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Bridging the Gap Between Learning and Fun: Is There a Relationship Between Video Game Use and Self-Regulated Learning?

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Abstract

Self-regulated learning (SRL) occurs when students proactively optimize their learning. Ingrained within this process is metacognition: the knowledge, control, and regulation of cognition. A high level of metacognition helps students to maximize learning. Video games may have an influence on metacognition, though past research on video games has found varying effects. While some studies found improvements in problem solving and task perseverance, others found correlations with aggressive behaviours and addictive behaviours. To contribute to the literature surrounding video game effects and to explore possible categorizations with video games, two studies were done. The first study explored the possibility of characterizing video game genres according to complexity and sociability. The results of Study 1 were used to aid the interpretation of Study 2 to potentially explain the interaction between video game use, metacognition and academic performance. The results suggested that complexity ratings for each genre of video games were significantly different from each other. However, sociability ratings did not capture enough detail to be used as a useful indicator. The second study explored the relationship between video game use, socialization in video games, metacognition, and academic performance. More specifically, the study examined the possibility that video game use and socialization in video games can predict academic performance. This relationship was expected to be mediated by metacognition. The results suggested that there was no mediation effect. It seems that, as a whole, video game use, socialization in video games, and metacognition can predict academic performance. However, each individual predictor was not significant by itself.

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This project piqued Shih-Chieh's interest in data analysis. Now that he has graduated, he hopes to continue to improve his skills in data analysis and put them to use.
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Introduction

In 2015, Canada had 19 million video game players, constituting 52% of the nation’s population (Entertainment Software Association of Canada, 2015). Statistics Canada (2015) found that Canadians played on average 2 hours and 20 minutes of video games a day from data collected in 2010. With over half of the nation’s population playing video games, and many being young, video games’ impact on learning becomes one of great interest. Studies have suggested that gaming enhances various cognitive functions, such as problem-solving and learning (Adachi & Willoughby, 2014; Gabbiadini & Greitemeyer, 2017). Other studies have found that gaming can hinder learning (Lehenbauer-Baum & Fohringer, 2015). Mixed results from the literature show that further research is needed to uncover the relationship between gaming and how this nearly ubiquitous activity affects our ability to learn.

Self-Regulated Learning

Learning is the process of acquiring new skills. In school, students constantly absorb new materials from their courses; however, learning is not limited to the academic environment. People can learn other skills, such as chess, darts, or volleyball. Moreover, learning is not limited to students. New business owners may have to learn the legal procedures that comes with owning a business. Likewise, a newly hired employee will need to learn the skills to navigate their job. Whatever their age, people are always learning. This process of learning can take many forms and varies greatly across individuals. While some learners may need constant guidance and motivation from others, others seem to motivate themselves and take charge of their own learning. These highly motivated learners set study goals, plan study strategies, and adjust their behaviour to best achieve learning. These individuals are said to be self-regulated learners.

Zimmerman’s cyclical phase model of Self-Regulated Learning (SRL).

Influenced by Albert Bandura’s social learning theory, Zimmerman proposed a model for SRL to understand the processes that underlie self-regulated learners. This model has three distinct phases: forethought phase, performance phase, and self-reflection phase.

The forethought phase. The forethought phase begins the SRL cycle. Here, the learner prepares for SRL by analyzing study materials, planning learning strategies, and setting learning goals (Zimmerman, 2013). This marks the beginning of a SRL cycle, which requires sufficient self-motivating factors to initiate (Cetin, 2015; Evans, Kirby, & Fabrigar, 2003; Zimmerman, 2002).

The performance phase. Following the forethought phase is the performance phase, where learners conduct their learning strategy. In this stage, perseverance helps students in resisting adversity and persisting to accomplish long term goals (Wolters & Hussain, 2015). Throughout the performance phase, learners are monitoring their progress and adjusting, improving, or maintaining effective learning (Cleary et al., 2006). They may manipulate study environments to maximize studying outcome by removing distractions or distancing themselves from disruptive environments (Zumbrunn et al., 2011). Self-regulated learners also maintain good management of time and resources (Paris & Paris, 2001) while seeking help when necessary (Newman, 1994).

The self-reflection phase. The final phase is the self-reflection phase, which feeds back into the forethought phase. In this phase, learners judge their progress against their standards and react accordingly. Self-regulated learners can use the goals developed during the forethought phase to guide their judgment and adjust strategies in response to perceived failures (Zimmerman, 2013).

