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Exploring player interaction and team cooperation in MMOG playability enhancement

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ABSTRACT

The massively multiplayer online games (MMOGs) continue to grow in popularity, and it has become particularly important to understand the key factors that influence team playability. While existing research has focused primarily on system functionality and individual player experience, insufficient attention has been paid to the role of team dynamics in player satisfaction. This study focuses on the core variables that influence team playability, including teamwork, task dependency, team loyalty (TLO), and team relationships (TR), and explores how these variables work together to influence player experience. This study used a combination of exploratory research (multi-variates) and a questionnaire survey (N=1064) to initially construct a team playability model, which was validated by structural equation modeling (SEM). The results show that TR have a significant positive effect on teamwork efficiency, and captains with transformational leadership (TL) styles not only enhance TR but also further improve overall team effectiveness (TE) and player satisfaction. This study provides MMOG developers with theoretical support for designing game mechanics centered on team interaction to enhance overall playability and player stickiness.

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1. INTRODUCTION

Massively multiplayer online games (MMOGs), have recently gained a significant amount of importance in the gaming market all over the world. These games are appealing to players because they provide them with the opportunity to collaborate and communicate in real-time within a highly interactive virtual world. Within this world, they tackle a variety of tasks and challenges together. In contrast to traditional single-player games, MMOGs emphasize synchronous multi-user participation, complicated job division, and socially dependent interactions. As a result, they emphasize team cooperation as a foundational element of the gaming experience [1]-[3].

In recent years, studies on online game playability have focused more on system functionality (e.g., latency optimization, interface design) and user experience (e.g., immersion, behavioural analysis). However, there are times when the relevance of team cooperation is overlooked, particularly the impact of team-level dynamics on player experience and game pleasure [4]. Team cooperation is the process in which players support each other and collaborate to strive to achieve a common goal network [1]. It is through player interaction (the process of interaction between players and other players during the game) which directly affects the player"s game experience and engagement, thus enhancing the playability and immersion

of the game. The ability of players to work together as a team not only affects their ability to complete tasks but also plays a significant role in fostering player involvement and loyalty [5].

When it comes to MMOGs, team cooperation takes the form of cooperative combat, the accomplishment of tasks, and the sharing of resources, which builds a complex social network [1]. Players can build close relationships inside this network through the interactions that they have with their teammates. These relationships contribute to the overall appeal of the game and assist in keeping players engaged. Role allocations, resource allocation, and the general player experience are substantially influenced by the interdependence among team members [6]. But game design research has so far paid scant attention to these team-level elements, sometimes ignoring the important roles of team efficacy, loyalty, and task interdependence (TI) in forming player experience. Team cooperation in MMOGs strongly affects players" emotional involvement and immersion in the game, and not only serves as a practical tool. Therefore, a better knowledge of team dynamics is necessary to grasp their effect on player satisfaction.

To address the complex and multifaceted nature of teamwork in MMOGs, this study utilized a two-phase research design. First, an exploratory survey was conducted to identify key variables that influence team dynamics and to draw insights from prior literature and player behavioral patterns. This phase laid the groundwork for the construction of a conceptual model that encompassed the interplay between TI, loyalty, leadership, and team relationships (TR). Subsequently, a large-scale questionnaire survey was conducted to empirically test the model using structural equation modeling (SEM). The results confirmed significant interrelationships between the variables of TI, team loyalty (TLO), and transformational leadership (TL). This hierarchical methodological framework not only enhances the theoretical rigor of the proposed team playability dynamic model (TPDM) but also provides empirical evidence for improving cooperative game design strategies in MMOG environments. By identifying and quantifying factors that enhance or hinder teamwork and communication, this study aims to provide actionable insights for MMOG developers and designers. These insights are intended to help identify and address challenges in teamwork, ultimately creating a more immersive and enjoyable MMOG experience.

2. LITERATURE REVIEW

Playability is an important means of assessing a game's appeal, interaction quality, and player experience in usability, challenge, social interaction, and feedback [7]. Current research uses user tests, questionnaires, and behavioral data to quantify interface intuitiveness, task completion, and game pleasure [8]. These research approaches focus on the experience of a single player [9], lacking consideration of multiplayer interaction dynamics, especially in complex environments like MMOGs. Due to MMOGs" unique structure, teamwork, communication, and cooperation are essential [10]. Therefore, this study defines team playability as comfortable, pleasurable, and interactive behaviors, including coordination, mutual support, and goal-oriented teamwork that occur when players work together to achieve a goal or explore the game world.

Early studies have examined user interface design, single-player task completion efficiency, and user satisfaction metrics [7], but this individual-based approach makes it hard to determine how teamwork affects MMOGs. Ducheneaut *et al.* [8] observed World of Warcraft that players do not always collaborate during group play. This study found a discrepancy between social interaction and collaborative behavior, but did not investigate the team mechanics that caused it. In their study, Gong [11] suggested that players" "social identity" and "online social capital" affect their psychosocial results. Social network strength and sense of belonging among players are important for psychological well-being and game stickiness, but the study focused more on the individual effects of social capital and did not discuss structural factors during teamwork, such as task dependence, leadership style, and TLO.

