Collegiate eSports as Learning Ecologies: Investigating Collaborative Learning and Cognition During Competitions

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ABSTRACT
We explore the ways that a collegiate esports team's play and performance evidences micro-level shifts in learning, domain mastery and expertise through simultaneously collaborative and competitive game play. Specifically, to this aim, we evaluate how esports provide evidence of processes and practices that are important for learning-relevant trajectories in and beyond higher education. Collegiate players demonstrate decision-making, reflection and elements of individual and collaborative learning during high stakes matches. Our findings help highlight evidence of perceptual learning, as it occurs over time and through the refinement of individual and collective skills, which is demonstrated through the players' flexibility to adapt to increasingly complex challenges. We further see evidence of task cohesion and psychological safety, which corresponded with productive risk taking and group potency (or collective self-efficacy). Players also exhibit integration of effective reflection techniques and improved task and outcome interdependence. We contend that findings underscore the importance of esports as meaningful and noteworthy learning ecologies.

Keywords
esports, games and learning, collegiate athletics, computing competitions, learning ecologies, live streaming, collaborative learning, cognitive apprenticeship, perceptual learning

INTRODUCTION
The rise of gaming as spectator sport (i.e., esports) has propelled gaming competitions and interest-driven game-based learning practices into the mainstream (e.g., Richard, 2017; Takahashi, 2016; Taylor, 2012; Wingfield, 2014). While there has been a history of video gaming competitions since the 1970s, the past few years has seen tremendous growth in part due to livestreaming. Figures from just the past year estimate that Twitch alone has over 100 million viewers per month with over 21% of viewership dedicated to esports competitions (Takahashi, 2016), mostly focused on games like League of Legends (i.e., multiplayer battle arena games). Furthermore, most gaming viewership has surpassed other visual media consumption, and annual revenues are on par to match traditional sports spectatorship (Taylor, 2017).

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We contend that learning ecologies in learner-initiated spaces, such as esports and gaming competitions, need further examination. A wealth of research over the past two decades has demonstrated the potential for commercial and educational games to engage learners and players through motivation and in processes such as distributed and situated learning, problem solving, spatial skill development, systematic thinking, content area knowledge (such as history), and adaptive reasoning (Connolly, Boyle, MacArthur, Hainey & Boyle, 2012; Squire, 2011; Steinkuehler & Squire, 2014; Young, et. al, 2012). However, scholars have found that educational and serious games often have limitations that inhibit widespread adoption, such as antiquated design features, a narrow focus on simulations or puzzle-type games (Connelly, et. al, 2012) or constrained scope beyond an intervention (Durkin, Boyle, Hunter & Conti-Ramsden, 2015), and commercial games, though well-designed for learning goals (Gee, 2007), often have aims more centered on entertainment that often run counter to schools' individual play or short expository approach to learning (Young, et. al, 2012).

Though there have been several notable studies on learning-relevant practices in Massively Multiplayer Online Games, many of these have focused on collaborative role-playing genres (e.g., Steinkuehler & Duncan, 2008). This is not to say that there has not been extensive game and simulation integration research across multiple educational and informal contexts (NRC, 2011). However, these kinds of learning models are comparatively lower stakes. Specifically, there have been few educational research endeavors studying the learning contexts of high stakes competitive matches in Multiplayer Online Battle Arenas (MOBAs). We make a distinction between more extensive work on organizational behavior (e.g., Kim, et al, 2016) and sociocultural implications (e.g., Taylor, 2012; Witkowski, 2012) in esports. The scope of our research is especially important as colleges have begun investing in esports in various ways, with some offering official support through collegiate athletics or scholarships and others offering unofficial support through student organization models (Wingfield, 2014), such as the one under investigation. Thus, it is important to assess some of the cognitive, social, and collaborative dimensions that have been extensively studied in mainstream competitive sports. Lastly, an area particularly important for educational gaming audiences is how game mechanics around teamwork, socialization and objectives influence relationships between distributed learning and performance of that knowledge.

In this paper, we explore the ways that players invest in learning-relevant practices and cognitive processes through esports and livestreaming. We explore a detailed case study of one team's progression throughout a collegiate tournament as evidence of micro-level shifts in perceptual learning through simultaneously collaborative and competitive game play. This particular team was chosen because the players had both strong and weak ties, due to last minute changes in team composition, and different levels of expertise (though all were proficient enough for competition). To this end, we explore the following research questions: How do players engage in learning and collaboration during esports competitions? How are these interactions influenced by individual and collaborative expertise and processes? How are these interactions influenced by learning-relevant practices?

