legends Wiki, 2022). Hence, in-game challenges lead players to depend on one another, thus creating a strong level of attachment (Hsiao & Tang, 2021). Moreover, as teamwork is essential to obtaining in-game achievements, players are encouraged to form player groups. Team play can facilitate social interactions (Petter et al., 2020), thus developing identification with peer players (Liao et al., 2020). That is, social interactions can enhance the sense of relatedness with others (Tsai et al., 2021). This results in relatedness satisfaction (Kuem et al., 2020). Hence, we hypothesize:

H2c. Game achievability is positively related to relatedness satisfaction.

Feeling immersed in the game world is an important gameplay motivation (Yee, 2006). Game immersibility gives players the perception that they are in the game world and that they are their avatars (Snodgrass et al., 2011). This feeling boosts players' further gameplay engagement (Teng, 2021). That is, it results in players putting more effort into gameplay. For example, Pokémon GO induces players to go anywhere and use their avatars to capture and collect virtual creatures (Hsiao & Tang, 2021). Moreover, immersion in the Pokémon world results in meaningful gameplay (Laato et al., 2021a; Laato et al., 2021b), as in-game immersion helps satisfy players' autonomy needs (Xi & Hamari, 2019). Such gameplay behavior reflects players' freedom to choose what to do and where to go. This freedom satisfies players' need for autonomy, which is a key need satisfaction in SDT (Ryan & Deci, 2000). In short, game immersibility instills a sense of immersion, which can satisfy players' autonomy needs (Xi & Hamari, 2019). Hence, we hypothesize:

H3a. Game immersibility is positively related to autonomy satisfaction.

Game immersibility can instill a sense of absorption in online game players (Dickinson et al., 2020). Absorption offers players the sense that they are in the game world, and that their avatars represent themselves (Teng, 2021). The role-playing of avatars is a key immersion component in gameplay motivations (Yee, 2006). Gameplay enables players to make friends who may not be easy to meet in the real world, thus strengthening close relationships (Esteves et al., 2021). For example, some online games provide functions for adding other avatars to a friend list or inviting other avatars to play together to establish relationships among players. That is, players immersed in the game can feel closer to other players. Closeness with other players can satisfy players' relatedness needs (Kuem et al., 2020). Hence, we hypothesize:

H3b. Game immersibility is positively related to relatedness satisfaction.

Satisfaction is a strong predictor of continuance intention (Mishra et al., 2023). According to SDT, competence satisfaction is important to individuals (Ryan & Deci, 2000). Feeling enhanced competence is also a driver of action (Wong et al., 2022), including goal pursuit during gameplay (Teng et al., 2022b). Enhanced competence (or self-efficacy) can induce further use of system elements (Meske et al., 2023). In online games, high competence satisfaction can thus motivate players to repeatedly engage in overcoming gaming challenges. Proficient skills can transform challenges into positive outcomes, further strengthening the level of continuance intention (Tomer et al., 2022). For example, such skills allow players to feel that they have sufficient skills to accomplish more gaming tasks (Teng et al., 2022b), thus encouraging more in-game progress. In-game progress further motivates players to continue gameplay (Teng et al., 2022b). Hence, we hypothesize:

H4a. Competence satisfaction is positively related to game continuance.

Autonomy is another important psychological need posited by SDT (Ryan & Deci, 2000). Autonomy satisfaction reflects the condition that users can make choices based on free will (Kuem et al., 2020). That is, users that can control their own choices perceive enhanced autonomy (Menard et al., 2017), which offers them enjoyment (Ke et al., 2012). Autonomy satisfaction is also important to online players. For example, players can choose whether to purchase game outfits that can improve their gaming skills (Fang et al., 2019). Making decisions autonomously can offer enjoyment during gameplay (Rogers, 2017). Enjoyment evokes positive emotions, strengthening users' intention to play further (Lee et al., 2021). That is, enjoyment induces gameplay continuance (Hamari et al., 2020). Hence, we hypothesize:

H4b. Autonomy satisfaction is positively related to game continuance.

SDT defines relatedness need satisfaction as the need for interpersonal closeness (Kuem et al., 2020). Individuals are eager to satisfy social needs in an online environment (Islam et al., 2022). This need is important, as social participation resolves loneliness (Goodarzi et al., 2023) and the social influences of others strongly predict online users' behavioral intentions (Hooda et al., 2022; Rana & Dwivedi, 2015) and actual behaviors (Liao et al., 2023). In our research context, players perceiving high levels of relatedness satisfaction can maintain good relationships with other players. For example, players can maintain relationships with other players through in-game chat functions. Moreover, players' positive relationships facilitate the formation of gaming teams, thus strengthening their identification with their gaming team (Liao et al., 2020). During team gameplay, players are willing to send virtual gifts to other players to contribute to the gaming team and facilitate gaming team commitment (Sharma et al., 2021). This represents a way for players to build solid relationships with other players, thus encouraging game continuance (Tseng et al., 2022). Hence, we hypothesize:

H4c. Relatedness satisfaction is positively related to game continuance.

Continuance refers to behavioral persistence over time (Mishra et al., 2023; Yan et al., 2021). In online games, players' behavioral persistence in gameplay refers to multiple and continued engagement with the game, which accumulates as actual usage. Moreover, the continuous devotion of effort toward achieving goals also results in the accumulation of actual game usage (Teng et al., 2022b). Furthermore, continued use can cultivate habits, which further facilitate repeated use (Sun et al., 2020). Hence, we hypothesize:

H5. Game continuance is positively related to game usage.

We developed these research hypotheses based on the plausible links between game design elements and various player satisfaction needs. Therefore, we did not develop links from all game design elements to the satisfaction of all player needs. This is due to the mixture of possible positive and negative impacts that restrained us from developing further hypotheses. Specifically, we did not develop hypotheses on two particular links. First, we did not develop a hypothesis on the relation between game creatability and relatedness satisfaction. Game creatability enables players to freely create in-game avatars or items (Bunjak et al., 2022). Some extraordinary creations can be highly impressive (Liao, Cheng, & Teng, 2019), thus satisfying players' needs for relatedness. However, in most cases, players' creations may not impress others and, even worse, may dismay them, thus likely leading to relatedness frustration (Liao et al., 2022). The mixture of possible positive and negative effects of game creatability on relatedness satisfaction restrained us from developing a hypothesis in this regard.

Second, we did not develop a hypothesis on the relation between game immersibility and competence satisfaction because game immersibility may also show a mixed effect on competence satisfaction. Specifically, game immersibility refers to players feeling absorbed in the game world, and thus strengthening their motivation to overcome challenges (Wang et al., 2021). Overcoming in-game challenges can satisfy players' competence needs (Shoshani & Krauskopf, 2021). However, not all players can smoothly overcome most in-game challenges. Repeated failed attempts to overcome challenges frustrate players, thus hindering their competence satisfaction (Hall et al., 2020). Such a mixed effect prevented us from developing a hypothesis on game immersibility and competence satisfaction.

Behavioral engagement may lead to satisfaction in online gameplay, creating the possibility of reverse causality. However, we argued that this is not always the case. Behavioral engagement reflects continual gameplay, in which players may or may not overcome gaming challenges, may or may not have sufficient autonomy to choose where to go in the game world, and may or may not have good relationships with other players, thus limiting gameplay satisfaction in all aspects, i.e., competence, autonomy, and relatedness. In short, reverse causality for H4a, H4b, and H4c may not actually occur. Moreover, it may be supposed that gameplay satisfaction can lead players to perceive the benefits of game design features. However, satisfaction may come from various sources, so mere satisfaction may not be attributable to the perceptions the benefits of specific game design features. Hence, reverse causality of the pertinent hypotheses, i.e., H1 to H3, may not be reasonable.

