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Geunyoung Kim

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GEUNYOUNG KIM

Abstract

Multiplayer gaming highly depends on teamwork, making the spatial arrangement of players an important design factor. This study examines how two seating configurations—linear seating and stellate polygonal seating—affect multiplayer performance, communication, and overall collaborative experience. Twenty-four participants played in teams under both arrangements, followed by surveys from sixteen participants evaluating eight aspects of teamwork and interaction. While linear seating resulted in higher kill counts and thus stronger quantitative performance, players consistently rated stellate polygonal seating more positively, emphasizing its advantages for communication and team-centric engagement. These findings note the complex relationship between spatial layout and team effectiveness in gaming environments and suggest that optimal multiplayer setups require balancing functional performance with social and spatial dynamics. Future work should explore additional spatial variables that may further enhance collaborative gameplay.

Keywords

Multiplayer games; seating configurations; interactive communication; spatial dynamics; gaming performance; computer games; mobile games

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Background

Multiplayer gaming has evolved into an integral component of gaming culture. From mobile games to esports tournaments, the realm of multiplayer gaming spans a diverse range of genres, including multiplayer computer games (MCGs) and massively multiplayer online games (MMOGs). It has seamlessly woven itself into every corner of the gaming landscape, becoming an omnipresent phenomenon that captivates players worldwide.

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The world of multiplayer games is flourishing, fuelled by the inherent competitiveness of contemporary gaming, and players are instinctively drawn to seek out strategies that enhance their in-game performance. Technical strategies involve optimizing the gaming experience through equipment and environmental enhancements. One such approach entails reducing network latency, a pivotal factor that influences gameplay smoothness and responsiveness (Dick et al., 2005). Additionally, purchasing high-end graphics cards with an outstanding graphics processing unit (GPU), allows for indulgence in gaming with elevated frame rates and reduced image lag (Cuervo et al., 2015). Communication architecture, or how computer units are networked in gameplay, can also induce different levels of game performance in multiplayer games (Smed et al., 2002). Smed, Kaukoranta, and Hakonen present four types of communication architecture based on their respective degrees of deployment—(i) single unit (split screen), (ii) peer-to-peer (nonhierarchical units connected to each other), (iii) client/server (one server and multiple clients), and (iv) server-network (server pool of more than one interconnected servers) (3).

While attending to technical aspects is important, the essence of multiplayer gameplay extends far beyond the realm of utilizing high-end devices. It encapsulates the spirit of collaboration within gaming—teammates synergistically uniting their efforts. This team unification comprises numerous components, but at its core, it relies on answering this fundamental question: how will a team of players bring multiple minds together to think as one cohesive unit?

Context and scope of effectiveness and teamwork

In multiplayer gaming environments, how players are spatially arranged can influence the dynamics of teamwork and overall performance. This paper explores the broader concepts of 'effectiveness' and 'effective teamwork' within these settings, recognizing that interpretations of effectiveness may vary depending on player intentions and gaming contexts (Dick et al., 2005). For instance, a casual player may value enjoyment or communication, while a competitive player may equate effectiveness with winning. Understanding these distinctions provides a foundation for examining how different seating configurations may shape team-based play.

Here, 'effectiveness' refers to the seating configuration's ability to facilitate team success and victory, with 'team performance' measured by higher kill counts, as detailed in the Method I overview. To capture a more nuanced understanding of teamwork, observer notes were also taken to examine match dynamics from a third-person perspective.

Effective teamwork, though challenging to define, is inherently tied to collaboration in multiplayer gameplay. Defined as working together toward shared goals (Debkowski et al., 2016), effective teamwork in this study refers to collaboration that drives successful outcomes, characterized by efficient communication and coordi-

nation (Leavitt et al., 2016). Given this, it was anticipated that the most accurate evaluation of effective teamwork would come from those directly engaged in the experience, making participant self-reports the chosen method of measurement. Understanding how spatial elements of these seating configurations influence effective teamwork is a central focus of this study. However, specific settings, such as professional tournaments involving pro-gamers or casual multiplayer matches between amateurs, were not explicitly considered in this analysis.

Spatial and interactive factors

The spatial placement of actors plays a pivotal role in cultivating team coordination, as it induces multiple nodes of interaction to emerge during complex multiplayer scenarios, analogous to cell interactions within a multicellular organism (Depping, 2017).

Different seating arrangements cater to gaming teams of varying sizes. Some configurations benefit smaller teams like duos or trios, promoting close collaboration and streamlined communication. Conversely, other arrangements favour larger teams of eight or more members, providing ample space for coordination.

When devising seating strategies, the two crucial factors determining communication levels are often proximity and orientation (Wannarka, 2008). A noteworthy study from the past explored the correlation between students' seating placement in a sizable lecture hall and their academic performance. The findings revealed that students positioned closer to the primary source of information, typically where the professor stands and delivers lectures, demonstrated greater knowledge absorption owing to their immediate proximity to the information source (Benedict et al., 2004). While the study refrains from definitively attributing the findings to improved visual and auditory capabilities or heightened focus, it demonstrates a strong correlation between closer proximity and increased engagement and immersion within the learning environment.

The research conducted by Norazman, Ismail, and Ja'afar (2019, p. 32–35) studies optimizing learning efficiency in classroom ecology, particularly for smaller student populations. The study explores and compares five distinct formations: rows and columns, U-shaped, runway-style, clustered, and stadium. Each formation's efficacy is intricately tied to its orientation. Traditional rows and columns (p. 32) or stadium formations (p. 35) are well-suited for teacher-centric lectures, as they facilitate direct visual engagement between the teacher and students. Conversely, U-shaped (p. 33) and runway-style (p. 34) configurations enhance student interaction opportunities, with students oriented towards each other, enabling greater utilization of classroom space and facilitating teacher intervention. The clustered formation (34), uniquely, prioritizes group work, with students focused solely on their group members rather than the entire class, and the teacher positioned separately from the interactive spatial perimeter.