BACKGROUND

In many ways, livestreaming and collegiate esports organizations work like communities of practice (Lave & Wenger, 1991). Increasingly, communities of practice framing has been utilized to document game-based learning through communities. For example, members of the esports student organization under investigation gather at weekly meeting

to discuss patch notes and strategies. More expert players offer their time to provide advice and training to newer players. They also engage with media platforms like Discord to facilitate team chat, and Facebook to share ideas around game play. Furthermore, they utilize livestreaming, primarily through Twitch.tv, to broadcast their team play and reflect on it, as well as learn from other player's strategies.

Matches themselves represent a moment in time when mastery can be tested and thus an interesting case study to explore when investigating how learning occurs when effortful practice can be tested. With most esports games, like League of Legends ("League"), a popular MOBA, drafting is a crucial part of the game, similar to traditional athletics. As of April 2016, when the data was collected, there were 134 different "Champions" (characters), each of which brings something different to the game. Before the match begins, teammates collaboratively negotiate their strategy, which includes (a) choosing Champions each individual can play effectively, (b) negotiating which Champions work together based on individual skill and team balancing, and (c) banning other Champions, which would strengthen the opposing team. Kim and colleagues (2016) describe this as the proficiency-congruency dilemma, which was developed through team-based research from organizations, sports teams, and video games.

The proficiency-congruency dilemma extends upon deliberate practice (e.g., Ericsson, Krampe & Tesch-Römer, 1993), and describes how people become experts in their given fields through extensive and effortful practice. In other words, more experienced players have gained an understanding of the intricacies involved in play, such as choosing characters based on anticipated or actual complexities that can occur. Research shows that teams that are better able to capitalize on team proficiency (expertise on the character roles needed on the team) instead of individual proficiency (individual expertise with certain characters) perform better, as do teams that have good congruency, or group cohesion. Congruency is achieved through matching the best roles needed on the team and with the characters available for the team. Unsurprisingly, more expert players are better able to have both high team proficiency and congruency because they have developed "superior mental models of how in-game roles complement each other [which] novices have to develop…over time" (Kim, et. al., 2016, pp. 4359). However, unfamiliar teams and blended teams with expert and novice players can partially bridge the gap through discussion.

Of particular interest to our investigation are learning theories that highlight the ways that knowledge occurs in or is applicable to real life, thus suggesting applicability for near and far transfer to other learning or performance contexts. Cognitive apprenticeship (Collins, Brown & Newman, 1989), for example, derives from models in traditional apprenticeship and sports with emphasis on cognitive rather than physical skills. According to cognitive apprenticeship, many people start learning complex physical skills through imitation, such as when a coach or expert teaches you how to perform an action. However, cognitive apprenticeship further suggests that there are three major forms of reflection that can significantly affect learning for which multimedia technology provides a unique advantage: replay, when a coach videotapes your actions and compares them to experts; abstracted replay, when a coach focuses on specific critical points of action; and spatial reification, which happens when several critical points of action are mapped out over time so you can see your learning progression. Perceptual learning, on the other hand, is thought to happen over time through different reflection processes that help learners flexibly adapt to complex challenges (Bransford, et. al, 1989).

In addition to individual domain mastery, learning often happens collaboratively through mutually shared cognition, which results in increased performance (e.g., Miyake & Kirschner, 2014). For example, teammates could learn from deep knowledge sharing with one another during practice and competitions, in line with distributed expertise (Brown et al., 1993). Four team level interpersonal beliefs were identified that could affect learning behavior: psychological safety, cohesion, interdependence and group potency. Psychological safety indicates a collective belief that the team is safe for interpersonal risk taking (Edmondson, 1999; Kreijns, Kirschner & Jochems, 2002). Task interdependence refers to interconnections between sub-tasks that contribute to overall group performance (Van der Vegt, Emans & Van der Vliert, 1998). Since sub-tasks are dependent on each other, task interdependence can lead to open and effective communication between team members. Outcome interdependence refers to team members' "personal benefits and costs" being tied to "successful goal attainment" by other members of the group (Van der Vegt, Emans & Van der Vliert, 1998, pp. 130), similar to team and individual proficiency and congruency. Cohesion has two dimensions: task cohesion and social cohesion. Task cohesion refers to the collective effort by all members to work collaboratively towards completing an enjoyable and motivating task, whereas social cohesion is dependent on emotional bonds between team members. Research suggests that task cohesion leads to better learning and performance behavior. Group potency describes group self-efficacy, or the shared belief in the group's effectiveness, which has also been shown to increase performance, along with satisfaction (Miyake & Kirschner, 2014).