It can be seen that traditional studies usually assess player behaviour and satisfaction at the individual level [12], without a dynamic observation of the quality of team interaction and collaboration. While the player experience in large-scale MMOGs is influenced by interface design and game features, it also relies heavily on effective teamwork, including factors such as task-related interdependence and TLO [13]. However, current research tends to emphasize individual traits in virtual teams (VT), such as emotional intelligence and leadership [14], resulting in a lack of systematic analysis of the complex dynamics of team interactions in online game playability assessment. In addition, studies have tended to focus on individual games without expanding the scope to a variety of game types. Moreover, most studies investigated only one type of game and failed to generalize to other types of games. This narrowness leads to significant differences in players" game behaviours, such as their willingness to cooperate in teams and their choice of social modes, especially in diverse and international online game communities, where empirical analyses of playability are scarce [1].

3. HYPOTHESES DEVELOPMENT

3.1. Task interdependence

TI [15] reflects the extent to which team members rely on each other to achieve [16]. In the complex environment of MMOGs, tasks are frequently interdependent and demand players to depend on each other for certain abilities and collaborate to achieve common goals [17]. By removing physical interaction, Teammates are compelled to rely on one another to cooperate and accomplish multifaceted, shared targets. Such dependence builds up norms of collaboration in the team, promotes the sharing of knowledge and experience about the cooperative approaches, and also boosts affective attachments and TLO [18]. Therefore, hypothesize the following:

Hypothesis 1: TI will be positively correlated with TLO.

3.2. Team loyalty

TLO refers to the long-term engagement and participation of team members [19]. It includes the notion of commitment to the team context in the game, and team dynamics are usually solidified by strong member loyalty [12]. Causal antecedents of TLO comprise team participation experience (TPE), cooperation knowledge (CK), and team norm (TN). High levels of trust, cohesion, and collective efficiency in pursuit of shared goals (SG) indicate that loyalty is strong among the team [5]. Enhancing these elements will not only promote stable team bonds but will also help satisfy the social needs of players and stimulate persistence in the game [19]. Therefore, hypothesize the following:

Hypothesis 2: TLO will be positively correlated with TR.

3.3. Team relationship

TR are a dynamic network of social interactions that reflect the quality of mutual trust, role expectations, and information exchange among team members, and have a central impact on team adaptability and learning capacity [20]. Although relevant research remains limited, the few studies that have explored the relationship between team trust (TT) and team cohesion (TC) reveal that effective teams create stratified TR with TT, sharing, collaboration, and TC [6]. We have identified four core aspects of TR, including TT, SG, cooperative attitude (CA), and TC, to align with the MMOG player experience. Specifically, the TT promotes cohesion and willingness to work, and helps members to support each other and share knowledge, leading to improved team productivity [14]. In this manner, TC promotes a high degree of member engagement and satisfaction, as they are incentivized to work towards common goals [21]. Moreover, CA reflects an attitude of helping and supportiveness, which also improves internal communication and group problem-solving in the team [22]. SG itself brings team members having similar interests close to each other to work in close cooperation, thus enhancing both team effectiveness (TE) and the probability of desired outcomes [23]. Therefore, hypothesize the following:

Hypothesis 3: TR will be positively correlated with TE.

3.4. Transformational leadership

TL boosts team cohesion and effectiveness via shared vision, open communication, and individual growth support [24]. TL positively influences TR and boosts TE through the promotion of a shared vision, transparent communication, and support for individual development [25]. This leadership approach fosters trust and cohesion, establishing a psychologically safe environment where team members feel encouraged to voice ideas, take calculated risks, and align with group objectives [15]. Therefore, hypothesize the following:

Hypothesis 4: TL will be positively correlated with TR.
Hypothesis 5: TL will be positively correlated with TE.

3.5. Team effectiveness

TE describes the degree to which the outcomes of a team meet established criteria or imply some share of the end state or outcome [26]. According to Purvanova and Kenda [27], team performance (TP), team viability (TV), and team member satisfaction (TMS) play a significant role in the efficiency of VT. Effective teams support the well-being of team members, as well as improve in-game performance in pursuit of common goals [28]. Thus, TE is an observable indicator of the impact of player satisfaction at the team level on game outcomes. Therefore, hypothesize the following:

Hypothesis 6: TE will be positively correlated with member satisfaction.