Metacognition. Metacognition is defined as the ability to understand and control cognition. Brown (1978) and Zimmerman (1986) believed metacognition to be a central component in SRL. Flavell (1979) described the importance of metacognitive monitoring in academic performance. He described the importance of metacognition in self-evaluation and knowing effective learning strategies. This closely resembles the processes explained in the cyclical phase model. Perhaps unsurprisingly, several researchers have succeeded in improving academic performance by enhancing metacognitive aspects of SRL in learners (Dignath, Buettner, & Langfeld, 2008). This is done through a variety of teaching techniques.

Teaching SRL techniques. To date, researchers have succeeded in teaching SRL inside and outside of academia by teaching metacognitive strategies. Outside academia, researchers trained participants to incorporate the phases of SRL into training sessions for various sports, such as basketball, volleyball, and dart throwing (Cleary et al., 2006; Kitsantas & Zimmerman, 2002; Zimmerman & Kitsantas, 1997). Inside academia, research has taught SRL by integrating the three phases into school curricula (Paris & Paris, 2001). Schmitz and Weise (2005) created a direct method where students are taught the three phases of SRL and various techniques in time-management, self-motivation, and concentration. This training method improved study time, study efficiency, and satisfaction with learning in a college sample (Schmitz & Weise, 2005). Other researchers encouraged personalized goal setting and incorporated a variety of self-tests and exercises in school curricula. These students improved their SRL behaviours (Bellhauser, Losche, Winter, & Schmitz, 2016). However, for these study strategies to be successful, they require scaffolding through social collaboration among teachers and peers within the classroom setting (Paris & Paris, 2001).

SRL through socialization. Research has found evidence for relationship building interventions that improved academic performance (Delay et al., 2016). Indeed, there had been advocates of peer support, and relationship building in acquiring and achieving effective SRL. Zimmerman (2002) considers mentor and student relationships to be crucial in the building and development of individualized SRL. The student would need to observe, emulate, and then internalize the learning processes of their mentor (Zimmerman, 1999). Ryan, Pintrich, and Midgley (2001) consider help seeking and peer support important elements in learning outcome, and warn of potential detriments from avoidance of help seeking. It seems that a classroom structure that encourages communication and social interaction can affect the way students structure their learning goals, encouraging extrinsically motivated goals (e.g. achieving a competitive grade), instead of intrinsically motivated goals (e.g. mastery of lesson material).

Video Games

Video games and learning. Today, researchers are constantly finding new ways to improve learning. With the introduction of computer entertainment, researchers became interested in using video games as a medium for improving education (Helms & Sawtelle, 2007). In the past, video games were often associated with aggression and violence (Elson & Ferguson, 2014). However, more recent research has debated the results of past research and found many benefits from video games (Elson & Ferguson, 2014; Granic, Lobel, & Engels, 2014). Video games are an inherently attractive medium with the potential to both motivate and enhance SRL. Currently, there has already been research showing positive relationships between video game use and cognition.

***Video games and cognition*.** While research between video game use and learning is sparse, there have been several studies exploring the influence of video games on cognition (Eichenbaum, Bavelier, & Green, 2014; Granic et al., 2014). Basak, Boot, Voss, and Kramer (2008) found that an eight-week training session in a genre of video game that required strategic thinking and information gathering—also known as strategy games—can attenuate cognitive decline in older adults. In a study by Goldstein et al. (1997), elderly participants were asked to play video games of the puzzle genre for five hours a week for five weeks. They found improvements in participants' reaction time and increase in positive mood when compared to the control group. Extending this research, a longitudinal study on strategy games and role-playing games found improved problem-solving skills and, consequently, academic grades in grade 9 to 12 students (Adachi & Willoughby, 2013). A genre that required quick thinking, multiple object tracking, and complex hand eye coordination – also known as first person shooters (FPS) – has been found to correlate with better visual attention in both central and peripheral vision, longer sustained visual attention, and faster switching of visual tasks (Green & Bavelier, 2003). Research has further suggested that spatial skill can be improved through FPS games (Uttal et al., 2013). In addition, spatial skills have been found to significantly predict performance in science, technology, engineering, and mathematics (Wai, Lubinski, & Benbow, 2009). This expands the potential for FPS games to improve academic performance. These results suggest that improvements in cognition are possible. In addition, these improvements can potentially lead to benefits in academic performance. Indeed, researchers have examined several SRL related mechanisms in video game players which suggested that video games have the potential to become effective learning environments (O'Neil, Wainess, & Baker, 2005).