Multiplayer gaming shares similarities with group work among students, as both involve a collective pursuit of a shared objective through cognitive and social processes (Voulgari et al., 2011), encompassing the exchange of information and feedback. Consequently, the significance of proximity and orientation becomes dominant. However, multiplayer gaming diverges in that it often intertwines competition with collaboration, resulting in tightly-knit and fast-paced interactions. Players bear the responsibility of processing and responding to a myriad of stimuli within a short time frame. This encompasses tasks such as preemptively assessing teammates' positions and strategies, as well as swiftly formulating and executing instantaneous decisions (Peña et al., 2006). Hence, with the significance of the clustered formation in multiplayer gaming acknowledged, it becomes crucial to develop a seating configuration that is aligned with the specific requirements and relevance of gaming.

Although numerous seating configurations exist, the focus is placed on these two arrangements, given their notable differences. Table 1 presents key differences in desk arrangements, as informed by previous research on the efficacy of desk arrangements (Rosenfield et al., 1985). It summarizes variations in player proximity and orientation, the existence of a centerpoint, typical usage scenarios, and how these arrangements are perceived in gaming culture.

	Stellate Polygonal	**Linear**
Proximity	• Equal between players • Far end seats don't exist	• Unequal between players • Far end seats exist
Orientation	• Facing different directions	• Facing the same direction
Centerpoint	• Pronounced centerpoint	• Obscure centerpoint
Common Use	• Strong focus on interaction • Collaborative team tasking • Meetings, workshops, seminars, creative studios, etc.	• Weak focus on interaction • Individual tasking • Examinations, presentations, waiting spaces, lectures, etc.
In Gaming Culture	• Emerging seating layout	• Traditional seating layout

Table 1. Stellate polygonal seating versus linear seating breakdown.

Linear seating

Linear seating, currently the dominant and extensively employed seating configuration, positions team players in a straight line. Players are devoid of face-to-face interaction, but oriented in the same vertical direction, as visible from Figure 1, a visualization of linear seating. When seated linearly, the distances from a single player

to the centerpoint as well as the interaction distance between two players vary by player.

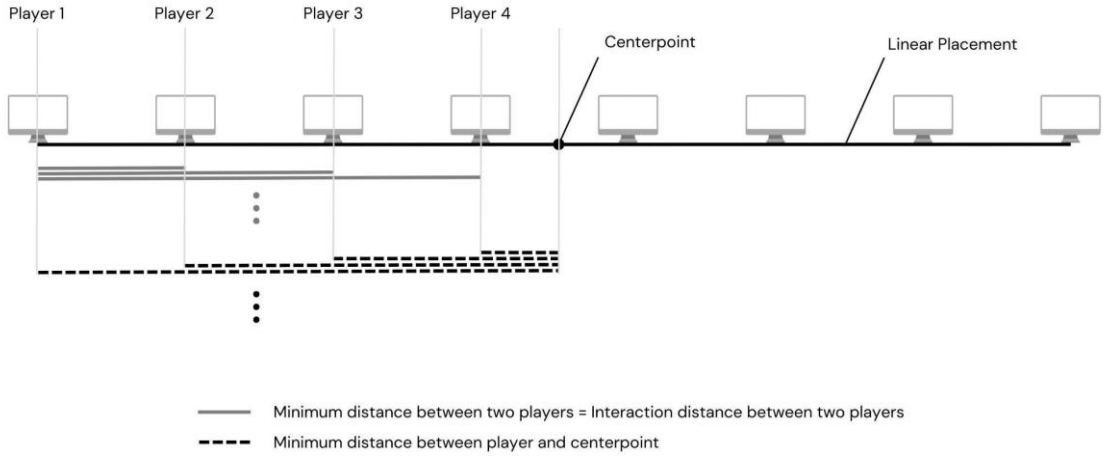

Figure 1. A visual description of linear seating (eight players).

The prevalence of linear seating in gaming can be attributed primarily to the constraints of limited space. In scenarios where the gaming area is compact yet must accommodate multiple gamers, opting for a linear layout becomes pivotal in maximizing space efficiency. Furthermore, linear seating facilitates streamlined organization and optimal placement of gaming equipment, encompassing computers, monitors, keyboards, and mice. This configuration not only simplifies the wiring process but also enhances cable management, culminating in an uncluttered setup.

The rise in popularity of linear seating configurations within gaming environments may be influenced by the prevalent setups seen in online gaming streams and esports tournaments. Platforms like Twitch, which surpassed 3 billion total hours watched in the first quarter of 2020 (TechCrunch, 2020), and Facebook Gaming, with its significant rise to 822 million hours watched, a threefold increase from the previous year (Streamlabs, 2020), have not only captivated gaming audiences but also subtly shaped gaming culture and practices. The linear seating often showcased in these streamed events, selected for optimal camera angles and production values to enhance viewer engagement, appears to have set a perceived standard. Many gamers, both in streaming and non-streaming contexts, might be adopting these configurations, assuming their effectiveness in enhancing the gaming experience. The visibility and success of these streaming platforms suggest a correlation between their preferred seating arrangements and the adoption of similar layouts in everyday gaming settings.

Through such platforms, viewers now have enhanced access to immersive sportified content that promotes active competition among teams and participants (Turtiainen

et al., 2020). These popular platforms also provide a captivating window into the world of professional gamers, showcasing their meticulously crafted game-specific environments that optimize the gaming experience and facilitate extraordinary gameplay moments (Hamari et al., 2017, p. 9–11). The highly renowned esports event, the League of Legends (LoL) World Championship, amassed 142 million total viewing hours in 2022 alone (EarlyGame, 2022). This spectacle, alongside other prominent tournaments such as The International (Dota 2), Fortnite World Cup, Counter-Strike: Global Offensive (CS:GO) Major Championships, and Overwatch League Grand Finals, has leveraged multimedia platforms to engage with a vast audience, where they employ the linear seating style throughout most, if not all, rounds.

Stellate polygonal seating

The crux of this research revolves around the stellate polygon, which is a concept derived from the clustered formation. Stellate polygons, by definition, encompass polygonal structures that perpetually expand either through infinite length or iterative replication of the original shape (Salatino, 2019). Figure 2 below is a visualization of stellate polygonal seating. Fundamentally, stellate polygonal seating takes the form of a stellar configuration, where players are strategically positioned at each vertex. As demonstrated in the figure, the stellate polygon in this study exemplifies a symmetrical star shape, and all players are equitably positioned at its vertices. Notably, this polygon maintains equal distances between each player and the central focal point, in an impartial arrangement for all participants.