3.6. Team playability dynamics model

This study adopts the input–process–output (IPO) as the foundational framework. The IPO framework expresses the essence of how TP influences in a classical systems model manner. This model is commonly employed in empirical studies of team and virtual TP, with many related studies explicitly or implicitly utilizing the IPO model [29]. Although this study involves related factors such as team trust and sharing, it fails to conduct a comprehensive investigation into team collaboration. Therefore, this study integrates the IPO model with social identity theory [30] to provide a comprehensive perspective on team collaboration, focusing on the full-process experience of team players regarding game playability.

Therefore, based on the integration of the IPO model and social identity theory, a conceptual framework was proposed. By introducing the proposed hypotheses, the TPDM was constructed in Figure 1.

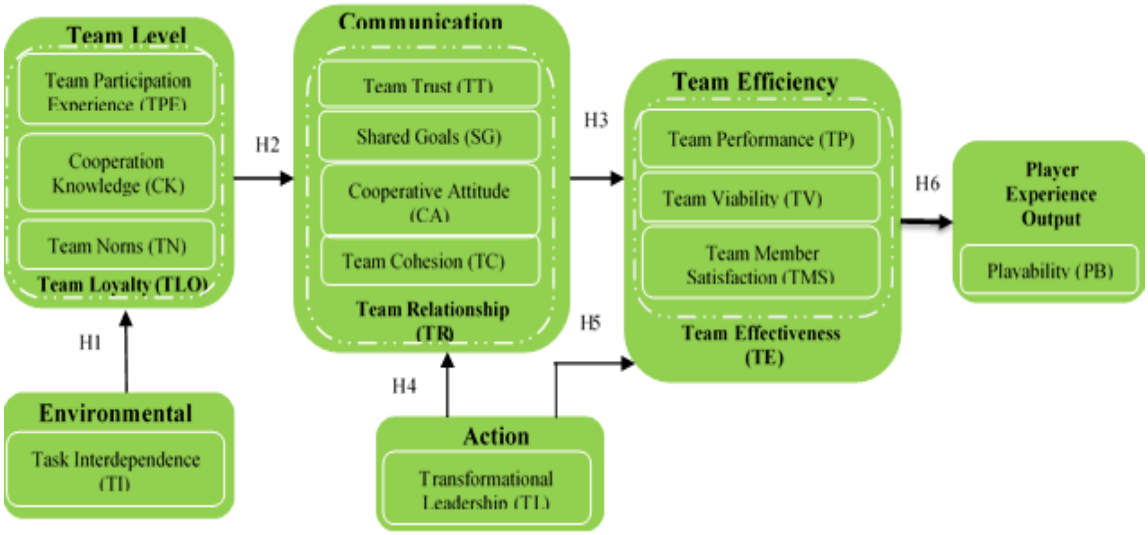

Figure 1. Team playability dynamics model

4. RESEARCH METHODOLOGY

This study employs a mixed-methods approach, integrating quantitative methods with exploratory research. Initially, exploratory research was conducted to identify factors influencing team collaboration in exploratory studies [31]. Given the limited scope of existing literature on MMOG playability, a comprehensive review of relevant literature was performed to identify specific variables and hypothesize potential. Subsequently, quantitative analysis was utilized to conduct detailed mathematical and statistical evaluations of the collected data, aiming to uncover relationships among the variables [32]. By collecting original data, this approach enables researchers to perform a more intuitive analysis of the model. Partial least squares structural equation modeling (PLS-SEM) has been used for data analysis due to its suitability for modelling complex structures involving latent variables and multiple causal pathways [33]. PLS-SEM enhances the robustness and flexibility of the modelling process in an exploratory setting, in addition to its ability to perform predictive and explanatory analyses [32].

The target population of this study comprises MMOG players in China. Considering the large size of this demographic, the minimum required sample size was determined to be 667 participants (based on an effect size of 0.5, α level of 0.05, and power of 0.99). A total of 1,081 questionnaires were collected, and after excluding incomplete or invalid responses, 1,064 valid questionnaires were retained, with specific demographic information as shown in Table 1. Following the standards suggested by Sarstedt *et al.* [32], the rate of missing or problematic data in social science research should remain below 5%, which aligns with the requirements for SEM studies. To address regional and linguistic differences between researchers and participants, the survey was conducted online using Question Star and was available in both Chinese and English.

Table 1. Population information

Option	Counts
Gender	
Male	578
Female	460
Age	
18-25 years	454
26-35 years	409
36-45 years	150
46-55 years	15
Above 56 years	10
Education	
High school or lower	239
College/University	482
Graduate institute	317
Weekly hours spent playing	
＜ 5 h	192
≥ 5 and ＜10h	231
≥10 and ＜ 30 h	323
≥30 and ＜ 50 h	234
≥50 h	58
The massively multiplayer game you play most often is	
Arena of valor	230
PUBG	397
Cross fire	103
World of warcraft	116
League of legends	192

5. DATA ANALYSES AND RESULTS

The current data analysis elucidates the relationships between TI, TLO, TR, and TE, and their collective impact on the enhancement of Playability (PB) in MMOGs. Structural equation modelling (SEM) was applied, yielding significant path coefficients for each hypothesized relationship and supporting the interplay of team dynamics on player satisfaction.