Summary of Learning Theories

In summary, since we know that more expert players and more expert teams are better able to navigate the proficiency-congruency dilemma (i.e., deliberate practice), we use this frame to understand both decision-making and domain mastery. Due to the mixed expertise of the team under investigation, we would expect to see, (1) interactions based on blended expertise, which should lead to more discussion and negotiation, (2) instances of reflection within and between matches, (3) heightened task interdependence leading to more open communication, and (4) micro-level shifts in effective individual and collective performance. As a newly formed team in a high stakes tournament, we would also expect to see more outcome interdependence, which would improve over time. Due to the nature of the high stakes tournament, we would expect that the team would exhibit high task cohesion. Finally, we would further expect to find more risk-taking if the team feels psychologically safe, and group potency (or self-efficacy) as their performance and team dynamics improve, which would lead to perseverance against the odds.

METHODS

Data Collection and Analysis

Data sources included participant observation, both during physical club meetings and tournaments, and during online streams of practices on Twitch.tv. The following analysis is a case study of a match between the "Team B" vs. "Top Big East" in the 2016 Home Institution Collegiate eSports Tournament (we have given pseudonyms for confidentiality). We video recorded the interactions of Team B during the tournament and two members of the research team analyzed the data for themes, utilizing constant comparison analysis techniques (Strauss & Corbin, 1997). Specifically, two coders analyzed similar parts of a subset of the data (2 games) and transcription using open coding techniques, followed by discussion and negotiation of codes with all three team members. Most codes were in agreement, though refinement was needed for naming constructs from which axial codes were derived. The original videos and remaining game's data were coded with axial codes.

All team members then reviewed the video data with the axial codes, followed by analytic memo writing. Themes were derived from the collective fine-grained analysis of the data, codes and analytic memos over several team meetings. Findings were also checked with other researchers and League players (n=3) who sat in during some of the meetings and verified thematic connections.

Participants and Setting

One team made up of 5 participants (herein, "Team B") was observed during a major collegiate tournament hosted by their home institution. There were a total of 4 teams from the home institution competing, along with 4 teams from universities across the United States. This particular institution did not have official support for esports and instead maintained their collegiate esports status through a student-run organization.

As college students, team members sometimes had to skip practices, or withdraw from teams in order to deal with other pressing matters such as school. When "Team B" entered the LAN, they were not well practiced as a team. For example, the Division 1 team at the home institution consists of top players in the organization who compete for the spot and represent the organization in most national esports competitions. It also has a manager, coach, and two analysts who are dedicated to weekly coaching sessions where they and the team examine competing teams' strategies, evaluate the Division 1 team's play at the individual and group level, and focus on areas for continued development. Team B, the team examined in this study, did not have such support. Team B was largely considered to be the underdogs of the tournament because they had formed only shortly before the tournament due to another team disbanding. In particular, C5, who was in the organization's leadership for the League division, was not originally on any of the competitive teams, but was widely regarded as knowledgeable and capable of filling the empty position. It should be noted that, unlike the other Team B players, who were at the diamond level (i.e., top 2% of players nationally), C5 was at the platinum level (i.e., top 8-9%), thus considered highly competitive but perhaps lower tier than most of the players in the tournament. We chose to focus on this team because they were blended in expertise and, perhaps as a result, were the most vocal during the tournament in describing their interactions, thus providing a salient case study of the kind of learning-relevant practices observed during collegiate esports play.

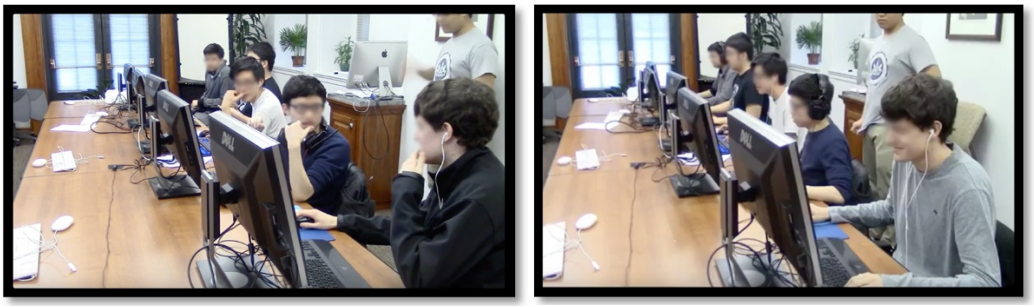

Figure 1: Left: Picks and Bans phase; Right: In game. Study Participants (closet to the furthest): *C1* - Tank (Top Laner); *C2* - Jungler; *C3* - Mid Laner; *C4* - Attack-Damage Carry (ADC); *C5* - Support / Team Captain.