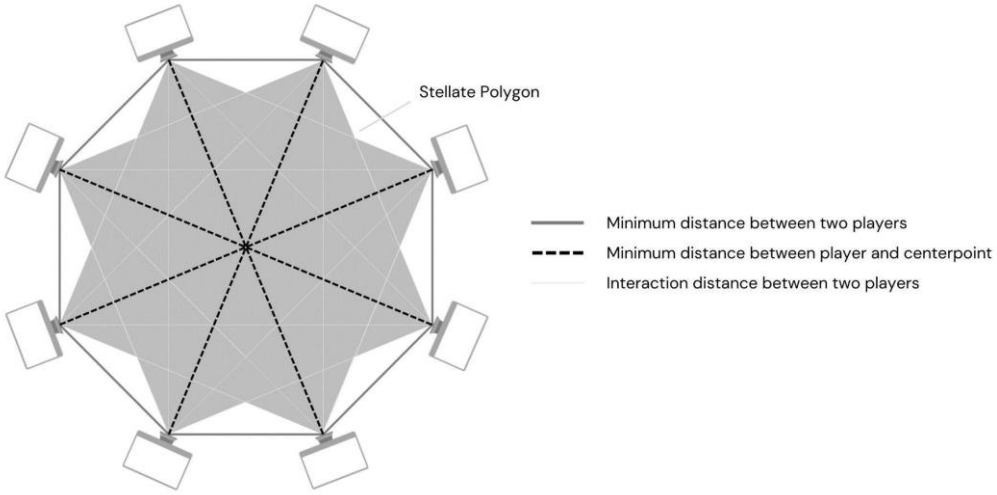

Figure 2. A visual description of stellate polygonal seating (eight players).

Note that in Figure 2, the seating arrangement exemplifies a scenario with an 8-player team. It is important to acknowledge that when accommodating a different

number of players, the stellate polygon will possess a corresponding number of additional vertices for seating. However, all other conditions and principles governing the seating arrangement remain unaltered regardless of the specific player count.

The stellate polygon accentuates spatial elements to a greater extent when compared to basic circular seating, exemplified through the following facets:

- Straight Line Distances: Unlike circular seating, where the minimum distances between adjacent players are represented as arcs, the stellate polygon ensures that these distances are conveyed as straight lines, reinforcing a direct and unobstructed spatial relationship.

- Farthest Point Distances: The stellate polygon emphasizes the equal minimum distances between the centerpoint and each player. In this regard, the stellate polygon considers the longest distance, extending from the centerpoint to any individual point within the polygon.

- Interactive Distance Depiction: A distinctive characteristic of the stellate polygon lies in its ability to effectively portray the interactive distance between every player. Each connection between players within the configuration forms a stellate polygon in itself, accentuating the interconnectedness and spatial dynamics of the seating arrangement.

By virtue of these elements, stellate polygonal seating is visually represented and studied in this research instead of circular seating.

Research objectives and hypotheses

However, the question arises: does the prevalence of linear seating in gaming environments necessarily imply that it is the most effective seating configuration? Is it possible that we might be overlooking a more effective seating arrangement for gaming simply because we stick to the prevailing norm? This study aims to compare the effectiveness of two primary seating configurations – stellate polygonal and linear – in various identifiable aspects.

The research objectives of this study are as follows:

- Compare the effectiveness of stellate polygonal seating to linear seating in esports, focusing on whether and how they impact team performance and outcomes.

- Investigate the potential of stellate polygonal seating as a catalyst for enhancing team collaboration and interaction within spatial dynamics of gaming environments.

- Determine if stellate polygonal seating, as opposed to conventional linear seating, yields increased levels of spatial and team interaction in esports settings.

Based on these objectives, this study proposes the following hypotheses to empirically test the impact of seating configuration on gaming performance and team dynamics.

> H1: A correlation exists between seating configuration and in-game performance.
>
> H2: Stellate polygonal seating will yield higher kill counts compared to linear seating, implying that the specific arrangement of seating positions in a stellate polygonal configuration enhances players' in-game performance.
>
> H3: Participants will rate stellate polygonal seating more favourably than linear seating in most categories, reflected by higher scoring.

Methods

Method I overview

The method I aim to evaluate the effectiveness of stellate polygonal versus linear seating configurations in multiplayer gaming, focusing on their impact on team performance and dynamics. This method tests the hypothesis that seating arrangements significantly influence in-game performance by engaging real players in competitive matches.

In this method, gameplay was carried out involving participants selected based on two key factors: their level of familiarity with the chosen game (PUBG) and their proximity to the physical location where the matches took place (Busan, South Korea). Furthermore, in order to ensure minimal constraints during matches, participants were required to possess prior experience in playing both PUBG and PUBG Mobile. It should be noted that proficiency in the game was not a mandatory criterion for participation. This was accomplished by recruiting participants from an online gaming community. Subsequently, those who expressed their willingness to take part and were conveniently located were requested to provide a self-assessment of their proficiency in playing PUBG. This evaluation was based on three specific criteria: (i) K/D ratio (kill-death ratio), calculated by dividing the total number of kills by the total number of deaths, (ii) tier, as determined by the most recent tier system in effect since C1S1 (Cycle 1 Season 1) in July 2021, and (iii) the number of years they had been actively engaged in playing the game, as indicated in their account information. Finally, following participants' provision of informed consent, participants were meticulously selected and organized into three well-balanced

teams of eight, taking into account their individually assessed skill levels in PUBG. The teams were formed to comprise players categorized as SSS (expert; K/D Ratio: 7.00 ≤ K/D; Tier: Ace Dominator ~ Conqueror; Playtime: 3 Years ≤ PT), SS (advanced; K/D Ratio: 5.00 ≤ K/D < 7.00; Tier: Crown ~ Ace Master; Playtime: 2 Years ≤ PT < 3 Years), and S (intermediate; K/D Ratio: 3.00 ≤ K/D < 5.00; Tier: Platinum ~ Crown; Playtime: 1 Year ≤ PT < 2 Years), with the aim of minimizing significant skill disparities between teams that could potentially impact outcomes. Candidates at the beginner level were excluded for similar reasons.