Video games and SRL. Researchers have found that strategy games positively predict self-regulation, which they describe as willpower, perseverance and self-control (Gabbiadini & Greitmeyer, 2017). Several researchers have supplemented this finding, suggesting that video games can improve perseverance and focus (Green & Bavelier, 2012; Ventura, Shute, & Zhao, 2013). These improvements may be carried into the classroom setting and improve the ability to self-regulate. Another way to improve SRL is through socialization. Role-playing games can potentially aid individuals in learning social and emotional skills (Gallup & Barbara, 2017). Role-playing games provide an avatar for the players to control and interact with other player-controlled avatars. The avatars are given simple ways to communicate, such as text or icons of faces depicting certain emotions. The ability to interact with other human players and the simple functions for communication may be what allows participants to practice and improve their social and emotional skills (Gallup & Barbara, 2017). The learned social skills can improve their relationship with their mentor to improve help seeking behaviour and potentially develop individualized SRL.

Negative effects of video games. While video games are attractive mediums and can promote skill building, the effects of video games have been in constant debate (Elson & Ferguson, 2014). Contrasting the positive effects of video games, studies have also revealed several negative consequences from video game use that can potentially distract learners from their SRL. One factor contributing to negative consequences is video game violence.

Video game violence. Violent video games often expose players to glorified violence, turning video games into promoters of violent behaviour through learning and imitation (Anderson & Dill, 2000; Fischer, Aydin, Kastenmüller, Frey, & Fischer, 2012). Utilizing various surveys, Anderson and Dill (2000) found that long-term exposure to violent video games was related to a decrease in feelings of safety and an increase in aggressive personality and delinquent behaviours, such as physical violence, verbal assaults vandalism, theft, and destruction of property. Similar effects were also found in fighting games. Fighting games have players control on-screen avatars and fight other players, often creating a violent experience on screen. Frequent playing of these violent video games is related to the development of aggressive personalities, depression, and learning problems (Fischer et al., 2012; Lehenbauer-Baum & Fohringer, 2015; Lemola et al., 2011). This implies that negative effects of violent video games could affect how students learn, and the anti-social behaviour can be a detriment to developing good peer support. Another area that could have a negative effect on learning is video game addiction.

Video game addiction. Video games are attractive sources of entertainment, but when this attraction causes players to ignore other aspects of their lives, it can become a dangerous source of addiction. The World Health Organization (2018) has recognized gaming disorder as a form of substance abuse and has included it in the International Classification of Diseases. The fifth edition of the Diagnostic and Statistical Manual of Mental Disorders (DSM-5) included internet gaming disorder as a disorder that is being considered for entry in a future version of the DSM (American Psychiatric Association [APA], 2013). Internet gaming disorder, also known as gaming disorder by the International Classification of Diseases, is a preoccupation with video games that is negatively affecting an individual's social, vocational, and psychological well-being.

Addicts often find themselves unable to quit the habit of excessive gaming (APA, 2013; World Health Organization, 2018). Indeed, excessive use of video games seems to lead to troubles in school, and possibly depression (Lehenbauer-Baum & Fohringer, 2015; Lemola et al., 2011; Schmitt & Livingston, 2015). Excessive gaming is also related to social isolation. Research on rhythm games has found that unmonitored play in rhythm games is related to low self-esteem and solitary game play (Davies & Hemingway, 2014). Despite a positive relationship with problem-solving skills, research on online role-playing games found that role-playing games can be a source of addiction (Sioni, Burleson, & Bekerian, 2017). Sioni, Burleson, and Bekerian (2017) theorized that role-playing games are addictive because they provide the stable social identify and self-esteem that some would not otherwise find outside of role-playing games. In a separate study looking at university students, it was found that playing strategy games and role-playing games positively correlated with scores of internet gaming disorder (Eichenbaum, Kattner, Bradford, Gentile, & Green, 2015).

Although causality could not be determined, there seems to be a relationship between certain game genres and internet gaming disorder.

Video game genres. Thus far, video games have been associated with academic, metacognitive, and cognitive improvement. However, studies also suggest that video games are related to delinquent behaviour, addiction, and social isolation. These mixed findings indicate that further research is needed to isolate the contributing factors. Many of these studies have defined video games by their respective genres. A more detailed description of video games seems to be needed to isolate video games' effects. In an article by Granic et al. (2014), various gaming genres were characterized based on the dimensions of complexity and sociability. Complexity in video games can be understood as the number of interacting elements. For example, in a strategy game, players control different units that have different skills and attacks. This creates dynamic situations that require vigilance from the player. This, in addition to the various tasks that players must manage, makes strategy games extremely complex. Comparatively, rhythm games sit at the other end of the spectrum. In a rhythm game, players press buttons to the beat of a song. The songs may become faster or the timing of the button presses may become more stringent, but the number of interacting elements is few. Corresponding with the genre's complexity, strategy games seem to be related to several benefits (Adachi & Willoughby, 2013; Gabbiadini & Greitmeyer, 2017), while rhythm games had little to no benefit in skill enhancement (Davies & Hemingway, 2014). Similarly, more social video games, such as role-playing games, showed benefits in learning and social development. Comparatively, fighting games have less opportunities for socialization. This isolation may contribute to the negative influences on their players. Unfortunately, the proposed classification by Granic et al. (2014) is a conceptualized classification without empirical evidence supporting the categorization.