The tournament was hosted on-campus at the home institution. During play, competing teams were separated into meeting rooms with a referee assigned to each room. Spectators

watched the entirety of the tournament in an auditorium where gameplay was projected on a large viewing screen as it was livestreamed on Twitch.tv, with commentary provided by broadcasters – many of them students honing their sportscasting skills at the same time. We focus here on the interactions in the room where Team B played, and where we set up a camera and microphone. While these cameras were checked regularly between matches, the researcher was not in the room while the competitive matches were played to reduce interference. We labeled each participant from C1-C5 based on his distance from the camera (see figure 1).

Top Lane (C1)	Diamond
Jungler (C2)	Inferred at Platinum or Diamond (Unable to locate)
Mid Lane (C3)	Diamond
ADC (C4)	Diamond
Support (C5)	Platinum
Tiers from the lowest to highest (Percentage of total player base on League in each tier in parenthesis): Unranked (N/A); Bronze (25.40%); Silver (39.15%); Gold (25.05%); Platinum (8.41%); Diamond (1.95%); Master (0.03%); Challenger (0.02%) Divisions in League from the lowest to highest: V, IV, III, II, I	

Table 1: Participants' solo queue season ranking during tournament (Season 6)

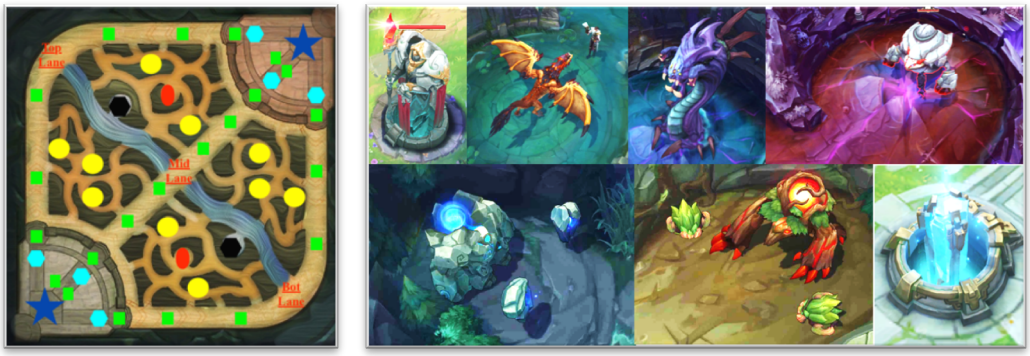

Figure 2: Left: Mini Map of Summoner's Rift (Nexus: Blue Stars; Turrets: Green Squares; Jungle Camps: Yellow Ovals; Dragon/Baron: Black Hexagon; Inhibitor: Blue Hexagon). Right: Objectives, Left to Right: (Top) Tower, Dragon, Baron, Rift Herald, (Bottom) Blue Buff (Dark Blue oval), Red Buff (Red Oval), Inhibitor.

Game Setting

In League of Legends, two teams of five champions battle it out. The goal of the game is to march to the other team's base with your fellow teammates and minions to destroy the enemy's Nexus (see simplified map in figure 2). The players control a character known as a "Champion," of which there were 130 as of April 2016 when the data was collected. Each Champion falls into a different role: Marksmen/Attack-Damage Carry (ADC), Mid-Laner, Tank, Jungler, and Support (see table 2). As one can imagine, there is a complex interplay between each role, and certain characters may even swap roles throughout the course of a match. Further, there exists a large amount of complexity around the mechanics of play. Each champion has 4 skills, natively mapped to the Q-W-E-R keys on the keyboard. Each

skill has a different effect, and the "R" skill (or "Ultimate" ability), when used effectively, can be game changing. Once a player is in control of a champion in game, they must plan out a build path for itemization. League currently has about 200 separate items to choose from in any one match. This helps illustrate the complexity of decision-making that any single champion in a vacuum would need to make in order to be successful. However, not only are items needed to maximize one character's effectiveness, but also in balance with the team's choices and in countering the enemy team's build path. Finally, due to the nature of strategic team play and coordination, communication is the backbone of successful game outcomes. League has facilitated communication via an in-game ping system, where players can signal information to their teammates with the click of a mouse, and chat through a window when needed for more detailed messaging. This is further enhanced by either utilizing popular team communication platforms, like Discord, which can be used for both text and voice chat when at a distance or talking in-room when co-located.