Analyses of reliability and validity were carried out to assess the external factor coefficients of the variables, ensuring the accuracy and consistency of the data collected. According to the hair study, reliability index measurements included internal consistency, Cronbach"s alpha, and composite reliability (rho_c) above the threshold of 0.7 for each construct, and average variance extracted (AVE) above the threshold of 0.5 for each construct [32]. As can be seen from the results in Table 2, each variable is above the parameter thresholds, confirming that the variable data have satisfactory convergent validity. For example, the Cronbach's alpha value of 0.906 for TMS, 0.941 for rho_c, and 0.842 for AVE confirms that the structure consistently captures the intended concepts, and the reliability of the data results is very high. Similarly, the constructs for the other variables demonstrated strong reliability and validity, confirming the robustness of the model in accurately measuring team-related factors in the MMOG environment.

Subsequently, discriminant validity was assessed using the Fornell–Larcker criterion to ensure that each construct was distinct from the others. Each structure was required to have a mean-variance extraction greater than the mean difference with the other structures [33]. Thus, Table 3 shows that the internal consistency within each structure is less than AVE, confirming that each structure is different and captures that each latent variable in the MMOG is independent. Therefore, the proposed variables have high reliability and validity.

Hypothesis testing, as shown in Table 4 and Figure 2, reveals statistically significant positive relationships among the constructs. TI, by necessitating interdependent actions among players, fosters loyalty through a collaborative environment that reinforces players' connections and shared experiences. Notably, the SEM results for Hypothesis 1 confirmed that TI has a strong, positive effect on TLO (Mean=0.543, T=17.895, $p<0.001$), substantiating the idea that reliance on teammates cultivates longer-term collaboration, ultimately boosting player loyalty. Similarly, TLO proved instrumental in reinforcing TR, as evidenced by Hypothesis 2 (Mean=0.690, T=30.097, $p<0.001$). This finding aligns with prior literature indicating that a cooperative mindset within VT enhances trust and unity, which are foundational to TR. This relationship between TLO and TR was strengthened by the active involvement of players in common objectives, supporting Hypothesis 3 (Mean=0.280, T=11.230, $p<0.001$). The SEM analysis confirmed that TR, facilitated by SG and CA, serves as a key driver for overall team cohesion and mutual support among members. The influence of TL on TR and TE was substantiated through Hypotheses 4 and 5 (Means=0.198 and 0.685, T=7.162 and 29.280, respectively, both $p<0.001$). This indicates that leaders who actively engage

in fostering a collaborative environment play a crucial role in strengthening intra-team relationships, ultimately improving team outcomes. Furthermore, the positive correlation between TL and TR underscores TL's value in promoting a cohesive, goal-aligned team culture that enhances both TE and individual satisfaction. Lastly, Hypothesis 6 confirmed the positive effect of TE on playability (PB), with a substantial path coefficient (Mean=0.548, T=18.932, p<0.001). High-performing teams that meet or exceed in-game objectives contribute significantly to player satisfaction, underscoring TE as a core determinant of playability in MMOGs. This pathway suggests that TE not only fulfills immediate game goals but also promotes long-term player engagement, as players within effective teams report higher satisfaction and are more likely to reengage. In summary, the SEM analysis highlights the crucial roles of TI, TLO, TR, and TL in enhancing team-based playability.

Table 2. Reliability and validity

	Cronbach's alpha	Composite reliability (rho_c)	Average variance extracted (AVE)
CA	0.856	0.897	0.634
CK	0.861	0.900	0.643
PB	0.932	0.942	0.594
SG	0.817	0.879	0.646
TC	0.823	0.883	0.654
TEP	0.918	0.936	0.710
TI	0.869	0.910	0.717
TL	0.917	0.931	0.601
TLG	0.823	0.883	0.653
TMS	0.906	0.941	0.842
TP	0.788	0.876	0.702
TT	0.877	0.907	0.619
TV	0.883	0.911	0.632

Note: cooperative attitude=CA, cooperation knowledge=CK, emotional intelligence=EI, team norms=TN, shared goals=SG, team cohesion=TC, task interdependence=TI, transformational leadership=TL, team participation experience=TPE, team trust =TT, team performance=TP, team viability = TV, team member satisfaction = TMS.