Subsequently, the three teams were assigned randomly to either the tested teams or the fixed opponent team. One team was designated as the fixed opponent team, responsible for assuming the role of the opponent in all matches. The opposing team was instructed to remain at their respective locations and participate in the match, with all forms of communication, including popular platforms like Discord, blocked. On the other hand, the remaining two teams were instructed to be physically present at the gameplay area, where designated seating arrangements were implemented. Moving forward, the two tested teams were referred to as Team I and Team II, while the fixed opponent team was identified as Team C.

In order to establish a fair gameplay setting, several decisions were made regarding the matches and gameplay settings. The following decisions were implemented:

Selection of game and control of variables

PUBG was selected for this study due to its multiplayer battle royale format emphasizing team strategies and agility, coupled with its user-friendly controls. The game also encourages diverse player interactions, including combat, looting, item sharing, revival, and zone management.

PUBG is typically played in two primary squad modes: (1) physically present as a squad with direct communication and (2) online, often accompanied by microphones, headphones, or voice chat, connecting players from different locations. Squads can be formed through automated matchmaking or by pre-arrangement among clan members or co-players. To ensure unbiased results, this research specifically avoided pairing players who had previously teamed up, excluding unrecorded random matchmaking from consideration. This precaution was taken to avoid situations where players who had previously teamed up might have already developed efficient strategies and strong bonds, potentially hindering natural interactions during gameplay.

As gamers who physically gather in shared spaces predominantly do so in urban internet cafés equipped with multiple linear seating arrangements and internet-accessible gaming devices (Powell, 2004, p. 12), it is worth considering that the participants in this study may have greater familiarity with linear seating than with stellate polygonal seating. Nonetheless, it is important to note that this variable was not

controlled during the study, aligning with the broader research objective of investigating whether stellate polygonal seating can facilitate improved gameplay performance, even when contrasted with the more acquainted and conventional linear seating.

Utilization of PUBG Mobile *on a laptop platform*

To facilitate a comprehensive exploration of proximity and orientation effects, a departure from the conventional 4-person team structure was made, and instead, 8-person teams were employed for testing purposes. Among the available match modes in PUBG Mobile, the 8 vs 8 Santorini Team Deathmatch was identified as the most fitting for the study's objectives. This particular match mode was chosen due to its clear-cut scoring system and time-efficient nature, with the winning team being determined simply through a higher kill count and each match lasting no more than 10 minutes.

Although the specific type of game platform (PC or mobile) was not a significant factor in this study, a deliberate decision was made to present this mobile game on a larger screen. Notably, mobile gamers have a tendency to assume a flexed-head and unsupported-arm posture, naturally leaning forward while intensifying their focus or straining their eyes on handheld screens (Ashok et al., 2020; Lam et al., 2022, p. 7–8). Recognizing that such behaviour could impact the proximity between team members, the mobile game was accordingly adapted to a laptop screen-friendly format using BlueStacks X software and played on larger screens. Given that all participants were experienced players of both PUBG and PUBG Mobile, they quickly adapted to new control systems.

Utilization of chair–desk combos

Similarly, the potential issue of inadvertent chair movement, as players unknowingly drag their chairs in and out while engrossed in the game, emerged as a concern. This tendency, particularly evident when rollable gaming chairs are employed, can contribute to a head-forward slumping posture (Zwibel et al., 2019, p. 757). Moreover, it may unintentionally lead to variations in the distances between players. To mitigate this factor, a strategic decision was made to furnish the gameplay area with chair-desk combos instead of traditional gaming chairs. These chair-desk combos consist of individual units where the chair legs are merged or securely interlocked with the desk legs, restricting free movement of the chair without displacing the entire unit. This approach ensures more precise and consistent gameplay outcomes, minimizing the potential for unintended disparities in player-to-player distances. For each seating configuration, the spacing between each chair-desk combination was arranged to be 2.62 feet (80cm), determined according to the dimensions of the gameplay area.

Match mode and game setting details

Furthermore, various additional configurations were standardized to ensure consistency throughout the study. Specifically, the laptops employed in this research were comprised either personal or rented MacBook Airs or MacBook Pros. To facilitate the matches, two distinct private rooms were established, one allocated for Team I and the other for Team II, while Team C competed in both rooms. These rooms were acoustically isolated, ensuring that communication within one team's space could not be overheard by the opposing team. Team C, the fixed opponent, was located remotely and had no auditory or visual access to either Team I or Team II during gameplay. Furthermore, to maintain uniformity, game settings including graphics, audio, and sensitivity were harmonized as follows: graphics set to smooth, frame rate set to medium, style set to realistic, anti-aliasing set to close, brightness set to 120%, sensitivity set to most used, and loadout consisting of one M416 and one frag grenade, with the provision to acquire new weapons throughout the match. It is noteworthy that all matches were conducted in third-person perspective (TPP).

Table 2 below visually depicts the match schedule for this study. In total, a series of eight matches were conducted, four matches each day. As previously mentioned, Team C was involved in all eight matches, playing four matches against Team I and four matches against Team II. Team I and Team II, on the other hand, each competed in four matches, with two matches conducted in a linear seating arrangement and two matches in a stellate polygonal seating arrangement. It is worth noting that all matches for Team I were held on the same day, while the matches for Team II took place on the subsequent day.

Match Name	Team I	Team II	Team C
	Day 1		
I-1	Linear Seating	×	Remote
I-2	Stellate Polygonal Seating	×	Remote
I-3	Linear Seating	×	Remote
I-4	Stellate Polygonal Seating	×	Remote
	Day 2		
II-1	×	Linear Seating	Remote
II-2	×	Stellate Polygonal Seating	Remote

II-3	×	Linear Seating	Remote
II-4	×	Stellate Polygonal Seating	Remote

Table 2. Method I Match Schedule.

Additionally, brief observer notes were recorded to capture immediately noticeable behaviours during gameplay. The goal was not to document every interaction between players but to gain insight into the types of communication and key communicative patterns that emerged.

Method II overview

Method II seeks to understand participants' perceptions and insights, both qualitatively and quantitatively, regarding linear and stellate polygonal seating configurations based on their firsthand experiences. This method examines the hypothesis that participants will generally rate stellate polygonal seating more favourably than linear seating across different categories, as indicated by higher scores.