Position	Position Description	Example Champions	Category
Tank **Top Lane**	Typically, a solo lane that is filled with characters who are specializing in higher health, armor, and/or magic resistance.	Malphite, Trundle, Rammus, Ekko, Nautilus, Poppy, Graves, Vladimir	Tank, Bruiser
Mid Lane	Splits battlefield in half. Filled with champions who use ability power or Assassins, it has a high impact on the early and mid-game.	Zed, Vel'koz, Ekko, Kassadin, Annie, Ahri, Azir, Talon, Vladimir	Mage, AP Carry, Assassin
Jungle	Takes up most space on the map. Champions in the jungle are very mobile and constantly looking for easy ambushes	Graves, Hecarim, Trundle, Kha'Zix, Kindred, Vi	Jungler (Almost any role)
Attack Damage Carry (ADC) **Bottom Lane**	Comprising one half of the bottom lane, the ADC is responsible for killing minions (farm) and dominating the enemy ADC and support to build powerful late game items.	Graves, Ezreal, Corki, Ashe, Vayne, Tristana, Jinx, Twitch	Marksman, Assassin, ADC
Support **Bottom Lane**	Support is there to keep the team alive and frustrate the opposition. They accomplish this through slows, stuns, heals, and shields.	Braum, Malphite, Morgana, Nautilus, Brand, Sona, Soraka	Tank, Support, Mage

Table 2: Champion Roles and Mechanics in League.

Preparing for a Match

Before the match is played, both teams must draft their champions. In League Tournament Mode, there are three phases of drafting: ban phase, pick phase, and the trade phase. Each team receives three bans and has thirty seconds to decide which champion to ban, in an alternating fashion. In the picking phases, a team picks a champion for their team and has 60 seconds to do so. The order is A/BB/AA/BB/AA/B, where A represents Team 1's pick and B represents Team 2's pick. Once a "five-champion roster" is selected, each team is

given sixty seconds to trade champions within their team. This enables changes based on both individual abilities and team balancing.

Once in game, players are able to view other players' profiles for information such as their rank and their most played champions. Profiles can reveal just-in-time feedback for the purpose of last-minute strategizing and final preparations.

FINDINGS

Our primary emphasis on micro-level shifts are comparisons between game 1 and game 3. The tournament matches consisted of the best of three games. In our discussion of findings, we begin during the picks and bans phase. Before game 1, the Top Laner (C1) discussed one of the champions the other team favors by looking at his profile. The Jungler (C2) prompts the team that they should look at the opposing team's match history in hopes that it would provide critical information that can help them refine their strategy. C1 points out another champion that the other team is probably going to pick and C2 quickly responds with the idea of banning that champion.

> **C1:** One of them plays Malphite [*viewing opposing player's Summoner profile*]
> **C2:** Yeah look at their history
> **C1**: He plays Aurelion
> **C2:** Should we ban Aurelion just to troll him?

In particular, this exchange reveals important aspects of the proficiency congruency dilemma; for example, if the team knows what their opponents are comfortable with, denying the option to play as those champions may reduce their effectiveness. By knowing who their opponents are likely to play, the team can begin crafting strategies on how to counter those particular champions.

Through the first game of the match, the team is observed refining their strategies and synergies amongst the team. In game 1 the team made more predictions of what the opposing team would play based on their Summoner profile, whereas, by game 3, there is a more in-depth discussion surrounding the new knowledge they have over the last two games played. For example, during game 3's picks and bans phase, Team B starts debating a choice for the ADC on their team during their 60 second window. They reflect on the last game, focusing on how their team composition seemed to counter the enemies if proper execution techniques were utilized. C1 mentions that they tried to "peel" (i.e., protect their ADC from) the enemy Morgana ("Morg") but alludes to the strategy being unsuccessful in the prior game (game 2). Finally, in order to pick the proper ADC, Team B needed to determine who the enemy Top Laner/Tank was likely to pick and set up an effective counter-ban.

> **C2**: Is there an ADC that can kill tanks really well? Like Corki?
> **C3**: You play Vayne, just play Vayne.
> **C4**: Vayne's not that good at (…)
> **C2**: Corki he's ...
> **C1**: There's Lucien, Lucien is pretty broken
> **C2**: Corki with BotRK
> **C3**: They were doing the double AD comp last game like, where do they go, like…
> **C3**: They would do all the initiating, we just had to pick em like Malz would peel Morg
> **C1**: Idk I tried like…idk

C2: Did we ban Poppy?
C1: Yeah because, well I don't know if their top laner plays Poppy…I don't see him playing it
C4: Yeah let's just see what he plays first. He picked Trundle last game right?
C1: Umm he played Trundle, then Malphite
C1: We aren't planning on banning Malphite, are we?