Table 3. Fornell-larcker criterion

	CA	CK	PB	SG	TC	TEP	TI	TL	TLG	TMS	TP	TT	TV
CA	**0.796**												
CK	0.660	**0.802**											
PB	0.452	0.420	**0.771**										
SG	0.705	0.673	0.437	**0.804**									
TC	0.540	0.496	0.458	0.508	**0.809**								
TEP	0.639	0.719	0.400	0.614	0.497	**0.843**							
TI	0.564	0.510	0.477	0.570	0.503	0.451	**0.847**						
TL	0.555	0.474	0.529	0.557	0.547	0.469	0.535	**0.775**					
TLG	0.656	0.748	0.435	0.667	0.488	0.712	0.509	0.503	**0.808**				
TMS	0.590	0.620	0.357	0.583	0.469	0.598	0.454	0.457	0.553	**0.918**			
TP	0.547	0.487	0.426	0.500	0.804	0.474	0.531	0.523	0.445	0.474	**0.838**		
TT	0.680	0.757	0.438	0.704	0.511	0.729	0.495	0.522	0.753	0.614	0.511	**0.787**	
TV	0.529	0.466	0.535	0.508	0.504	0.430	0.516	0.567	0.438	0.446	0.504	0.483	**0.795**

Note: cooperative attitude=CA, cooperation knowledge=CK, emotional intelligence=EI, team norms=TN, shared goals=SG, team cohesion=TC, task interdependence=TI, transformational leadership=TL, team participation experience=TPE, team trust =TT, team performance=TP, team viability = TV, team member satisfaction = TMS.

Table 4. Path results

HYP	Path	Mean (M)	St. deviation (STDEV)	T statistics (|O/STDEV|)	2.5%	97.5%	P values	Remark
H1	TI -> TLO	0.543	0.030	17.895	0.482	0.600	0.000	Yes
H2	TLO -> TR	0.690	0.023	30.097	0.647	0.736	0.000	Yes
H3	TL -> TR	0.280	0.025	11.230	0.230	0.327	0.000	Yes
H4	TL -> TE	0.198	0.028	7.162	0.144	0.252	0.000	Yes
H5	TR -> TE	0.685	0.023	29.280	0.640	0.731	0.000	Yes
H6	TE -> PB	0.548	0.029	18.932	0.487	0.602	0.000	Yes

Note: emotional intelligence=EI; transformational leadership=TL; task interdependence=TI; team loyalty=TLO; team relationship=TR; team effectiveness=TE.

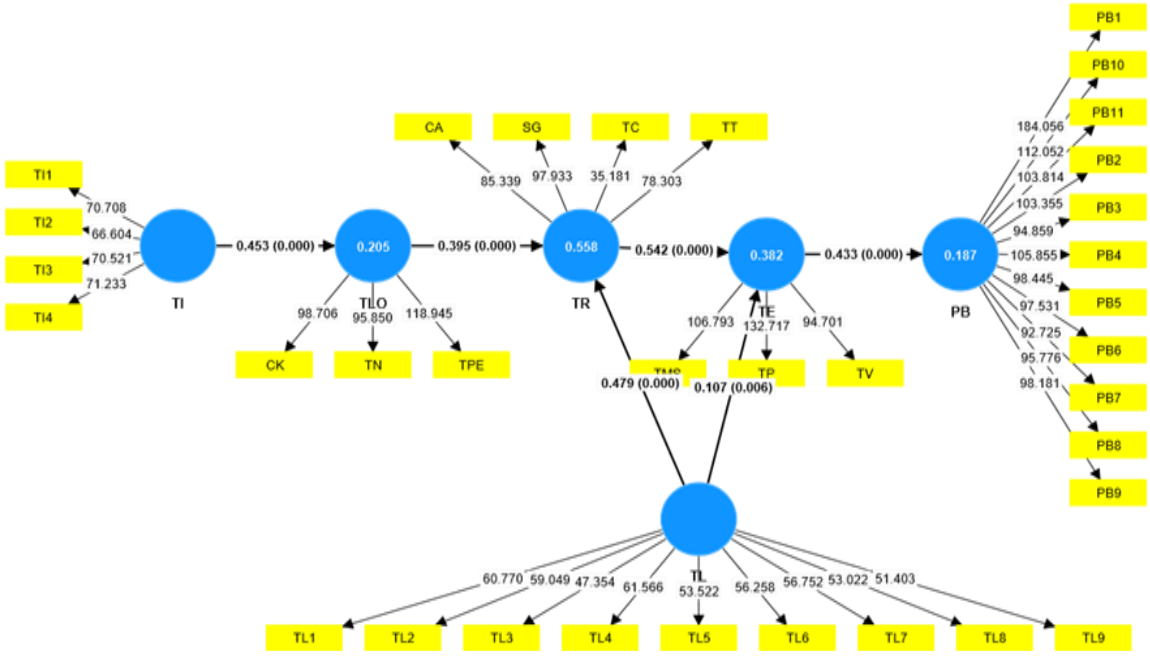

Figure 2. Structural model results

6. FINDING AND DISCUSSION

This study highlights the critical role of team collaboration in enhancing player experience within MMOGs. First, TI is confirmed to significantly facilitate team cooperation in MMOGs. Unlike previous research, which mainly focuses on the direct influence of TI on team achievements [5], this study explores its potential value in promoting TLO and interaction quality. By fostering knowledge and resource sharing among team members, TI establishes a sustained cooperative relationship, strengthening both interaction frequency and closeness among players.