Conclusion from Past Research

SRL is an important skill that improves study quality and study efficiency. Video games have the potential for affecting SRL. While some studies suggest that games can enhance cognitive and metacognitive abilities, others suggest that they can lead to aggression, addiction, and isolation. To better understand the effects of video games, further research is required. While past research has divided video games by genres, this has produced mixed results. It seems that a more specific classification system may be needed. Although conceptual, Granic et al. (2014) provides a classification system that divides video games into more specific traits of complexity and sociability. This classification could be the first step in a more accurate description of video games. Past research seems to suggest that video games are more than their respective genres. A better classification system can help isolate the factors that contribute to the benefits that are possible in video games. The hope is that educators can utilize this knowledge to create entertaining and educational systems that maximize learning potential.

Overview

The current research was divided into two studies. Study 1 was based on Granic, Lobel, and Engels' (2014) conceptual categorization of video game genres on levels of complexity – the extent of cognitive taxation – and sociability – the extent of social interaction accessible in a game. Study 1 attempted to further classify seven video game genres (strategy, role-playing, shooting, racing, puzzle, fighting, and rhythm) by their levels of complexity and sociability. The seven genres were selected based on two criteria. First, the genre must be present in Granic, Lobel, and Eagels' (2014) conceptual categorization of video game genres. Second, there must be past research that has examined each genre. It was hypothesized that the complexity ranking, from most complex to the least complex, would be strategy, role-playing, shooting, fighting, racing, puzzle, then rhythm (Granic et al., 2014). The sociability ranking, from most social to least social, would be role-playing, shooting, fighting, strategy, racing, and puzzle.

Study 2 explored the possible effects that video games have on improving metacognition. This study looked at weekly video game use and video game play with others. It was expected that the relationship between video game use and grade point average (GPA) would be a curvilinear relationship and that metacognition would mediate the interaction. Video game use is expected to improve metacognition which, in turn, will improve GPA. However, excessive use of video games would take time away from completing school assignments and learning. This means a declines in academic performance despite metacognitive improvements (Lehenbauer-Baum & Fohringer, 2015; Lemola et al., 2011; Schmitt & Livingston, 2015). For video game play with others, this study expected to find a linear relationship between social play and academic performance that was mediated by metacognition. In accordance with Ryan et al. (2001) and Zimmerman (2002), it was expected that social play would be a predictor for metacognitive functions. This improvement would be reflected in academic performance. Like video game use, a mediation model was expected for social play where the relationship between social play and GPA would be explained by metacognition. However, unlike video game use, high level of social play was not expected to lead to declining GPA. To explore the impact of complexity and sociability, results from Study 1 were used to aid interpretation of Study 2. Previous research demonstrated varying effects from video game use in different genres (Adachi & Willoughby, 2013; Davies & Hemingway, 2014; Gallup & Barbara, 2017; Stinchcombe et al., 2017). This seems to map on to the complexity ratings by Granic et al. (2014). Based on this, we expected a video game genre's ability to improve metacognition to reflect the ranking of a genre's complexity from Study 1. It was also expected that sociability would share the same mechanism as social play. In summary, video game use of highly complex and highly social genres would benefit metacognition more than less complex and less social genres. It was also expected that this improvement in metacognition would lead to improvements in academic performance.

Study 1

Study 1 examined the complexity and sociability of seven video game genres.

Method

Participants. Participants (*N* = 82) were recruited from social media platforms and various online forums. Posts were made to a social media website called Reddit and various chat forums created by video game companies. Participants were provided with an anonymous link to the survey where they rated the seven video game genres on complexity and sociability. No demographic information was collected.

Procedure. Data were collected using an online data collection platform (www.qualtrics.com). Participants rated the complexity and sociability of the seven video game genres: strategy, role-playing, shooting, racing, puzzle, fighting, and rhythm. The participants responded on a 7-point Likert ranging from 1 (*not complex*) to 7 (*very complex*). The participants took no more than two minutes to answer all the questions.