In this exchange, we fundamentally see changes from game 1 to game 3. For example, during the champion selection phase, the team presented more confidence in their decision-making by applying knowledge from prior games to make informed predictions of the enemy's picks. In particular, we start to see elements of refinement in their group potency (i.e., collective self-efficacy), which, in turn, leads to modifications in their strategies for picks and bans. In many ways, group potency highly influences task cohesion, which occurs when learners collaboratively work toward completing a task and is connected to better learning and performance. Thus, these improvements in performance could be considered a benefit of their effective and distributed collaborative learning. We also see specific instances of reflection, when team members discuss the previous team composition as well as the successes and failures of countering the enemy's strategy.

Dedicated players, particularly those competing formally or informally, spend several hours each week attempting to improve their gameplay, either through formal team practice or analyzing past matches on Twitch.tv or Youtube. In other words, they engage in reflection techniques such as replay or abstracted replay, in order to compare their strategies to those of experts. During game 1, when the match was finished, the players were allowed to use their web browser. Realizing that the game was being broadcasted on Twitch, the players quickly tuned in to the livestreams. The stream was showing footage (on a built-in delay to prevent cheating) of one of the bigger team-fights during the match. C4 (who died during the fight) points out the instance in which he attempted to heal his character but for whatever reason wasn't able to (12:05). He knew the moment in which he needed to heal but was unable to complete the action, blaming technical issues.

C2: Are they casting?
C4: Oh look right there…. *[points to screen]* I couldn't heal! The f---! Literally my screen froze!

By honing in specifically on one action, we could argue that he was engaging in abstracted replay. In this particular case, he does so individually; thus, while he may have learned from the exchange to improve his individual performance (i.e., individual proficiency), his team was not integrated into the process. By game 3, however, the team engages in a collective review of a past game where there were errors in team fight execution:

C3: I should have went Kha'Zix
C4: Dude Malphite was going on you then
C3: No I was watching for the ult, I was back far enough, Ezreal just ulted me so I'd say yes.
C4: *[Laughs and shakes head]*
C3: The lazer worked pretty good
C4: *[Laughs]*
C3: The same thing
C5: *[claps]*

In the exchange, we see that C3 was questioning his champion pick in the last game, saying he should have went with Kha'Zix based on the gameplay. Yet C4 did not agree because the enemy tank, Malphite, was focused on C3 for the game and Malphite would have countered Kha'Zix in that matchup. Paying attention to the screen where he is watching the replay of their last game, C3 explains the rationale for his actions, "No I was watching for the ult, I was back far enough, Ezreal just ulted me so I'd say yes." By moving from individual abstracted replay to team abstracted replay, there is evidence they are engaging in a holistic review that capitalizes on their shared expertise. As a result, they can collaboratively correct their shared schema through discussion in order to heighten their team proficiency and congruency. In many ways, the team's heightened congruency can be argued as a byproduct of minute yet distributed shifts in perceptual learning happening through reflection and discussion.

Throughout the following exchange during game 3, there were many instances elicited where members were able to ask questions, test strategies, and enact risky maneuvers for the overall benefit of the team. For example, the exchange below shows the team communicating their plans to push out their lanes to take the next tower. While this is happening, the team gets vision on the enemy Hecarim and the Mid Laner (C3) attempts to kill him. C3 ultimately takes a risk in attacking Hecarim but ends up failing because he got stunned and exhausted (had his damage output reduced). Killing Hecarim would have provided the team more time to be aggressive and push out the lanes more safely.

C3: I think we're fine
C5: we have vision
C4: Switch switch
C2: Alright he's going to try and come in
C4: Just shove in shove in
C3: Shove down work mid
C5: Yeah we're shoving
C2: I'm going to go get the uhh…
C2: Hecarim's at blue
C4: You can go warpath if you want
C5: Hecarims right there, sitting gromp
C2: You gonna go in?
C3: One second
C2: You gotta go in and kill him
C3: Omg
C2: I thought you had him dude
C3: I got like, stunned again
C3: Yeah I was exhausted so…
C2: Oh you were exhausted
C3: Yeah
C2: Oh ok that's why
C5: Let's just stay there hold blue

As seen above, not all risks pay off. The Mid Laner (C3) failed to capitalize on destroying Hecarim. Often individual players may make a decision to take a risk without the consensus from the rest of the team. However, in this case we see that C3 was pressured to go against Hecarim by C2, perhaps at a time where he was not entirely ready for the exchange. Teams benefit when they can take risks, fail and are still supported by their team. In the exchange below, occurring after the completion of the game, team members start poking fun at the

Mid Laner (C3) for having the most deaths on the team.