TLO was found to significantly enhance the stability and cohesiveness of TR, particularly in TT, SG, and communication quality. Existing research typically examines loyalty in the context of brand marketing or user retention and rarely considers how loyalty impacts relationship quality within VT [5]. By positioning loyalty as a central variable in VT dynamics, this study validates its positive impact on improving team interaction quality and member satisfaction. Research has shown that the establishment and stabilization of TR are critical to the overall effectiveness of a team. This study found that the cohesiveness of TR not only facilitates the achievement of goals but also significantly increases members' motivation to participate, going beyond a single-level analysis of individual interactions. In addition, the lack of face-to-face interaction in virtual environments increases the complexity of member relationships [20]. The findings of this study contribute to a multidimensional analysis of TR and provide practical insights for designing effective team structures in online games.

Moreover, TL plays a particularly important role in VTs. Tan et al. argued that TL can effectively enhance the cooperative environment of VT, yet studies generally lack detailed analyses of leadership behaviours in complex virtual settings [12]. This study reveals that TL, through proactive communication and collaborative strategies, enhances goal alignment and trust within teams. This result confirms its dual contribution to both TE and team satisfaction, providing new avenues for future research on leadership in MMOGs. TE was found to be a central factor in improving overall player experience and fostering long-term engagement in MMOGs. Previous research predominantly focuses on TP concerning an individual player's feeling of accomplishment and neglects its role in the system of the experience of VTs as a whole [4]. This study found that making teams more effective makes task performance higher quality and improves players' immersion.

This study goes beyond simple aggregation of individual performance, deeply integrating player interactions and teamwork to provide strong empirical evidence for the idea that team efficiency fosters mutual satisfaction among group members and enhances players' enthusiasm within the socially constructed landscape of virtual embodiment. Game developers or designers should, in future designs, introduce new gameplay to promote more strategic communication among team players or optimize team interaction mechanisms, thereby improving player engagement and retention.

7. CONCLUSION AND FUTURE WORKS

This research addresses the novelty of team collaboration and personal relationships between players in MMOGs. Demonstrating how the multi-level approach of this study is different from traditional individual or player-oriented studies, the findings indicate that in MMOGs, team playability and quality of team interaction are improved by TI, TLO, team relationships, and TL. MMOG developers might use these findings to promote team cooperation by increasing TI, creating a sense of loyalty, and/or implementing leadership structures to ultimately better facilitate teamwork. The more informed we become about the ways team collaborative dynamics and mechanics specifically work, the better-equipped game developers can be with knowing what to multi-sense into awareness and eventually better meet the needs of gamers, leading to higher quality and satisfaction levels with the gaming experience.

However, this study only covers Chinese players, limiting the external validity of its conclusions. Future research should replicate experiments in other countries to compare collaborative behavior patterns among organizational members across different cultural contexts. Furthermore, the study is confined to MMOGs. Future work could extend to VT building, educational settings, and complex VT collaboration involving AI intelligence. Additionally, factors not addressed in the current methodology, such as cultural diversity and team size, should be incorporated into subsequent research.

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AUTHOR CONTRIBUTIONS STATEMENT

This journal uses the Contributor Roles Taxonomy (CRediT) to recognize individual author contributions, reduce authorship disputes, and facilitate collaboration.

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C : **C**onceptualization
M : **M**ethodology
So : **So**ftware
Va : **Va**lidation
Fo : **Fo**rmal analysis
I : **I**nvestigation
R : **R**esources
D : **D**ata Curation
O : Writing - **O**riginal Draft
E : Writing - Review & **E**diting
Vi : **Vi**sualization
Su : **Su**pervision
P : **P**roject administration
Fu : **Fu**nding acquisition

CONFLICT OF INTEREST STATEMENT

The authors declare no conflict of interest.

INFORMED CONSENT

We have obtained informed consent from all individuals included in this study.

ETHICAL APPROVAL

The research related to human use has been compiled with all the relevant national regulations and institutional policies in accordance with the tenets of the Helsinki Declaration and has been approved by the UPM review board.

DATA AVAILABILITY

Data available in this article.

REFERENCES

[1] S. S. Y. Kim, K. M. Huang-Isherwood, W. Zheng, and D. Williams, "The art of being together: how group play can increase reciprocity, social capital, and social status in a multiplayer online game", *Computers in Human Behavior*, vol. 133, p. 107291, Aug. 2022, doi: 10.1016/j.chb.2022.107291.

[2] M. Gong, C. Wagner, and A. Ali, "The impact of social network embeddedness on mobile massively multiplayer online games play", *Information Systems Journal*, p. isj.12479, Oct. 2023, doi: 10.1111/isj.12479.