4. Method

4.1. Participants and the data collection process

For this study, we adopted a two-wave and two-source design. Specifically, we collected the first-wave data through an online survey conducted between September 1 and 15, 2021. We asked participants to provide their game account names and to give us permission to collect their online public game usage records for a month from September 19, as the second-wave data. That is, the second-wave data were collected

after the first-wave data. This research design includes two sources of data: players' self-reported scores and system-captured online public records.

We used the online survey service SurveyCake, which is commonly used in Taiwan. Hence, participants tend to view it as trustworthy. We posted invitations to join our study on various websites, namely, Facebook, Dcard, ppt.cc, and www.gamer.com.tw. These sites contain various topic groups and greatly increase the prospective participant pool. In so doing, we aimed to prevent bias due to a limited participant source. We argue that recruiting participants from a wide range of sources allow our results to be generalized to the wider population in Taiwan.

In the online invitations, we explained that the survey was a means of understanding online game players' perceptions of game goals and need satisfaction. This goal is broad and unspecific, thus preventing participants from intentionally distorting their responses in such a way that could markedly change our results. We directed the interested participants to complete our online survey. The questionnaire cover page explained the survey aim and stressed that participation was voluntary. These processes insured an informed consent process, thus complying with ethical requirements. The participants joining our study were eligible to join a lottery, which resulted in 70 winners each being awarded a gift certificate of 7.20 USD. The expected value should be much less than the legal minimum hourly wage of 5.70 USD. We believe that the participants perceived this compensation as modest, which should not markedly trigger self-selection bias (Jia et al., 2017).

We received 4078 complete responses between September 1 and 15, 2021. Among them, 3491 were considered valid, as they met the following criteria: (1) indicated gameplay within one month; (2) nominated an existent online game (to identify the participant as an online game player); (3) indicated a number of gameplay years less than the participant's age; (4) indicated a number of gameplay hours per week larger than zero but smaller than 168 (a week only comprises 168 h); (5) indicated an age of 18 years or over; (6) provided an email that was not a duplicate of another respondent's email; and (7) passed an attention check. Valid responses that met all these criteria had sufficient validity for further analysis.

Online surveys are suitable for assessing online user psychology and behavior (e.g., Sharma et al., 2021). However, online surveys are limited in their ability to test non-response bias (Steelman et al., 2014). Hence, we compared the early respondents (the first quartile) with the late respondents (the last quartile), but did not find significant differences between the two groups in the scores of nearly all the constructs ($p > .05$). The only exception was that the late responses showed higher game usage, but the difference was only 0.36 on a five-point scale. Hence, we concluded that there was no marked non-response bias.

As only the most popular game, LoL, has public gameplay records (https://lol.moa.tw/summoner/), we asked the 622 first-wave participants who nominated LoL to provide their summoner account names and permit us to monitor their game usage in the month (September 19 to October 18) following the online survey. Among the first-wave participants, 583 agreed, but not all these account names were valid. Eventually, we successfully obtained the publicly available gameplay records of 546 participants in the second wave. Therefore, the survey responses of these participants comprise the first wave data, while their publicly available gameplay records comprise the second wave data.

Regarding the response rate, it is noteworthy that our first-wave data was collected using a survey, while this survey offered cues for the second-wave data, which was collected using online system-captured behavioral data (but not a follow-up survey). The response rate should be calculated based on the 622 players who nominated LoL in the first wave. Hence, we calculated the ratio between those that offered valid account names (for the second wave) in their first-wave responses, i.e., $546/622 = 87.8\%$.

Moreover, online surveys are known to have no accessible member list and therefore difficulties may be encountered when estimating response rates (Steelman et al., 2014). This is an inherent limitation of this data collection method. As surveys remain an important method for information systems research (Mazaheri et al., 2020), we argue that an inherent limitation of this method would signal the need for more research using other methods to complement our research (e.g., including various sources of data).

4.2. Measurement

First-wave study variables. In the first wave, we assessed psychological constructs by using items either adopted or adapted from the literature. Specifically, the three items used to assess game continuance came from Liao and Teng (2017). An example item is "I intend to play this online game frequently." The 12 items used to assess the level of satisfaction of the three needs (using four items for each need) were modified from Liao et al. (2020). Examples include "When I play this online game, I feel confident that I can do things well," "When I play this online game, I feel a sense of choice and freedom in the things I undertake," and "When I play this online game, I feel connected with people who care for me and for whom I care." The three items used to assess game immersibility came from Huang et al. (2017). An example item is "When I play this online game, I feel I am in a world created by the online game I am visiting." The two items used to assess game creatability were adapted from Jansz et al. (2010). An example item is "I play this online game to display my creativity." The two items used to assess game achievability were adapted from Cunningham et al. (2005). An example item is "I am confident that I can successfully achieve in-game task-related goals in this online game." The use of two items is acceptable, as the other psychometric properties perform well (Mäntymäki & Salo, 2013). We list all the items used in this study in Appendix A, and explain how we ensured the quality of the adopted or adapted items in Appendix B.

All the survey items have options that ranging from 1 (strongly disagree) to 5 (strongly agree). A larger value indicates a higher level in the assessed study construct.

Second-wave study variable. In the second wave, we assessed game use by using a system-captured behavioral indicator, namely, number of gameplay times in the month immediately after the first wave. This indicator has scores that range widely. Although a wide range is reasonable and fits reality, we applied Blom's rank normalization process to transform the scores of this indicator, thus avoiding the large and inadequate influence of extreme values on the analytical results. Transforming system-captured data is widely practiced for good reasons (Ryu & Suh, 2021). Hence, we deemed this normalization suitable.

Game usage was assessed using a single item. We argue that this was appropriate for two reasons. First, system use can be a variable without measurement errors, as it is assessed by using system-captured data, so using multiple items is unnecessary. Second, if we have the best indicator, then we do not need the second best or the third best indicator. Analogously, if we wish to assess customer consumption amounts in a restaurant, the best indicator should be the restaurant's transaction records. We need not rely on memory or perception as a second or third indicator.

Control variables. We followed the recommendations to include control variables (Shiau et al., 2024), i.e., we should include control variables based on past research or theories. Totally, we collected three variable types from a total of seven control variables. The first type comprises demographic variables, namely, gender, age, education, and annual income. The reasons are that gender has been shown to be the most frequently mentioned demographic variable used to explain why people play games (Hamari & Keronen, 2017; Teng et al., 2022a); age has been shown to be related to game usage (Teng et al., 2022b); and education and income can be used to explain continued gameplay intention (Liao et al., 2022). The second variable type comprises gameplay experience, namely, number of hours per week spent playing

the focal game and number of years spent playing the focal game, because both can be used to explain online gamer loyalty (Pham et al., 2023). The third variable type is the officially recognized gameplay skill variable, which is pertinent because skill is a key element in obtaining value from gameplay (Lin et al., 2015). We could collect the officially recognized skill level of each participant through a system-captured indicator.

4.3. Psychometric properties

Consistent with the literature (Islam et al., 2022; Sun et al., 2020; Sun et al., 2021), Table 2 lists the loadings and cross-loadings of the measurement items. The items loaded in our assumed factors provide preliminary evidence of our data validity.

All the Cronbach's α values are.76 or larger, indicating sufficient reliability (Nunnally & Bernstein, 1994). All the composite reliability (CR) values are.81 or larger, and all the average variance extracted (AVE) values are.55 or larger. These results indicate acceptable reliability (Bagozzi & Yi, 1988). As shown in Appendix A, all the indicator loadings are.65 or higher, suggesting good convergent validity (Hair et al., 1998). As shown in Table 3, all the positive square roots of the AVE values exceed the associated correlations, indicating discriminant validity (Fornell & Larcker, 1981). To offer enhanced evidence of discriminant validity, we tested and found that all the 95% confidence intervals of the correlations are smaller than all the positive square roots of the AVE values. Psychometric properties may include reliability, validity, and model fit performance. Our measurement model has sufficiently good performance in model fit, i.e., CFI= .97, IFI= .97, NNFI= .96, SRMR= .05 (Bagozzi, 2010).