> **C5**: That one Zed snipe that you had where you picked off the Ezreal, that's what we needed. It helped us a lot
> *[C3 and C4 laughing]*
> **C2**: This one here?
> **C5**: Yeah because Hecarim panicked and he went in…
> **C4**: Wait, wait - I was back in the bush with the Brand where he flash-Q'd me!
> **C4**: Then the Nautilus TP behind
> **C2**: The second they don't have a Maokai, it's safe

In order to ensure that team morale and individual worth was fostered, the Support (C5) pointed to a specific instance in a team-fight toward the end of the match. In this fight, C3 was able to perform his role effectively by eliminating the opposite team's ADC, Ezreal. In doing so, C3 was able to swing the encounter in their favor and allow for a clean fight that led to winning the match. This is important to mention here because, while the teasing was amicable, C5 felt that it was necessary to show the rest of the team that C3's contribution and performance was an integral component in their success. In fact, C5 served as the team's support champion literally and figuratively throughout the tournament. In other words, by helping refocus the team on their individual and collective strengths, and reinforcing positive exchanges, C5 helps ensure psychological safety, which, in turn, reinforces both their group potency and risk taking.

In high-stakes collaborative performance, the belief that the group is powerful and can adapt to problems that are encountered is vastly important to success. While the team elicited several instances of group potency, one of the more powerful instances can be found right before game 3 begins:

> **C2**: What if it's a Nautilus jungle?
> **C3**: Nah it will be Hecarim
> **C1**: I think it's going to be Nautilus support again
> **C2:** We're doing Zed?
> **C3**: Yeah, I feel like Zed is good cause I feel like they can't initiate if I can dive
> **C1**: I have confidence in you, you can get onto someone important
> **C2:** Plus, we need an assassin
> **C3**: Yeah I can pop to the backline so..
> **C2**: So, Zed will kill the back line and me and (…) will just kite out their…
> **C1**: Peel the Hecarim off the Corki and everything
> **C2**: They got Morgana support, that's fine no big deal

This exchange occurs in the pick and ban phase prior to the match beginning. Here one can see the team building confidence in one another around their individual skill with champions, as well as their overall need as a team to have a champion that can eliminate important enemy champions. Beyond just the importance of C3's pick of an Assassin champion, it can be observed that they are confident in their ability to "kite out" the enemy and "peel" for their ADC, Corki. These are integral mechanics to keep their most important champions alive to influence team fights and ultimately come out on top of exchanges.

For the most part, the interdependence on task and outcomes occurred at nearly any point in the game where the team members were coordinating an attack on a major objective. As a reminder, outcome interdependence is the connection between personal benefits and costs

being tied to collective goal attainment, and task interdependence acknowledges interconnections between tasks that contribute to group performance, which leads to open and effective communication. Objectives throughout the matches can be seen as, Towers, Dragon, Baron, Rift Herald, Blue Buff, Red Buff, Inhibitor, or the enemy ADC (see figure 2 in the preceding section). These each have very significant outcomes for an individual champion and for the team as a whole when they are secured efficiently. Usually this consists of one or two champions working together directly to secure the objective, while the rest of the team holds back the enemy, provides vision, applies pressure to other areas of the map, or provides healing/shields for the champions capturing the objective.

There are several tasks that a player needs to be thinking about constantly throughout play. They are thinking about farming and gaining experience, item progression, and need to be aware of the timers for objectives (Dragon, Baron, Buffs). Players also need to be able to keep in mind not only their abilities and cooldowns, but also attempt to remember when the enemy's abilities are on cooldown in order to coordinate an attack. During game 1, the excerpt below is a standard example of how players communicate with one another in order to coordinate:

> **C1:** Trundle is missing. I have TP and my Ult is up in 40
> **C2**: Want to do rift so we can push
> **C4**: I'm going mid. You can do it. I'll get bot there is a huge wave

In the first line, we have C1 stating that the enemy champion in his lane is missing, that he has a teleport ability ready (which allows him to teleport to a friendly location on the map), and that his ultimate ability will be ready in 40 seconds. C2 suggests that the team's next action should be to take the Rift Herald, a powerful neutral monster, which, if slain, would provide a game-changing buff to the individual who secures it and allow them to push down the lanes easier. C4 makes a calculated decision to not help his team take the objective. Instead by going mid and then rotating bottom he accomplishes 3 things: (1) he is continuing to gather farm and experience that he would have missed out on attempting to take the Herald; (2) he is keeping the lanes pushed out which not only gives his teammates a bigger cushion as well as providing more vision, but also makes it harder for the enemy team to take objectives; and (3) since C4 is shown in lane, the enemy team is less likely to think they are attempting to take a major objective.