[3] S. Müller, R. Ghawi, and J. Pfeffer, "Reviewing the potentials of MMOGs as research environments: a case study from the strategy game Travian", *PLOS ONE*, vol. 18, no. 2, p. e0281114, Feb. 2023, doi: 10.1371/journal.pone.0281114.

[4] M. Encheva, N. Krüger, and P. Zlatkova, "Playability of Serious games in information literacy: the findings of the European Project NAVIGATE", *International Information & Library Review*, vol. 55, no. 2, pp. 176–184, Apr. 2023, doi: 10.1080/10572317.2023.2198882.

[5] T. T. Linh Pham, T.-L. Huang, G.-Y. Liao, Y.-J. Chou, T. C. E. Cheng, and C.-I. Teng, "Cooperate to play: how in-game cooperation knowledge impacts online gamer loyalty", *Computers in Human Behavior*, vol. 143, p. 107686, June 2023, doi: 10.1016/j.chb.2023.107686.

[6] X. Yu, B. He, M. Liu, A. Wang, and Y. Yuan, "The effect of distributive justice climate on virtual team performance: a moderated mediation model", *Front. Psychol.*, vol. 13, Aug. 2022, doi: 10.3389/fpsyg.2022.950581.

[7] J. Jiang, P. P. W. Wong, and L. Wang, "Influence of playability on perceived game software quality: a comparison between Chinese and South Korean Gamers", *SAGE Open*, vol. 13, no. 3, p. 21582440231197506, July 2023, doi: 10.1177/21582440231197506.

[8] N. Ducheneaut, N. Yee, E. Nickell, and R. J. Moore, "alone together?": Exploring the social dynamics of massively multiplayer online games", in *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems*, Montréal Québec Canada: ACM, Apr. 2006, pp. 407–416. doi: 10.1145/1124772.1124834.

[9] K. Martinez, D. Checa, and A. Bustillo, "Development of the engagement playability and user eXperience (EPUX) metric for 2D-screen and VR Serious games: a case-study validation of Hellblade: Senua"s Sacrifice", *Electronics*, vol. 13, no. 2, p. 281, Jan. 2024, doi: 10.3390/electronics13020281.

[10] M. S. Akin, "Communication with the social environment in multiplayer online games: the Turkey Case", *International Journal of Game-Based Learning*, vol. 13, no. 1, pp. 1–14, Sept. 2023, doi: 10.4018/IJGBL.330755.

[11] M. Gong, C. Wagner, and A. Ali, "The impact of social network embeddedness on mobile massively multiplayer online games play", *Information Systems Journal*, vol. 34, no. 2, pp. 327–363, Mar. 2024, doi: 10.1111/isj.12479.

[12] X. Gong, N. A. Lili, M. N. Noris, and J. Azrul Hazri, "Challenges and issues in team gamer loyalty for massively multiplayer online game", in *Proceedings of the 4th International Conference on Advances in Computational Science and Engineering*, In: V. Thiruchelvam, R. Alfred, Z. I. B. A. Ismail, H. Haviluddin, and A. Baharum, Eds, Singapore: Springer Nature, 2024, pp. 331–341. doi: 10.1007/978-981-97-2977-7_20.

[13] X. Bian and A. Yang, "From spectatorship to loyalty: unraveling the influence of game streaming watch and gaming-related social connectivity on MOBA gamers", *Computers in Human Behavior*, vol. 162, p. 108433, Jan. 2025, doi: 10.1016/j.chb.2024.108433.

[14] M. P. Alves, I. D. Dimas, P. R. Lourenço, T. Rebelo, V. Peñarroja, and N. Gamero, "Can virtuality be protective of team trust? Conflict and effectiveness in hybrid teams", *Behaviour & Information Technology*, vol. 42, no. 7, pp. 851–868, May 2023, doi: 10.1080/0144929X.2022.2046163.

[15] S. Mysirlaki and F. Paraskeva, "Emotional intelligence and transformational leadership in virtual teams: lessons from MMOGs", *Leadership & Organization Development Journal*, vol. 41, no. 4, pp. 551–566, Apr. 2020, doi: 10.1108/LODJ-01-2019-0035.

[16] H. Zhang, S. Shi, F. Zhao, X. Ye, and H. Qi, "A study on the impact of team interdependence on cooperative performance in public–private partnership projects: the moderating effect of government equity participation", *Sustainability*, vol. 15, no. 17, p. 12684, Aug. 2023, doi: 10.3390/su151712684.

[17] S. I. Wong and S. van Gils, "Initiated and received task interdependence and distributed team performance: the mediating roles of different forms of role clarity", *AI & SOCIETY*, vol. 37, no. 2, pp. 781–790, June 2022, doi: 10.1007/s00146-021-01241-w.