Table 2
Item Loadings and Cross-Loadings.

	1	2	3	4	5	6	7	8
Game Creatability-1	**.77**	.11	.33	.19	.13	.16	.08	-.03
Game Creatability-2	**.86**	.15	.13	.19	.15	.10	.00	.00
Game Achievability-1	.16	**.78**	.13	.26	.20	.09	.18	-.01
Game Achievability-2	.13	**.78**	.13	.34	.11	.16	.15	-.01
Game Immersibility-1	.12	.05	**.87**	.02	.14	.04	.12	-.06
Game Immersibility-2	.07	.08	**.88**	.07	.13	.10	.11	.02
Game Immersibility-3	.17	.09	**.82**	.02	.05	.11	-.03	.01
Competence Satisfaction-1	.09	.18	.01	**.85**	.09	.09	.15	.09
Competence Satisfaction-2	.11	.17	.07	**.86**	.15	.16	.16	.01
Competence Satisfaction-3	.09	.12	.06	**.84**	.23	.14	.12	.03
Competence Satisfaction-4	.15	.14	-.00	**.77**	.14	.27	.11	-.03
Autonomy Satisfaction-1	.18	.07	.03	.04	**.60**	.24	.33	.09
Autonomy Satisfaction-2	.14	.07	.06	.19	**.79**	.14	.20	.07
Autonomy Satisfaction-3	.05	.07	.22	.19	**.72**	.18	-.05	.00
Autonomy Satisfaction-4	-.01	.22	.11	.25	**.64**	.17	.31	-.08
Relatedness Satisfaction-1	.08	.02	.06	.20	.11	**.79**	.10	-.05
Relatedness Satisfaction-2	.05	.10	.08	.11	.13	**.87**	.08	.07
Relatedness Satisfaction-3	.05	.12	.05	.14	.16	**.85**	.06	.11
Relatedness Satisfaction-4	.10	.02	.11	.13	.18	**.75**	.20	-.06
Game Continuance-1	-.01	.03	.07	.11	.17	.09	**.83**	.02
Game Continuance-2	.04	.06	.06	.16	.12	.15	**.83**	.05
Game Continuance-3	.06	.27	.06	.19	.15	.13	**.69**	.04
Game Usage-1	-.02	-.02	-.03	.07	.06	.04	.09	**.98**

4.4. Testing Common Method Bias

Common method bias (CMB) may be assessed using a marker variable method (Wei et al., 2020). We chose to use an item to assess the marker variable: the intention to be contacted by the investigators (defined as the inclination to be further approached by the authors of this paper): "whether you are willing to be contacted by the investigators in the future?" to represent the marker variable, which had the smallest correlation.03 with other concepts in our research.

We applied three measures to our research design to prevent CMB. First, we collected multiple-source data, which can effectively negate CMB (Podsakoff et al., 2003). Second, we collected multiple waves of data. These provided temporal separation of the data, which can confirm a reduced likelihood of CMB (Podsakoff et al., 2003). Third, we collected system-captured data, which greatly reduces CMB concerns (Sharm et al., 2009). These measures should collectively minimize any CMB in our study. After the study was conducted, we found that all the measurement items had correlations ranging from − .04 to.56. These correlations are not high enough to trigger concern about CMB. However, we still formally tested CMB through several means. First, following the literature (Alalwan, 2020; Alalwan et al., 2017; Nusair et al., 2024), we conducted Harman's single factor test. Specifically, the first factor accounts for 32% of the variance of measurement, not indicating CMB. Second, the second smallest correlation is − .01, which is unlikely to indicate CMB. Third, we used the marker correlation adjustment method (Bunjak et al., 2022). The mean correlation adjustment is.011. After adjustments, the significant correlations remained significant, revealing that CMB was not a concern in our study (Lindell & Whitney, 2001).

5. Results

5.1. Participant profiles

We obtained 546 complete responses through a two-wave data collection process. The data indicate that most of our participants were male (86.7%). This proportion is similar to that of the local player population, in which 83% of players are male (GNN, 2016). Most participants were aged ≤ 30 years (82.1%), had a college/university level education or higher (91.4%), and had an income ≤ NT $600,000.00 (79.5%). Most participants had played the focal game for ≥ 5 years (91.1%), showed weekly gameplay hours of < 21 h (87.7%), and had a skill level of gold or below (91.7%). Table 4 shows the demographic profile of the participants. However, the total numbers shown in Table 4 are not always equal to the total collected sample size due to some missing values in the profile data.

5.2. Hypothesis testing

We used LISREL v.8.53 software, which is a commonly used tool (Shareef et al., 2017; Shareef et al., 2020; Tsai & Bagozzi, 2014), to perform structural equation modeling analysis, which we then used to test our hypotheses. We set the significance at the typical.05 level. Fig. 2 shows the analytical results. Most of the study hypotheses are supported, with some exceptions. First, game creatability is not related to competence satisfaction, thus H1a is not supported. The reason for this may be that game creatability empowers players to unleash their creative potential but may also influence players' focus during gameplay. Specifically, players may prioritize showcasing their creativity rather than honing their playing skills, which is the key theoretical factor in competence satisfaction (Reer et al., 2022). Moreover, game creatability induces players to develop their own storylines. From a practical standpoint, different story endings are not always satisfactory. Players sometimes fail to reach their goal, which is unlikely to result in much competence satisfaction (Deci & Ryan, 2000). These reasons would explain the nonsignificant relationship between game creatability and competence satisfaction.

Table 3
Correlations among the Study Constructs.

	1	2	3	4	5	6	7	8
1. Game Creatability	***.83***							
2. Game Achievability	.42 *	***.84***						
3. Game Immersibility	.42 *	.30 *	***.87***					
4. Competence Satisfaction	.39 *	.56 *	.16 *	***.89***				
5. Autonomy Satisfaction	.39 *	.45 *	.32 *	.47 *	***.74***			
6. Relatedness Satisfaction	.31 *	.34 *	.23 *	.41 *	.48 *	***.84***		
7. Game Continuance	.21 *	.41 *	.20 *	.40 *	.49 *	.34 *	***.81***	
8. Game Usage	-.01	.02	-.04	.12 *	.12 *	.09 *	.15 *	***NA***
9. Marker (Contact Intention)	-.07	-.07	-.03	-.11 *	-.08	-.11 *	-.14 *	.03
Mean	2.86	3.60	2.24	3.53	3.53	3.20	3.81	0.02
Standard Deviation	0.99	0.85	0.93	0.85	0.73	0.97	0.74	0.96
Cronbach's α	.76	.78	.86	.91	.78	.88	.79	*NA*
Composite Reliability (CR)	.81	.83	.91	.94	.83	.91	.85	*NA*
Average Variance Extracted (AVE)	.69	.71	.76	.79	.55	.71	.65	*NA*

Note. * denotes p value $< .05$. Bolded and italicized numbers on the diagonal are positive square roots of the AVE values.

Table 4
Profile of the Participants.