A comprehensive evaluation of collaborative performance encompassed eight key categories deemed essential for effective task completion. In terms of the eight selected categories, this study employs the conceptual framework established in Manninen's research (2003) in defining the realm of player-to-player (PTP) communication within the context of multiplayer gameplay. Manninen's study on interaction within multiplayer games underscores the multifaceted nature of players' engagement in communicative gameplay, particularly focusing on PTP interaction encompassing oculesics, kinesics, facial expressions, language-based communication, nonverbal audio cues, physical contact, and spatial behaviour. Participants provided self-assessments in the following areas: team cognition (T), motivation (M), discussion (D), cue-reading (Q), speculation (S), flexibility (F), recognition (R), and bounce-back (B). While participants were unaware of the specific question-area correspondence during the survey, for reference purposes, these associations have been included in Table 3. The selection of these criteria was based on previous research in the field of collaborative tasking (Barros et al., 2000, p. 228; Gratton et al., 2007; Gutwin et al., 2004, p. 6–12; Kraut et al., 1996). The questions in this survey were presented twice to the participants; once after linear seating gameplay and once after stellate polygonal seating gameplay. A full copy of the survey is provided in Table 3.

Section 1

Gameplay Experience Evaluation ❶ Scale

Please answer this section reflecting on your gaming experience in linear/stellate polygonal seating.

Team Cognition (T)

How was your experience thinking as a team?

1 Worst	2	3	4	5	6	7	8	9	10 Best

Motivation (M)

How was your experience feeling motivated throughout?

1 Worst	2	3	4	5	6	7	8	9	10 Best

Discussion (D)

How was your experience engaging in verbal discussion with teammates?

1 Worst	2	3	4	5	6	7	8	9	10 Best

Cue-reading (Q)

How was your experience sharing non-verbal cues with teammates?

1 Worst	2	3	4	5	6	7	8	9	10 Best

Speculation (S)

How was your experience speculating about potential consequences?

1 Worst	2	3	4	5	6	7	8	9	10 Best

Flexibility (T)

How was your experience responding flexibly throughout?

1 Worst	2	3	4	5	6	7	8	9	10 Best

Recognition (R)

How was your experience giving or receiving recognition after an accomplishment?

1 Worst	2	3	4	5	6	7	8	9	10 Best

Bounce-back (B) How was your experience bouncing back after encountering difficulties?									
1 Worst	2	3	4	5	6	7	8	9	10 Best
Section 2 Gameplay Experience Evaluation ❷ Free Response									
What was the best part about playing a multiplayer game in linear/stellate polygonal seating? (Write one thing.)									
Response									
What was the worst part about playing a multiplayer game in linear/stellate polygonal seating? (Write one thing.)									
Response									

Table 3. Method II survey sheet.

As can be seen from Table 3, participants were requested to rate their experiences in these categories on a Likert scale from 1 (worst) to 10 (best), drawing from their gaming experiences in Method I. Following the scaling questions, participants were also presented with two open-ended questions to share their insights on the notable advantages and disadvantages of the seating configuration.

Participant profile

Table 4 provides an overview of the participant demographics for Method I and II. Each number in Table 4 represents the age of the participant, while the letters M and F indicate their sex. In the leftmost column, S, SS, and SSS represent the aforementioned game skill levels, determined by factors such as the K/D ratio, tier, and playtime. The cohort of 24 participants analyzed in this study comprised 19 male individuals and 5 female individuals. Demographically, 20 participants fell within the age bracket of their twenties, with the remaining 4 participants in their thirties.

	Team I	**Team II**	**Team C**
SSS (Expert)	23 / M	29 / M	27 / M
	24 / M	23 / F	20 / M
SS (Advanced)	28 / M	30 / M	24 / M
	20 / M	33 / M	26 / F

S (Intermediate)	27 / M	24 / M	20 / M
	29 / F	25 / M	26 / M
	22 / F	26 / M	30 / M
	32 / M	21 / F	28 / M

Table 4. Method II survey sheet.

Results

Method I results

Match Name	Kill Count		Kill Gap
	Team I	Team C	
I-1	80	65	15
I-2	48	80	32
I-3	80	71	9
I-4	58	80	22
	Team II	Team C	
II-1	80	77	3
II-2	42	80	38
II-3	80	67	13
II-4	60	80	20

Table 5. Method I results: kill count.

A total of four matches were conducted for each of Team I and Team II, utilizing distinct seating arrangements for each match. Specifically, the first and third matches were played in a linear seating configuration, while the second and fourth matches utilized stellate polygonal seating.

Results were recorded for all eight matches, and Table 5 is a depiction of these outcomes. As the table denotes, in linear seating, both Team I and Team II scored 80 kills in each of the four matches. However, when matches were conducted using the stellate polygonal seating arrangement, the number of kills varied with values of 48, 58, 42, and 60 for matches I-2, I-4, II-2, and II-4 respectively. Interestingly, in all

matches played with stellate polygonal seating, Team I or Team II was defeated, and the difference between 80 (the target kill count) and the losing team's actual kill count was notably larger compared to the losing gap of Team C, who played separately without communication.

	Team I Average Kills	Team II Average Kills	Average of Average Kills
Linear Seating	80	80	80
Stellate Polygonal Seating	53	51	52

Table 6. Method I results: average kills.

Table 6 shows the average number of kills per team in each seating scenario. Results suggest that the stellate polygonal seating configuration may have negatively impacted the performance and outcomes of Team I and Team II, as can be seen from the steep drop in average kill counts for both teams.

During the course of the matches, an interesting pattern emerged. When Team I or Team II was seated in a linear configuration, they won. However, when they were seated in a stellate polygonal configuration, they were defeated.

Source	Sum of Squares (SS)	Degrees of Freedom (df)	Mean Square (MS)	F-statistic	F-critical
Between Groups	1568.0	1	1568.0	43.56	5.99
Within Groups	216.0	6	36.0		
Total	1784.0	7			

Table 7. Method I results: ANOVA test.