[18] L. Kanse, E. K. Stephenson, F. E. Klonek, and S. Wee, "Interdependence in virtual teams—A Double-Edged Sword?", *Small Group Research*, p. 10464964231206129, Oct. 2023, doi: 10.1177/10464964231206129.

[19] R. Chen, Y. Guo, and M. Yu, "Investigating the impact of chinese cultural elements on player loyalty in video games: a cross-national exploratory study", in *Proceedings of the 2023 3rd International Conference on Social Development and Media Communication (SDMC 2023)*, vol. 807, S. A. Qalati, M. F. Mohd Sharif, Mohd. K. Ahmad, and D. Ostic, Eds, in Advances in Social Science, Education and Humanities Research, vol. 807, Paris: Atlantis Press SARL, 2023, pp. 282–289. doi: 10.2991/978-2-38476-178-4_34.

[20] S. W. J. Kozlowski and D. R. Ilgen, "Enhancing the effectiveness of work groups and teams", *Psychological Science in the Public Interest*, vol. 7, no. 3, Dec. 2006, doi: 10.1111/j.1529-1006.2006.00030.x.

[21] S. J. Guastello *et al.*, "Team situation awareness, cohesion, and autonomic synchrony", *Human Factors: The Journal of the Human Factors and Ergonomics Society*, vol. 66, no. 4, pp. 1186–1200, Apr. 2024, doi: 10.1177/00187208221118301.

[22] A. A. Araújo, M. Kalinowski, M. Paixao, and D. Graziotin, "Towards emotionally intelligent software engineers: understanding students" self-perceptions after a cooperative learning experience", Feb. 07, 2025, *arXiv*: arXiv:2502.05108. doi: 10.48550/arXiv.2502.05108.

[23] C. Tu, P. D'Odorico, Z. Li, and S. Suweis, "The emergence of cooperation from shared goals in the governance of common-pool resources", *Nature Sustainability*, vol. 6, no. 2, pp. 139–147, 2023, doi: 10.1038/s41893-022-01008-1.

[24] M. Z. Fareed, Q. Su, and A. A. Awan, "The effect of emotional intelligence, intellectual intelligence and transformational leadership on project success; an empirical study of public projects of Pakistan", *Project Leadership and Society*, vol. 2, p. 100036, Dec. 2021, doi: 10.1016/j.plas.2021.100036.

[25] N. S. Greimel, D. K. Kanbach, and M. Chelaru, "Virtual teams and transformational leadership: an integrative literature review and avenues for further research", *Journal of Innovation & Knowledge*, vol. 8, no. 2, p. 100351, Apr. 2023, doi: 10.1016/j.jik.2023.100351.

[26] J. Kovalčík, M. Švecová, and M. Kabát, "Viability of using digital games for improving team cohesion: a systematic review of the literature", *Acta Ludologica*, vol. 6, no. 1, pp. 46–65, 2023, doi: 10.34135/actaludologica.2023-6-1.46-65.

[27] R. K. Purvanova and R. Kenda, "The impact of virtuality on team effectiveness in organizational and non-organizational teams: a meta-analysis", *Applied Psychology*, vol. 71, no. 3, pp. 1082–1131, July 2022, doi: 10.1111/apps.12348.

[28] P. Nalepka *et al.*, "Assessing team effectiveness by how players structure their search in a first-person multiplayer video game", *Cognitive Science*, vol. 46, no. 10, p. e13204, Oct. 2022, doi: 10.1111/cogs.13204.

[29] Z. Fan, H. Sun, L. Wang, M. Zhu, and T. Peng, "Team idiosyncratic deals and team breakthrough innovation: based on the perspective of input-process-output model", *Frontiers in Psychology*, vol. 13, Sept. 2022, doi: 10.3389/fpsyg.2022.974569.
[30] A. Setterstrom and J. Pearson, "Social influence and willingness to pay for massively multiplayer online games: an empirical examination of social identity theory", *Communications of the Association for Information Systems*, vol. 44, no. 1, Jan. 2019, doi: 10.17705/1CAIS.04402.
[31] J. Hair, M. Sarstedt, C. M. Ringle, and S. P. Gudergan, *Advanced Issues in Partial Least Squares Structural Equation Modeling*. SAGE Publications, 2023.
[32] M. Sarstedt, L. Radomir, O. I. Moisescu, and C. M. Ringle, "Latent class analysis in PLS-SEM: a review and recommendations for future applications", *Journal of Business Research*, vol. 138, pp. 398–407, Jan. 2022, doi: 10.1016/j.jbusres.2021.08.051.
[33] J. Hair, G. T. M. Hult, C. M. Ringle, M. Sarstedt, N. P. Danks, and S. Ray, *Partial Least Squares Structural Equation Modeling (PLS-SEM) Using R: A Workbook*. in Classroom Companion: Business. Cham: Springer International Publishing, 2021, doi: 10.1007/978-3-030-80519-7.

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