Variable	Category	Number	Percentage
Gender	Female	73	13.3
	Male	473	86.7
Age	18–20 years	29	5.3
	21–25 years	239	43.8
	26–30 years	180	33.0
	≥ 31 years	98	17.9
Education	High school or lower	47	8.6
	College/university	398	72.9
	Graduate institute	101	18.5
Income	≤NT$300,000.00	285	52.2
	NT$300,001.00–600,000.00	149	27.3
	NT$600,001.00–900,000.00	77	14.1
	≥NT$900,001.00	35	6.4
Gameplay Years	< 1year	7	1.3
	≥ 1 year and < 5years	47	8.6
	≥ 5 years and < 10 years	396	72.5
	≥ 10 years	96	17.6
Gameplay Hours	< 7 h	172	31.5
	≥ 7 and < 14 h	186	34.1
	≥ 14 and < 21 h	121	22.1
	≥ 21 and < 28 h	27	5.0
	≥ 28 h	40	7.3
Skill Level	Unranked	300	54.9
	Iron	5	0.9
	Bronze	24	4.4
	Silver	74	13.6
	Gold	98	17.9
	Platinum	32	5.9
	Diamond	13	2.4

In addition, game creatability is not related to autonomy satisfaction, thus H1b is not supported. The reason may be that game creatability induces players to provide their own unique ideas when playing the game. Accordingly, players may allocate their resources to displaying their creativity, such as designing their own in-game islands. However, this creative pursuit may not necessarily enhance their competitiveness and may even cause players to perceive that all other players are high-level competitors (e.g., they are building much better islands), which can reduce player autonomy satisfaction (Cao et al., 2023). Moreover, game creatability is limited by the design functions of a game. In a game, it is difficult for all the design functions provided to players to meet all the players' creative inspirations, limiting the ability of game creatability to satisfy the autonomy needs of gamers.

We also found that relatedness satisfaction is not related to game continuance, thus H4c is not supported. The reason for this may be that the relationship among players is not just maintained by playing games. For example, other social media also enable players to maintain their relationships (e.g., players can stay in touch via Facebook or Instagram). Moreover, from a theoretical perspective, relatedness satisfaction pertains to the desire for meaningful relationships (Deci & Ryan, 2000). A meaningful relationship implies that the interaction should not be limited to mere gameplay. Moreover, social interaction may fuel social overload, affecting continuance (Lin & Wang, 2023). Hence, in-game relatedness satisfaction may not significantly motivate game continuance merely to meet the goal of connecting with other players.

As shown in Fig. 2 and Table 5, our structural model explains significant variances in the endogenous constructs: 57% in competence satisfaction, 49% in autonomy satisfaction, 26% in relatedness satisfaction, 49% in game continuance, and 11% in game usage. We suppose that 11% may be adequate, as game usage may be easily affected by schoolwork or workplace and family responsibilities. Moreover, the well-known phenomenon of the intention—behavior gap predicts a high discount in transforming intention to behavior (Fennis et al., 2011).

5.3. Model fit and effect size

Our structural model performs acceptably in terms of model fit; i.e., CFI= .95, IFI= .95, NNFI= .93, and SRMR= .06 (Bagozzi, 2010). The structural model explains the variances in the endogenous variables in proportions ranging from 11% to 57% (as in Fig. 2). These proportions represent medium to large effect sizes (Cohen, 1992).

5.4. Post hoc analyses

Bootstrapping analyses. It may be noted that our model contains many possible mediations. Although we have not explicitly developed hypotheses on these mediations, we performed analyses using the bootstrapping method (Preacher & Hayes, 2008). We report and discuss the results in Appendix C.

Most influential game design element. To offer enhanced insight, we compared the total effects of the three game design elements on continuance. Among them, the most influential is game achievability, which exerts a stronger impact than game immersibility (.47 >.07, $p < .05$) or game creatability (.47 >.02, $p < .05$).

Testing reverse causality. We have argued that the causality in our model cannot be reversed. However, it may be noted that it is feasible to test for reverse causality. Accordingly, we reversed the directions of all the modeled paths. The model fit significantly deteriorated ($\Delta df=30$, $\Delta\chi^2 = 362.31 > \chi^2(df=30, \alpha = .05) = 43.77$) as a result. This indicates that reverse causality is unlikely.

Impacts of control variables. Among the seven control variables, female gamers report stronger continuance, while the level of actual game usage does not significantly differ between the genders. Moreover, weekly hours spent playing reflects game usage. This encompasses both gaming enthusiasm and gaming habits. Furthermore, officially recognized skill level predicts game usage, but not game intention. This

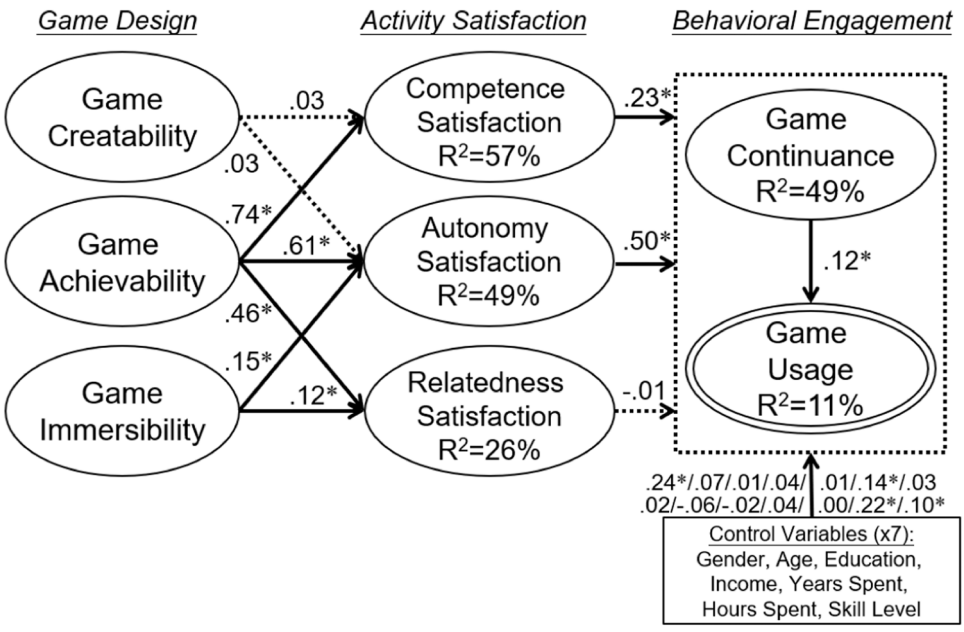

Fig. 2. Analytical Results. *Note.* * denotes $p < .05$. Dotted lines indicate links that have insignificant coefficients.

Table 5
Results of Hypothesis Testing.

Hypo	Independent Variable	Dependent Variable	Path	*p*-value	Result
H1a	Game Creatability	Competence Satisfaction	.03	0.56	Not Supported
H1b	Game Creatability	Autonomy Satisfaction	.03	0.58	Not Supported
H2a	Game Achievability	Competence Satisfaction	.74	< .001	Supported
H2b	Game Achievability	Autonomy Satisfaction	.61	< .001	Supported
H2c	Game Achievability	Relatedness Satisfaction	.46	< .001	Supported
H3a	Game Immersibility	Autonomy Satisfaction	.15	< .01	Supported
H3b	Game Immersibility	Relatedness Satisfaction	.12	0.01	Supported
H4a	Competence Satisfaction	Game Continuance	.23	< .001	Supported
H4b	Autonomy Satisfaction	Game Continuance	.50	< .001	Supported
H4c	Relatedness Satisfaction	Game Continuance	-.01	.83	Not Supported
H5	Game Continuance	Game Usage	.12	< .01	Supported

Note. Hypo=hypothesis; *Path*=standardized path coefficient

interestingly shows that highly skilled players may play the game for honor, which is not necessarily as a result of being attracted to the game content. This conjecture requires further examination in future research.