In game 3, we observe an exchange across the team about securing a very important objective, Dragon. They are negotiating their positioning strategy for repelling the enemy team, the need to establish vision and clear out the enemy vision wards, while constantly keeping track of the enemy Jungler, Hecarim. This is important because the Dragon is a neutral monster that can be secured by the summoner skill Smite, which does a very large amount of "true damage" to a monster or minion. One strategy that is commonly used is "stealing" the dragon, where an enemy Jungler waits until the precise moment that Smite would kill the monster and sacrifices themselves to smite the objective and secure it for their team. This almost always leads to the enemy team collapsing on and killing the Jungler, but the objective being secured is more important to the team's overall success. Finally, as mentioned earlier, interdependence is shown throughout the match. Below we see instances where effectively managing your individual role, balanced with the needs for the team, lead to rapid instances of communication around securing objectives. While the communication may seem shallow, it is deeply infused with knowledge about the game, as well as understanding how fellow teammates will react to these tense situations.

C5: They have a pink ward in here and Hecarim is in there
C4: Dragons in twenty we should move soon, swap down, swap down
C5: Yeah Nautilus is staying here
C1: I have TP
C1: I don't know where Hecarim was, he tele'd last time I did
C2: Dragon is in five
C1: I'll TP too
C4: Yeah there is pink ward right here
C4: Watch this right here
C5: Nautilus is trying to TP
C1: Nautilus is walking down
C4: Uhh, you're alone
C1: Should I come?
C4: Yeah come, come, come, come. Brand's really low.

Task cohesion, as mentioned before, refers to the degree to which a team works together to solve an interrelated task or problem. In a high stakes tournament, individuals have self-selected a team to compete against others. At the Diamond level in League, in particular, players are competing in the top 2% of players in the world. It is necessary that the team work together efficiently in order to win in League. We found that task cohesion was prevalent throughout the interactions that team members had, in general. A specific instance can be found when the team won game 3 and celebrated their tournament win:

C2: That was fun
C4: That was ace
C5: Yeah!
[*C1 and C3 Laughing*]
C3: Oh my god
C2: Dude why did our Zed feed guys? [*Jokingly*]
C5: Way too much feeding bro [*Jokingly*]
C4: Looks at C3's screen [*Laughs*]
C4: Nice feed! Four times! That's 80% of our deaths [*Laughs*]
C3: [*Laughs*]
C3: Oh my goddddd, yeah 80%, oh my god
C2: Omg Maokai did so much damage! Holy crap!

You can see here that team members are laughing, overtly expressing that the match was, "fun," along with some good-natured teasing about the score from the Mid Laner (C3). Implicit actions and communication such as these helped highlight the enjoyment of the task of game play in competition.

DISCUSSION AND CONCLUSION

Throughout this case study, we saw strong evidence that learners are engaged in meaningful aspects of individual and collaborative learning processes important to our considerations of learning ecologies around informal game-based learning, such as improved decision-making, knowledge mastery, and reflection. Over the course of the game, we see evidence of micro-level progressions in domain mastery as evidenced through the proficiency-congruency dilemma framework. As expected, we observed their high investment in gaming, and strong task cohesion. As a newer team, we also saw more discussion and negotiation, but also engagement in reflection, through replay and abstracted replay, which improved their task interdependence and outcome

interdependence over only three games. Specifically, we argue that even within the short temporal scale of a weekend tournament, we saw evidence of perceptual learning, or the improvement of learning over time through the refinement of individual and collective skills, as demonstrated through their flexibility to adapt to increasingly complex challenges. While they seemed to display strong team proficiency and congruency, the progression through the three matches strengthened. Overall findings indicated that the team exhibited psychological safety and engaged in productive risk taking. These, in turn, worked in tandem with their group potency, which improved over time, and, according to theory, would also positively influence persistence and perseverance. We see evidence of this happening, not only by continuing to persist through the tournament, but in their dedication to improvement over the course of several matches. In fact, we would argue that this played a key role in them winning the tournament, particularly as the least likely to be predicted to do so.

As mentioned previously, these findings are strongly connected to educational research on effective collaborative learning, and a vast body of research on traditional athletic performance and improvement. As the legitimacy of esports increases at a societal level, we must focus on increasing the general awareness of the individual and team level expertise development of players. By analyzing these psychological, social, and performance-regulatory techniques as they are connected to informal learning, we can start to understand the value of competitive esports as a legitimate informal learning ecology. Future work will explore more longitudinal analysis of collegiate esports team members moving from beginners or peripheral members to more expert players and central members over longer periods of time, such as from the beginning of club membership through the tournament phase. We will also explore barriers to participation that inhibit psychological safety in learning to understand the continued lack of diverse gender and racial participation in high stakes esports learning and performance more generally.

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