An ANOVA test was performed to evaluate the outcomes of Method I and whether there is a significant difference in players' gaming outcomes according to seating configuration. The mean number of kills was 80 for teams in linear seating and 52 for teams in stellate polygonal seating. Conducting the test with a significance level of 0.05, the calculated F-statistic of 196 exceeded the critical F-value of 5.99. Therefore, the null hypothesis was rejected, providing evidence to support that there is indeed a significant difference in gaming outcomes. This difference in gaming outcomes directly addresses the first research objective, which aims to compare the

impact of stellate polygonal and linear seating on team performance, thereby testing the first hypothesis (H1) regarding the correlation between seating configuration and in-game performance.

Additionally, observer notes were taken for each match and compiled based on the seating arrangement of the on-site team. The table below presents a condensed version of the raw notes collected.

Linear
• Frequent shouting • Intense screen focus, minimal eye movement • Far-end players fidget when interacting with those opposite • Low levels of dialogue
Stellate Polygonal
• Frequent head movement • Players often look up to make eye contact • Occasional conversations unrelated to gameplay • Frequent shared emotions, like group laughter or shouting

Table 8. Method I results: observer notes.

The observer notes revealed significant contrasts between the linear and stellate polygonal setups. In the linear arrangement, players demonstrated strong focus on their screens with minimal interaction, though louder vocalizations and fidgeting were more common among those seated at the far ends. Conversely, the stellate polygonal setup encouraged more head movement and eye contact, with occasional conversations unrelated to gameplay. Additionally, this arrangement fostered more shared emotional expressions, such as group laughter and raised voices. These findings will be further analyzed alongside the results of Method II in the Method II Discussion section.

Method II results

Initially, the survey responses from Section 1 were compiled and visualized into Table 9, presented below. Within each figure, each bar encapsulates the mean score, maximum score, and minimum score for the respective categories of team cognition (T), motivation (M), discussion (D), cue-reading (Q), speculation (S), flexibility (F), recognition (R), and bounce-back (B). Mean scores per seating for individual categories were rounded to the nearest whole number, with the total average being the mean value of those means.

	Linear			Stellate Polygonal			p-value	Significance
Category	Mean	Max	Min	Mean	Max	Min		
Team Cognition (T)	5	7	4	8	10	5	< 0.05	Yes
Motivation (M)	3	5	1	8	10	6	< 0.05	Yes
Discussion (D)	3	5	1	8	10	6	< 0.05	Yes
Cue-reading (Q)	1	3	1	6	9	3	< 0.05	Yes
Speculation (S)	6	8	3	6	8	3	0.84	No
Flexibility (F)	7	9	5	5	7	3	< 0.05	Yes
Recognition (R)	3	5	1	5	9	4	< 0.05	Yes
Bounce-back (B)	4	6	1	4	5	1	< 0.05	Yes
Total Average	4.16			6.34				

Table 9. Method II results: section 1 responses.

A Mann-Whitney U test was employed to analyze the data, revealing significant differences ($p < 0.05$) between the two seating configurations across all categories but speculation (S), which showed no statistically significant difference ($p = 0.84$).

The survey responses from Section 1 produced intriguing results. Despite linear seating yielding superior in-game performance, stellate polygonal seating had a higher overall mean score ($\mu = 6.34$) compared to linear seating ($\mu = 4.16$), indicating that participants perceived stellate polygonal seating more favorably, particularly for team collaboration—a key focus of the second research objective.

Stellate polygonal seating scored higher in six out of eight categories, reflecting its potential to foster a team-oriented environment, which is central to assessing its impact on spatial and team interaction. Speculation (S) showed almost no difference between the two configurations (linear seating $\mu = 5.5$; stellate polygonal seating $\mu = 5.63$), while flexibility (F) and bounce-back (B) scored lower in stellate polygonal seating compared to linear seating.

While the statistical significance of these findings is clear, the practical implications warrant further consideration. The measures used in this study—such as team cognition, discussion, and cue-reading—were adapted specifically for this research context and have not been previously validated in other studies. As such, while differences in mean scores across seating configurations were found to be statistically significant, it remains uncertain whether these differences reflect meaningful or impactful changes in actual gameplay experience. Similarly to how clinical significance is used alongside statistical significance in health research, future studies should

aim to evaluate the real-world significance of these effects in the context of multi-player gaming. Nonetheless, the trends observed here offer valuable starting points for further exploration.

Next, a Tukey's HSD Test was conducted to assess whether reported scores differed significantly based on three factors: age, gender, and proficiency.

*SP = Stellate Polygonal

Category	Comparison	Mean Difference	p-value	Significance (Yes/No)
Team Cognition (T) SP	SS vs. SSS	-2.75	0.0027	Yes
	SS vs. S	2.00	0.0111	Yes
	SSS vs. S	4.75	0.0010	Yes
Motivation (M) SP	SS vs. SSS	-1.75	0.0149	Yes
	SS vs. S	0.25	0.9000	No
	SSS vs. S	2.00	0.0045	Yes
Discussion (D) SP	SS vs. SSS	-1.75	0.0149	Yes
	SS vs. S	0.25	0.9000	No
	SSS vs. S	2.00	0.0045	Yes
Cue-reading (Q) SP	SS vs. SSS	-2.00	0.0045	Yes
	SS vs. S	0.25	0.9000	No
	SSS vs. S	2.25	0.0034	Yes

Table 10. Method II results: section 1 Tukey's test.

Table 10 shows the key statistics where significant differences were observed. Notably, player proficiency levels — classified as S, SS, and SSS — had a significant impact on the scores in the Method II survey, particularly within the four categories of team cognition (T), motivation (M), discussion (D), and cue-reading (Q), but only in the context of stellate polygonal seating. The findings suggest that higher proficiency levels corresponded with higher scores assigned to each of these categories. In contrast, neither age nor gender emerged as significant factors.

However, the question remains: what could explain the divergence between performance and perception? The free responses obtained from Section 2 could be effectively classified into the following categories with the number of respondents for each category.

Gameplay Experience Evaluation ❷ Free Response	
What was the best part about playing a multiplayer game in linear seating? (Write one thing.)	
Enhanced individual focus	10
Low levels of distraction	6
What was the worst part about playing a multiplayer game in linear seating? (Write one thing.)	
Difficult to communicate with teammates	9
Less team motivation	5
Felt more nervous	1
Felt spatially separate from the team	1
What was the best part about playing a multiplayer game in stellate polygonal seating? (Write one thing.)	
Team mindset	8
Felt more energized and motivated	7
Felt less nervous	1
What was the worst part about playing a multiplayer game in stellate polygonal seating? (Write one thing.)	
High levels of distraction	13
Scared to make a mistake	2
Team mood swings dramatically	1

Table 11. Method II results: section 2 responses.