Sensitivity analysis. We conducted a sensitivity analysis by temporarily removing the control variables. This removal did not affect the testing results, and all the significant paths remained significant. Moreover, the coefficient of one additional path (from relatedness satisfaction to game continuance) becomes significant, suggesting an interesting direction for future research.

Rival model. It may be noted that game continuance is merely an intention, while satisfaction can directly evoke actual repeated use. Accordingly, we built the rival model by adding direct paths from all satisfaction types to game use. This rival model has a similar model fit to our proposed model ($\Delta df=3$, $\Delta\chi^2 = 1.61 < \chi^2(df=3, \alpha = .05) = 7.81$). Moreover, the newly added paths do not have significant coefficients ($p > .05$). All these results indicate that the newly added paths are not relevant and only increase the complexity of the model. Thus, we conclude that our proposed model outperforms the rival model.

First endogeneity test. Satisfied gamers may be more likely to notice game design elements. This suggests an alternative model that presumes that the game design elements (rather than game satisfaction) are the endogenous variables. Accordingly, we reversed the directions of the paths linking game design elements to satisfaction, i.e., H1, H2, and H3. This reversal significantly degraded the model fit ($\Delta df=0$, $\Delta\chi^2 = 4.75 > \chi^2(df=1, \alpha = .05) = 3.84$), supporting the idea that the endogeneity issue is not substantial in the examined relations.

Second endogeneity test. Behavioral engagement may affect player satisfaction. Hence, we reversed the directions of H4a to H4c and H5. Similarly, this reversal significantly degraded the model fit ($\Delta df=0$, $\Delta\chi^2 = 78.43 > \chi^2(df=1, \alpha = .05) = 3.84$) and also indicates that the endogeneity issue is not substantial in the focal relations.

Third endogeneity test. We assessed a third potential endogeneity by using Bollen's (1996) two-stage least squares (2SLS) method for latent variables. Bollen's method was designed for covariance-based structural equation modeling, as used in our study. After doing so, all the testing results remained the same, except that two paths changed from nonsignificant to significant: the path from game creatability to competence satisfaction and the path from game creatability to autonomy satisfaction. These results indicate that our main results are conservative. Moreover, all the R^2 values during the process were.35 or higher, indicating that the selected instrumental variables are suitable.

Regression-based endogeneity tests. Although our study used structural equation modeling, we also implemented the widely known regression-based endogeneity tests and reported the results in Appendix D.

6. Replication studies

We are aware that a cross-sectional study may encounter issues. Hence, we followed the advice in the literature to conduct replication studies using improved methodologies (Maier, Thatcher, Grover, & Dwivedi, 2023). Specifically, we designed and implemented two replication studies: the first was a quantitative study that aimed to replicate the analytical findings of the main study while addressing any potential concerns of the main study. The second was a qualitative study that

aimed to provide an in-depth explanation of the analytical findings, thus adding value to the main study.

6.1. Replication study–quantitative

Since the first quantitative study was aimed at replication, it must share many of the same, or at least similar, elements with the main study. For brevity, we did not repeat those elements that are the same.

The first quantitative study applied a two-wave design: the first wave aimed to collect data on design elements in the last two weeks of May 2023, while the second wave aimed to collect data on activity satisfaction and behavioral engagement in the first two weeks of June 2023. This temporal separation approach ensures that the first hypotheses were tested with different waves of data. Moreover, it may be noted that the path from continuance to usage is intuitive. Hence, the replication study omitted this path to see whether the testing results would remain the same. The findings of the replication study verified nearly all the testing results, providing enhanced evidence in support of our findings (as in Fig. 2).

We further implemented two improvements. First, we omitted the skill level from the list of control variables because, in our theoretical model (Fig. 2), it was the only control variable that was significantly related to usage but not to continuance. Its removal simplifies the list of control variables. Second, we added a third item to assess game creatability: "I play this online game to create my own characters," and a third item to assess game achievability: "I am confident I can achieve the goals of making in-game progress in this online game." Both scales showed a higher level of reliability ($\alpha = .82$ and .87), providing future scholars with three-item scales to assess the two concepts. Fig. 3 illustrates the results.

We observed that nearly all testing results remained the same. Moreover, all the concepts had their explained variation either increased or sustained, indicating that the replication model also explained the data well. Hence, we concluded that this replication research was successful, increasing the robustness of the study findings. The only change in the testing results regards the path from game creatability to competence satisfaction, which turned out to be significant in the replication study results. This exception indicates the potential value of game creatability, thus motivating future scholars to further examine its value in satisfying game player needs.

6.2. Replication study–qualitative

Regarding the qualitative study, we designed structural questionnaires to collect qualitative data from four experienced game players. Their responses provide in-depth and highly contextualized reasons that explain the main study results; i.e., they explain why most hypotheses were supported and why a few hypotheses were not supported.

We recruited four experienced players, including three men and one woman. All participants were undergraduates, and each responded to a structural questionnaire containing open-ended questions that probed the hypothesized relations presented in the main study (Fig. 1). Each participant was asked to arbitrarily choose one game they had recently played. They had played their selected games for up to two-and-a-half years. Each of them spent one to two-and-a half-hours completing the questionnaire. The main results are summarized below, and participant responses were quoted to support the summarized results.

Games can have various functions to afford players the ability to display their creativity, indicating that game creatability can be assessed and implemented in online games.

- *"At the start of the game, I can create my avatar by finessing many of its visual characteristics. I can create the avatar I want and one that matches my aesthetic."*
- *"This game enables players to create various means of killing the rivals…* e.g.*, using portals … or hooks… These skills and their combos [combinations] can provide elaborate means to wipe out the rival team."*

However, such functions may not fully satisfy player autonomy and competence needs, explaining the results that did not support H1a (*Game creatability is positively related to competence satisfaction*) and H1b (*Game creatability is positively related to autonomy satisfaction*).

- *"Some options for creating avatar faces require paying real-world money."*
- *"However, team members who are not close friends may not know how to cooperate to successfully implement the combos."*
- *"Spending a lot of time creating an avatar's face is tiring. … During most of the gameplay time, the avatar's subtle facial features cannot be stably observable."*
- *"The success rate of implementing combos is very low."*

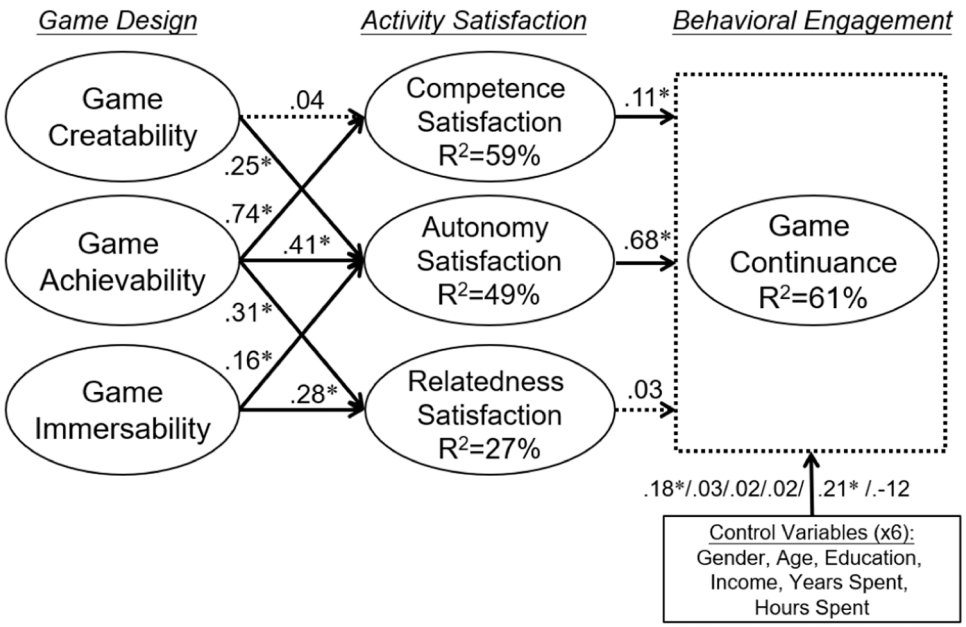

Fig. 3. Results of the Two-Wave Quantitative Replication Study.

The nominated games can also offer various ways for players to set their goals and achieve them, indicating that game achievability is a relevant and practical concept.

- *"There are many goals,* e.g.*, ACE (penta-kill), … displaying combos, while the most important goal is to win the team competition."*
- *"When viewing my avatar achieving the targeted level, I felt very moved and had a strong sense of achievement."*

Games' function-affording achievements can satisfy various player needs, including autonomy, competence, and relatedness, thus providing support for H2a (*Game achievability is positively related to competence satisfaction*), H2b (*Game achievability is positively related to autonomy satisfaction*), and H2c (*Game achievability is positively related to relatedness satisfaction*).

- *"For tough tasks, when I successfully killed the in-game boss, I felt I had progressed in my capabilities."*
- *"To win the team competition, all members' cooperation and communication are vital. Once we win, we have very high morale."*
- *"Choosing an avatar occupation I want at the beginning of gameplay satisfies my desire to be the same as the occupation in the game-related episode."*
- *"Teammates make free decisions to decide and implement team strategies."*
- *"To check whether my friends and I achieve our goals, we connect with each other every day."*
- *"Successful display of combos requires close cooperation. A large game world map creates information asymmetry, making it more complex. So I need to keep very close communication with teammates."*

The nominated games have functions that enable players to feel immersed in the game worlds. Hence, game immersibility is feasible and applicable in games.

- *"Avatars have their own voices, background music, and conversations with specific other avatars, making me feel as [though I am] in the game world."*
- *"When passing in-game stores, the music makes you feel that you are truly passing real-world stores."*
- *"The game has very beautiful scenes and well-planned plots, making me [feel as though I am] not playing a game, but actually experiencing the storylines."*

The mentioned game functions that give players a sense of immersion can also satisfy player autonomy and relatedness needs, thus supporting H3a (*Game immersibility is positively related to autonomy satisfaction*) and H3b (*Game immersibility is positively related to relatedness satisfaction*).

- *"There are many possible storylines. One can freely choose what you love when episodes go to the branch points."*
- *"Decisions can be made by players to trigger the game-world elements. I can decide to repeatedly pass by the stores to listen to the triggered music."*
- *"My teammates' avatars and mine will also engage in dialog and bicker."*
- *"My friends and I chose different episodes. When making choices, we exchange our feelings."*

Participants also indicated that immersive features in gaming can still be improved to help connect players, offering interesting directions for game makers and future scholars. For instance, a participant said, "*The game world elements may not need the help of others to trigger.*" Hence, game makers may need to devise more game-world immersive features that require triggering by two or more players in cooperation.

The participants unanimously indicated that autonomy and achievement are important when deciding to continue their gameplay, thus supporting H4a (*Competence satisfaction is positively related to game continuance*) and H4b (*Autonomy satisfaction is positively related to game continuance*).

- *"To make the avatar better-looking and more powerful induces me to continue gameplay."*
- *"Actualizing my thoughts and decisions provides me with the sense that 'I can fulfill what I want,' which makes me feel like a god in the game."*
- *"The desire to overcome all in-game challenges is my reason to continue gameplay."*
- *"I continue playing this game because this game continuously provides me with a sense of achievement."*

On the other hand, the participants indicated mixed statements on the link between relatedness satisfaction and game continuance, consistent with the unsupported H4c (*Relatedness satisfaction is positively related to game continuance*).

- *"Every day, I discuss our gaming progress with my good friends and [we] exchange our feelings, deepening our friendship, which is a reason for my game continuance."*
- *"When friends ask me to play the game, I will play it, not only for gameplay but also to chat with friends and [because I] care about them."*
- *"It can be important to connect with important friends by playing a game. However, this game does not let me feel it."*

This qualitative research contributes increased insights and contextualized motivations, which are valuable for game makers seeking to increase or change their game design elements. This qualitative replication study is supplementary to this article, offering room for future scholars to implement full-scale and more detailed qualitative studies to deepen an understanding of the focal research topic. Collectively, the findings of this qualitative research provide support for and add value to the findings of both the main study and the quantitative replication study, providing deepened confidence in the study findings.

Collectively, we implemented three studies: the main study, the two-wave quantitative replication study, and the structured-questionnaire qualitative replication study. Together, the three provide various angles to support the research model and the mostly consistent findings, offering enhanced scientific evidence.

7. Discussion

Prior game research has established that players are concerned about whether their needs can be satisfied during gameplay. If they cannot, then players would prefer to discontinue their gameplay. However, we have insufficient knowledge on the specific design elements that can comprehensively satisfy players' needs. If game providers do not have such knowledge, they arbitrarily or equally allocate their resources to improving game design elements, instead of taking strategic and targeted action to elevate players' behavioral engagement. Hence, our research is necessary for the provision of such knowledge. Accordingly, we proposed three game design elements and investigated how these could be used to comprehensively satisfy players' needs and, in turn, further increase their behavioral engagement. We found that game achievability and game immersibility are important elements in satisfying players' comprehensive needs, further resulting in increased game usage. Our findings contribute novel knowledge to the game literature and provide actionable insights for game makers.

Contribution to online game domain. Online game makers and game companies attach great importance to gamers' continuance behavior, which is the main determinant of their purchase intentions (Hamari et al., 2020), as this yields game makers and companies a competitive advantage in the highly competitive game industry. As a result, prior research has been conducted to investigate the antecedents of continued gameplay behavior and found internal gameplay

experience to be a key antecedent (Hsiao & Tang, 2021). For instance, players' continuance can be stimulated by perceived enjoyment (Esteves et al., 2021; Hamari et al., 2020), self-efficacy (Esteves et al., 2021), attachment (Hsiao & Tang, 2021), and need satisfaction (Formosa et al., 2022). However, these studies focused on the internal gameplay experience and did not explore its source. A relevant study is that of Teng et al. (2022a), which identified that strategic, offensive, and defensive engagement satisfy players' needs and further enhance their game usage. Such findings can help game makers better design their games, yet they are only applicable to games that provide competitive functions. That is, we have little knowledge of the psychological mechanisms underlying the process of satisfying players' needs and stimulating further usage. Accordingly, we closed this research gap by exploring how internal gameplay experience (e.g., need satisfaction in our study) can trigger player continuance. We identified three game design elements as sources of specific types of need satisfaction. Our findings can deepen game makers' understanding of the psychological mechanisms underlying the process of player need satisfaction. Moreover, our findings can be applied to most online games, thereby making a useful contribution to the online game domain.

Contribution to gameplay motivation typology. As our study selected game design elements using the gameplay motivation typology, we should discuss our contributions to this typology. Gameplay motivation typology listed three major motivations, namely achievement, immersion, and socialization (Xi & Hamari, 2019; Yee, 2006). Unlike these studies, our research found mixed evidence on the effects of socialization, and theoretically inferred that *creatability* should consistently exhibit a positive effect. That is, our theorization added creatability as a fourth motivation.