Table 11 illustrates the differential impacts of linear and stellate polygonal seating on gaming experience. Linear seating was associated with improved individual focus, as reported by ten participants, yet it appeared to impede team communication, as reported by nine participants. On the other hand, stellate polygonal seating was conducive to fostering a team-oriented mentality, referenced by eight participants, and heightened motivation, mentioned by seven. However, this configuration also introduced greater distractions, which was problematic for 13 participants. In summary, while linear seating may augment individual performance, stellate polygonal seating seems to bolster team dynamics, though not without introducing certain challenges. These observations directly relate to the study's third objective,

which seeks to assess whether stellate polygonal seating leads to increased spatial and team interaction compared to traditional linear seating, thereby addressing the hypothesis that different seating configurations can significantly influence player experience and team dynamics.

Discussion

Method I discussion

The discussion of these results clearly aligns with the study's objectives of comparing the impact of seating arrangements on team performance and exploring the potential of stellate polygonal seating to enhance team collaboration. The results provide insights into the impact of seating configuration on gaming performance, specifically focusing on two hypotheses, H1 and H2.

Team	Kill Counts Linear	Kill Counts Stellate Polygonal	t-statistic	p-value	Significance
Team I	80, 80	48, 58	27.00	≅ 0.00	Yes
Team II	80, 80	42, 60	10.27	≅ 0.00	Yes

Table 12. Method I discussion: t-test.

A t-test performed to test the first hypothesis (H1) aimed to determine whether there is a significant correlation between seating configuration and in-game performance. The t-test for Team I revealed a significant difference in average kills between linear and stellate polygonal seating, with a high t-statistic (27.00) and very low p-value (≅ 0.00), strongly reinforcing H1 by demonstrating that seating configuration significantly affects gaming performance. Similarly, the t-test for Team II also indicated a significant difference, with a high t-statistic (10.27) and very low p-value (≅ 0.00), further substantiating the hypothesis that seating arrangement plays a crucial role in gaming outcomes for both teams.

Regarding the second hypothesis (H2), the data does not support the expectation that stellate polygonal seating will yield more kills compared to linear seating. In fact, the average number of kills for teams seated in linear seating was higher (80) compared to teams seated in stellate polygonal seating (52). This outcome, contradicting H2, suggests that while stellate polygonal seating may foster team interaction, it does not necessarily translate into better gaming performance as hypothesized. The conducted t-test demonstrates statistical significance in the disparities observed in average numbers of kills, providing a quantitative evaluation of H2's assumptions.

In summary, the pattern observed throughout the eight matches conducted, where Team I and Team II won when seated in a linear configuration but were defeated when seated in a stellate polygonal configuration, not only illustrates the practical implications of seating arrangements but also directly relates to the study's inquiry into the effectiveness of different seating configurations. The ANOVA test and t-test results support the hypothesis (H1) that a correlation exists between seating configuration and in-game performance. However, they challenge the hypothesis (H2) regarding better in-game performance of stellate polygonal seating, offering a comprehensive understanding of how seating arrangements influence multiplayer gaming dynamics.

Additionally, players' greater familiarity with the conventional linear seating likely contributed to their stronger performance in that configuration, introducing a potential confounding variable that warrants further examination in future studies. Furthermore, while kill count served as a clear and quantifiable outcome, it may not capture other important aspects of performance such as tactical positioning, communication efficiency, or strategic survival, suggesting the value of incorporating additional metrics in future experiments.

Method II discussion

The survey results provide deeper insight into the second and third research objectives, particularly the potential of stellate polygonal seating to enhance team collaboration and affect spatial dynamics. This supports the hypothesis that seating configurations influence team effectiveness. While the survey did not ask participants to explain their scores, higher ratings for stellate polygonal seating in teamwork-related categories, such as collaborative thinking and discussions, suggest that this arrangement improves team dynamics. However, lower scores in categories like speculation (S), flexibility (F), and bounce-back (B) highlight its limitations for individual focus. Future research could also replicate this experiment using headset-based voice communication rather than face-to-face interaction, to explore how mediated communication may impact team dynamics under different seating configurations.

Although stellate polygonal seating was preferred for teamwork, this did not result in superior game performance, indicating a complex relationship between seating arrangements and performance. These findings align with observer notes: in linear seating, players, especially at the far ends, struggled with communication, showing low dialogue and limited interaction, while stellate polygonal seating encouraged more communication and emotional exchanges but also introduced distractions, such as off-screen focus and irrelevant conversations.

Free responses confirmed these observations. Participants noted that linear seating reduced distractions and improved focus, but they found stellate polygonal seating more conducive to fostering a team mindset and motivation. This suggests that

while linear seating may boost performance, stellate polygonal seating offers a better team experience, demonstrating that effective teamwork does not always equate to an enhanced team experience. This suggests that teams unfamiliar with the stellate polygonal layout may initially struggle, but with dedicated practice, they might develop coordination strategies that improve their performance over time.

Unexpectedly, gaming proficiency demonstrated a significant effect on the scores in certain categories of Method II—specifically, team cognition (T), motivation (M), discussion (D), and cue-reading (Q)—within the context of stellate polygonal seating. Although this was not a primary focus of the study nor aligned with the initial hypotheses, the result offers valuable insights. The categories influenced by proficiency are characterized by more interactive and immediate team dynamics, in contrast to the unaffected categories—speculation (S), flexibility (F), recognition (R), and bounce-back (B)—which are more strategic and reflective. Given that stellate polygonal seating is less commonly used by most players, a potential interpretation is that higher proficiency enabled players to better adapt to the unfamiliar setup, resulting in reduced disorientation when executing immediate tasks. Moreover, age and gender did not emerge as significant factors. However, this analysis is based solely on the current observations; further research may uncover additional explanations for why more proficient players reported a better experience in stellate polygonal seating.