Contribution to the literature on user reactions to technological advancements. Technologies have advanced dramatically, causing issues regarding how users react to such technological advancements. Our study contributes to this research stream by focusing on technological advancements (i.e., new game design elements). Recent technological advancements include artificial intelligence (AI) and chatbots (e.g., ChatGPT). Specifically, users are not straightforwardly satisfied with such technological advancements. First, users are concerned about ChatGPT in terms of safety, accountability, and responsibility (Stahl & Eke, 2024). ChatGPT may be used for mass production, which causes burdens in terms of reception (e.g., review systems) (Dwivedi et al., 2023). Second, users require more suggestions for input (or prompts) from chatbots to help complete their tasks (Rese & Tränkner, 2024). Third, users must continuously learn how to use AI and explain AI outcomes (Maragno et al., 2023). Otherwise, users could become highly emotional (Chi et al., 2023) or resistant to AI (Merhi, 2023) because many users are not prepared for the changes caused by AI (Uren & Edwards, 2023). Even in the case of some established information systems, e.g., accounting information systems, users feel stressed due to receiving excessive information (Zhu et al., 2023). Our study also examines technological advancements and highlights novel elements in technological advancements, thereby offering increased materials for research on technological advancements.

Our study proposes several novel game design elements: creatability, achievability, and immersibility. These elements and their influences offer insights for research on information management in various contexts. Specifically, these elements can serve as technological components that facilitate information systems development, such as by evoking team creativity (Ciriello et al., 2024). Moreover, previous research has indicated that immersiveness could motivate users' engagement (Richter & Richter, 2023) and increase the amount of time they spend (Mogaji et al., 2023) but the mechanism underlying these impacts has not been verified. Our findings clarified that such an underlying mechanism should include the satisfaction of autonomy needs and relatedness needs. Furthermore, the intention to use technologies may not be sufficient in this context, which has triggered a call for research on this topic (Jeyaraj et al., 2023). Our study answers this call by linking system design elements to use intention as well as to actual usage.

7.1. Theoretical contributions and implications

Our research findings support the claim of SDT, i.e., positing that need satisfaction can increase user engagement in specific activities (Ryan & Deci, 2000), e.g., actual gameplay behavior. However, unlike past SDT research in game contexts (e.g., Formosa et al., 2022), we observed a theoretical anomaly to SDT, i.e., not all types of need satisfaction are important in our research context. Specifically, the results of our research indicate that competence satisfaction and autonomy satisfaction strongly influence players' behavioral engagement, while relatedness satisfaction exerts no significant impact. Such findings contradict our intuition on the impact of need satisfaction on further use, changing our understanding of SDT.

Previous SDT research indicates that need satisfaction can lead to behavioral engagement (Chiu, 2021). However, unlike this research, the results from our model indicate that need satisfaction may not directly increase actual usage. In fact, the findings from our model indicate that user continuance intention is the underlying mechanism that effectively results in actual usage. Moreover, most SDT research focuses on the impacts of need satisfaction, e.g., on the fact that need satisfaction can induce game enjoyment (Reer et al., 2022), increase harmonious and obsessive passion toward videogames (Formosa et al., 2022; Johnson et al., 2021), and prompt helping behavior (Johnson et al., 2021). Few studies have identified the root of need satisfaction, i.e., Teng et al. (2022a) and Qin (2021). Specifically, Teng et al. (2022a) proposed that three types of competitive engagement could satisfy player needs. However, game design guidance other than ways of boosting players' competition engagement are needed. On the other hand, Qin (2021) found that the perceived attractiveness of autonomy-, competence-, and relatedness-supportive elements is related to different types of need satisfaction. Compared to those studies, our study clarified the dynamics behind such elements, thus enabling game makers to formulate actionable strategies. Specifically, we identified three novel context-specific triggers of need satisfaction, thus providing a more comprehensive picture of SDT.

7.2. Implications for practice

Our findings support the claim that game achievability sharply improves competence need satisfaction and relatedness need satisfaction, suggesting that game makers should design in-game goals that are attainable through easy-to-learn skills. Recent advances in behavioral modeling have made it possible to measure players' perception of game difficulty. Therefore, game makers should create a game difficulty profile for each player and then adapt game difficulty levels accordingly. Moreover, game makers can design nonplayer characters that can offer hints regarding the achievement of gaming goals. Such hints can take the form of texts or videoclips, thereby offering multimedia cues that are easier to understand. Furthermore, informed by our qualitative results, game makers can design "combos" (combination of the skills of two or more players, which are typically much more powerful than individual skills) that players can help each other to implement the combos. In so doing, game tasks would be perceived as attainable, which can improve player satisfaction in competence and relatedness needs.

Our findings support the idea that game immersibility improves autonomy need satisfaction and relatedness need satisfaction, suggesting the importance of immersibility in game use. Game makers can exploit recent advances in virtual reality (VR) technology to induce stronger emotions in players. Elements of VR technology can be embedded in games, including visual and auditory elements. Visual elements can be improved by using vivid elements and fluent motion display technologies. Audio elements can be enhanced by employing sound effect experts or establishing strategic alliances with firms that

offer such expertise. These elements can effectively create an immersive virtual world and therefore tell a game world story and stimulate emotions more convincingly. Both storytelling and emotional gameplay can provide meaningful engagement, which in turn satisfies player needs.

Our findings support the idea that competence need satisfaction drives game continuance. Game makers could conduct big data analytics to provide players with the gaming statistics of the teammates, thus enabling players to strategically plan their gaming approach. Moreover, sophisticated analytics could be used to identify certain in-game achievements, e.g., the penta-kill (killing five members of the rival team in a short time), and present these on leaderboards. Players' notable achievements can also be celebrated through entire-server celebration messages, thus increasing players' sense of competence. Furthermore, according to our qualitative results, players enjoy the process of becoming stronger. Hence, game makers can include game indices that reflect players' growth or progress. Examples of such indices include the percentage of the game world map explored, a progress bar showing the completion ratio of certain notable achievements, the percentage of quests that have been solved, and the remaining amount of experience required to reach another game level. Such game indices can also remind players when they attain certain milestones. These analytics could help satisfy player competence needs.

To improve players' autonomy need satisfaction, game makers could adopt and simulate codesign strategies that have proven successful in other businesses. For example, game narratives can serve as a codesign target. Just as test screenings that change movie endings can improve the rating given by the audience, so game makers could adopt a similar strategy. Specifically, players could be invited to participate in game trials that included alternative narrative flows. This implication is informed by our qualitative results, i.e., the finding that players appreciate a game that offers many possible storylines and endings. Players thus have the chance to suggest which storylines to keep and which to eliminate. The avatars used in a game represent another target of codesign. Players can be invited or encouraged to submit avatar designs. Such invitations or encouragements can elicit innovative work from players while saving game makers' effort with regard to conceptualizing and creating new avatars. In this way, players can also enjoy codesigning the game avatars, thereby satisfying their autonomy needs. These codesign strategies let gamers participate in visual design and narrative design, enabling autonomy need satisfaction.

We found that game continuance increases game usage. Game makers could design gamer retention strategies, including off-game reminders and time-limited bonuses. Moreover, game makers could form partnerships with attractive brands to leverage the shared stores effect. For example, popular games can be played while game songs are played on music platforms. These strategies could be used to capture player attention and help players return to the game when they are not engaged with it, thus increasing their game usage.

7.3. Limitations and future research direction

In our study, we examine the ways that game design elements are related to player satisfaction, thus securing game continuance and game usage. We use two-wave and two-source data, indicating merit. However, future studies could use an experimental research design to confirm the causality embedded in our research findings.

We focus on a popular online game, LoL. Given that game genres are influential in affecting gameplay experience, future studies could consider other game genres (e.g., board and card games, music games, or adventure games) to replicate our study and seek to extend our findings, offering fertile ground for research opportunities.

8. Conclusions

Rapid technological advancements enable game makers to design system functions in a way that satisfies players. However, we do not have sufficient knowledge about which game-specific design elements can satisfy which psychological needs. We filled this void by drawing on SDT to build a theoretical model. Specifically, we proposed three game design elements—*game creatability*, *game achievability*, and *game immersibility*—and explored how they could help satisfy players' needs and increase their game continuance and usage. These new design elements can offer actionable means for game makers to design their games, thus more effectively increasing gameplay. In short, we found that game achievability and game immersibility are key triggers of need satisfaction, offering game makers actionable guidance and demonstrating both the theoretical and practical importance of this study.

CRediT authorship contribution statement

Ching-I Teng: Conceptualization, Methodology, Resources, Formal analysis, Writing – original draft, Writing – review & editing. **Tzu-Ling Huang:** Conceptualization, Investigation, Formal analysis, Writing – original draft, Writing – review & editing. **Guan-Ling Huang:** Data curation, Visualization, Writing – original draft. **Chieh-Ni Wu:** Investigation, Data curation, Writing – original draft. **T. C. E. Cheng:** Supervision, Visualization, Writing – review & editing. **Gen-Yih Liao:** Conceptualization, Project administration, Funding acquisition, Writing – original draft, Writing – review & editing.

Declaration of Competing Interest

The authors have no competing interests to declare.

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Appendix A. Scale Items and Statistics

Construct	Item	*M*	*SD*	*λ*
Game Creatability	I play this online game to create my own stories.	2.74	1.09	.89
	I play this online game to display my creativity.	3.00	1.11	.76
Game Achievability	I am confident that I can successfully achieve in-game task-related goals in this online game.	3.55	0.96	.83
	I am confident that I can achieve the goals of learning in-game skills in this online game.	3.66	0.91	.85
Game Immersibility	When I play this online game, I feel I am in a world created by the online game I am visiting.	2.43	1.11	.89
	When I play this online game, my body is in the real world, but my mind is in the world created by the online game I am visiting.	2.42	1.11	.93
	When I play this online game, the world generated by the site I visit is more real to me than the "real world."	1.87	0.93	.79
Competence	When I play this online game, I feel confident that I can do things well.	3.62	0.96	.88
Satisfaction	When I play this online game, I feel capable at what I do.	3.51	0.98	.95

(*continued on next page*)

(*continued*)

Construct	Item	*M*	*SD*	λ
	When I play this online game, I feel competent to achieve my goals.	3.59	0.93	.89
	When I play this online game, I feel I can successfully complete difficult tasks.	3.41	0.98	.82
Autonomy Satisfaction	When I play this online game, I feel a sense of choice and freedom in the things I undertake.	3.75	0.98	.69
	When I play this online game, I feel that my decisions reflect what I really want.	3.52	0.89	.81
	When I play this online game, I feel my choices express who I really am.	3.20	1.02	.65
	When I play this online game, I feel I have been doing what really interests me.	3.64	0.85	.81
Relatedness Satisfaction	When I play this online game, I feel that the people I care about also care about me.	3.15	1.11	.78
	When I play this online game, I feel connected with people who care for me and for whom I care.	3.39	1.12	.92
	When I play this online game, I feel close and connected with other people who are important to me.	3.41	1.15	.90
	When I play this online game, I experience a warm feeling with the people I spend time with.	2.84	1.16	.76
Game Continuance	This online game is my first choice when I consider playing online games.	3.95	0.87	.81
	I intend to play this online game frequently.	3.76	0.83	.87
	I feel I am loyal to this online game.	3.73	0.95	.74
Game Usage	The number of gameplay sessions in the entire month*	0.02	0.97	1.00

Note. *M*=mean score; *SD*=standard deviation; λ = indicator loading. * =rank-normalized score.

Appendix B. Processes Ensuring Scale Modification Quality

Our model includes three novel game design elements, namely, game creatability, game achievability, and game immersibility. These elements are new concepts to online game literature. However, related concepts have been explored in previous studies. Hence, we chose not to develop their scales from scratch, but rather to use the existing scales, as discussed in the Measurement subsection.

We ensured the quality of the scales for these new concepts in several ways. First, we adapted the wording of the measurement items to better fit their conceptual definitions. Second, we asked three experienced gamers to check and modify this wording to better fit gamer language. Third, we conducted detailed psychometric testing on the scales in terms of their loading patterns, reliability, and validity, as stated in the Psychometric Properties subsection.

Appendix C. The Results of Bootstrapping Analyses

Independent Variable	Mediator Variable	Dependent Variable	LL	UL
Game Creatability	Competence Satisfaction	Game Continuance	.08	.15
Game Creatability	Autonomy Satisfaction	Game Continuance	.10	.18
Game Achievability	Competence Satisfaction	Game Continuance	.07	.17
Game Achievability	Autonomy Satisfaction	Game Continuance	.11	.20
Game Achievability	Relatedness Satisfaction	Game Continuance	.04	.10
Game Immersibility	Autonomy Satisfaction	Game Continuance	.08	.17
Game Immersibility	Relatedness Satisfaction	Game Continuance	.03	.09
Competence Satisfaction	Game Continuance	Game Usage	.02	.10
Autonomy Satisfaction	Game Continuance	Game Usage	.02	.14
Relatedness Satisfaction	Game Continuance	Game Usage	.02	.08

Note. LL=lower limit; UL=upper limit.

We performed the usual bootstrapping process, i.e., 5000 resamplings at the typical significance level of.05 (Nusair et al., 2024). Although not all the path coefficients in our structural model have significant coefficients, the bootstrapping results indicate that all the mediations are significant. This is reasonable, as the bootstrapping method is designed to test the interactions of the path coefficients. Therefore, a single large path coefficient can result in a significant interaction among path coefficients.

All the mediation coefficients are significant, justifying the importance of the chosen mediators in our model. Moreover, our model shows that most (but not all) paths have significant coefficients, giving game makers useful insights into game achievability and game immersibility, but not focusing on game creatability.

Appendix D. The Results of Regression-Based Endogeneity Tests

Notably, behavioral engagement may influence activity satisfaction. Hence, the paths from satisfaction to game continuance may need to be further examined for endogeneity. We followed the work of Hult et al. (2018) in using three approaches to comprehensively address endogeneity issues, namely, the control variable, instrument variable, and instrument variable-free approaches. First, we included seven control variables. This number of control variables is large enough to alleviate endogeneity concerns (Chen, Zhang, Xiao, & Xie, 2021; Lu, Ding, Peng, & Chuang, 2018).

Second, regarding the instrumental variables approach, we followed the literature (Chen et al., 2021) and implemented a two-stage least square (2SLS) regression and a Durbin-Wu-Hausman test. Based on our understanding of the game literature, we chose four instruments: gaming skill, escapism, game complexity, and game familiarity. The joint *F* statistic was 0.60 ($p = .61$), which did not reject the null hypothesis, i.e., the inclusion or exclusion of instruments did not significantly change the coefficients. The *J* statistic was 0.05 ($p = .82$), which did not reject the null hypothesis; i.e., the instruments are valid.

Third, regarding the instrument variable-free approach, we found that instruments are not the only way to address endogeneity (Peng, 2023). The rationale of Gaussian copulas that is used in regression methods can be used here (Ebbes, Wedel, Böckenholt, & Steerneman, 2005); e.g., we can link the regressors to the error term of the dependent variable (Jean, Deng, Kim, & Yuan, 2016), which is particularly feasible when using the covariance-based structural equation modeling method (Jean et al., 2016). The results indicated that χ^2 *increased significantly* ($\Delta\chi^2 = 4.26 > \chi^2(df=1) = 3.84$) as a result of adding the three links from the satisfaction concepts to the error term of game continuance. That is, our model outperformed the model including endogeneity, reducing any remaining endogeneity concerns.

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