Applications to gaming culture

Addressing toxicity in gaming culture

While this study focuses on the impact of seating configurations—linear and stellate polygonal—on team performance and collaboration, it is crucial to place these findings within the broader context of multiplayer gaming environments, where toxicity remains a pervasive issue. Toxic behaviors, often driven by aggressive interactions in high-pressure gameplay (Kordyaka et al., 2023), manifest through profane language, insults, and exclusionary practices (Märtens et al., 2015). These behaviors severely disrupt teamwork and communication, making effective collaboration increasingly difficult. Players in competitive and violent multiplayer genres, especially in games involving large numbers of anonymous participants, are particularly vulnerable to such behaviors (Zsila et al., 2022), making toxicity a significant challenge within the gaming landscape.

In offline multiplayer gaming settings, stellate polygonal seating could offer a strategy to reduce toxicity by fostering more direct interaction between players. However, problematic behaviors in online environments often stem from the anonymity that cyberspace provides (Saarinen, 2017, 14), which makes individuals less likely to adhere to social norms and more prone to engage in behaviors they would other-

wise avoid in face-to-face interactions (17). This anonymity limits the direct applicability of stellate polygonal seating in fully online environments, as the physical presence that helps mitigate toxic behaviour offline is absent. Research has further stressed the normalization of toxicity in gaming culture, where toxic behaviours are accepted as part of the gaming experience (Beres et al., 2021, 1), perpetuating a cycle of moral disengagement in which players feel disconnected from the consequences of their actions (14).

Despite these challenges, the findings from this study offer valuable insights for addressing toxicity in online gaming spaces. By drawing on the principles of stellate polygonal seating, online environments could encourage more direct player interaction through features such as video chat, real-time voice communication, or personalized avatars. These tools can help foster accountability and reduce toxic behaviours by mimicking the face-to-face engagement that stellate polygonal seating promotes. In this study, players reported feeling more motivated, energized, and connected simply by adjusting their seating to face one another, emphasizing the positive effects of direct interaction. This aligns with research showing that cooperative team dynamics can significantly reduce hostility among teammates (Reid et al., 2022). Encouraging direct engagement, both online and offline, could be a powerful strategy for combating toxicity in gaming culture, warranting further research to explore this relationship more deeply.

Therapeutic potentials

With the rise of toxicity in modern online gaming and concerns like game addiction, positive aspects such as motivation and immersive enjoyment (Johannes et al., 2021) are often overshadowed. However, online gaming has increasingly been integrated into psychotherapy for conditions such as anxiety disorders, autism, and cognitive therapy (Wilkinson et al., 2008). Multiplayer gaming, in particular, offers rich opportunities for social interaction that can enhance players' socio-cognitive skills (Ozgur et al., 2022). As game therapy evolves—incorporating role-playing, virtual reality (Amichai-Hamburger et al., 2014), and therapeutic games shown to build emotional resilience (David et al., 2021)—the design of gaming spaces, both virtual and physical, could further amplify these benefits.

In this context, stellate polygonal seating may play a critical role in promoting mental well-being among players. Findings from this study suggest that, although this seating arrangement did not directly improve match outcomes, it significantly enhanced team interaction and cohesion. Participants reported feeling more motivated and described a stronger team mindset when seated in a stellate polygon formation. These results highlight the potential for spatial design in gaming environments to offer valuable therapeutic applications. The positive social effects observed with stellate polygonal seating call for further exploration, as studying how these design elements impact players' mental well-being could advance the role of online gaming in therapy.

Limitations and suggestions for future research

While the study employed two methods to ensure greater accuracy, it is important to note that the sample size was limited to only 16 participants (excluding the eight team members of Team C) and their respective gameplay evaluations. Consequently, it is crucial to recognize that expanding the number of test subjects significantly could potentially yield different outcomes. Additionally, since the study was conducted in South Korea where LAN cafés and communal gaming environments are common, the generalizability of these findings to countries where individual or at-home gaming dominates may be limited.

Furthermore, this study specifically focused on an 8-member team gameplay scenario, with the intention of examining interactive factors such as proximity and orientation. However, it is worth considering that outcomes may vary for smaller teams, such as duos or 3-man squads, as richness and accuracy in communication are significantly enhanced at group-level for smaller groups (Lowry et al., 2006, p. 656–657).

To enhance this study's findings and deepen the understanding of how spatial and interactive factors affect multiplayer gameplay, future research should include a more diverse range of participants. Additionally, exploring improvements to the commonly used linear seating and broader applications of stellate polygonal seating in gaming culture is recommended. This would provide a more comprehensive view of the subject.

Conclusion

This study investigated the effects of two seating configurations—linear and stellate polygonal—on team performance and dynamics in multiplayer gaming. Across eight matches, linear seating consistently resulted in higher kill counts, with both Team I and Team II averaging 80 kills per match. In contrast, stellate polygonal seating led to significantly lower performance, with Team I averaging 53 kills and Team II 51 kills. The ANOVA test confirmed that seating configuration had a significant impact on performance (F-statistic of 43.56, $p < 0.05$), indicating that linear seating is more suited to enhancing individual focus and in-game success. These findings highlight the competitive advantage of linear seating in terms of measurable performance metrics, especially in fast-paced, high-stakes gaming environments.

Despite the lower kill counts, Method II survey results demonstrated that stellate polygonal seating offered benefits in fostering team dynamics. Participants rated stellate polygonal seating higher in categories such as team cognition, motivation, and discussion, reflecting its role in promoting better communication and interaction among team members. While these benefits did not translate into improved performance metrics, they suggest that stellate polygonal seating contributes to a

more collaborative and cohesive team experience. The contrast between objective performance outcomes and subjective team experiences underscores the complexity of seating configurations, suggesting that the success of a seating arrangement depends not only on individual performance but also on the quality of team interaction it fosters.

Beyond performance, the study's findings point to broader implications for team-based esports, collaborative learning, and therapeutic gaming environments. Stellate polygonal seating, by promoting direct engagement and reducing anonymity, could help mitigate toxicity and enhance group cohesion in various gaming contexts.

However, the study's limitations, such as the small sample size and focus on 8-player teams, suggest that future research should explore these dynamics across more diverse participants, larger teams, and different game genres to strengthen the findings.

Conflicts of interest

The author declares that there is no conflict of interest.

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