Statistical Analyses. Study 1 was a within-subjects design where participants rated all seven video game genres on the complexity and sociability of those genres. Considering this, two repeated measures ANOVAs were conducted. One analysis compared the complexity scores between the seven video game genres and the other analysis compared the sociability scores of the video game genres. The Statistical Package for Social Science 17 (SPSS) was used to implement this analysis. Multiple post hoc comparisons were done after each ANOVA using Bonferroni corrections.

Results

Tests of Assumptions. Data were collected from 82 participants. By default, SPSS applies listwise deletion for handling missing data. For listwise deletion to be appropriate, the missing data must be missing completely at random (Little, 1992). Little's MCAR test resulted in a chi-square = 101.39 ($df = 118$, $p = .86$), which indicated that the data was missing completely at random. Listwise deletion method was applied to missing data. The repeated measures ANOVAs were done on the remaining 78 participants. Three outliers were identified from inspection of a box plot. Analyses were conducted with and without the outliers. There were no significant differences between the results; therefore, the results were reported with the outliers included. Normality of distribution was tested by the Shapiro-Wilk test of normality and was found to be violated. Due to the large sample size, the Shapiro-Wilk test may have been overly sensitive. Skewness and kurtosis were inspected instead, revealing abnormal distribution in three variables: complexity ratings of strategy, sociability ratings of shooter, and sociability ratings of puzzle. In large samples, even large deviations from normality do not substantially affect Type I errors (Blanca, Alarcón, Arnau, Bono, & Bendayan, 2017). Therefore, the repeated measures ANOVA was used without transformation of the data. The assumption of sphericity was not met, as assessed by Mauchly's test, for two variables: complexity scores, χ^2 (20) = 63.29, $p < .001$; and sociability scores, χ^2 (20) = 59.48, $p < .001$. Huynh-Feldt was used to correct the repeated measures ANOVA for complexity ($\varepsilon = .86$) and sociability ($\varepsilon = .82$).

Complexity. The analysis revealed a significant difference in complexity ratings among the seven video game genres, $F(4.8, 369.60) = 74.84$, $p < .001$, partial $\eta^2 = .49$. Strategy games had the highest complexity rating (5.89) followed by role-playing (4.76), fighting (4.03), puzzle (3.80), shooting (3.06), rhythm (2.91), then racing games (2.21) (see Figure 1).

Post hoc analyses with a Bonferroni adjustment revealed that each video game genre was significantly different from each other, except for the difference between fighting and puzzle games and the difference between shooting and rhythm games (see Table 1). This suggest that there is agreement in ranking of complexity in video game genres.

Sociability. The analysis revealed that there were significant differences in sociability ratings among the seven video game genres, $F(4.54, 295.10) = 29.10$, $p < .001$, partial $\eta^2 = .31$. Shooting games had the highest sociability rating (5.06) followed by fighting, (4.03), rhythm (3.76), role-playing (3.68), racing (3.46), strategy (3.17), then puzzle games (1.59) (see Figure 2).

Post hoc analyses with a Bonferroni adjustment revealed several genres that were significantly different from the rest (see Table 2). Two genres worth noting are shooting games and puzzle games. Shooting games were rated as having significantly more sociability than every other genre. The difference in average sociability rating between shooting games and fighting games, the next highest on the sociability rating, was 1.03 ± 0.23. Puzzle games were rated as having significantly lower sociability compared to the rest of the genres. The mean difference between puzzle games and strategy games, the next lowest on the sociability rating, was 1.58 ± 0.20. Fighting, rhythm, role-playing, and racing games were not significantly different from each other. However, fighting games were rated significantly higher than strategy games, 0.86 ± 0.25.

Discussion

Complexity. The results of Study 1 suggest that video game genres significantly differed in their complexity. It was hypothesized that the order of complexity from most to least complex would be strategy, role-playing, shooting, fighting, racing, puzzle, then rhythm. The results provided empirical evidence which suggested the order of complexity from most to least complex was strategy, role-playing, fighting, puzzle, shooting, rhythm, and then racing games. While the overall results were as predicted, some of the genres were not ranked as hypothesized. Shooting and racing games were rated as less complex than expected, with racing being rated as least complex. The complexity rating for strategy and role-playing games were as predicted, being the most complex out of the seven genres. In previous research, strategy and role-playing games correlated with problem solving and self-regulation (Adachi & Willoughby, 2013; Gabbiadini & Greitmeyer, 2017). It is possible that the more complex video games could aid metacognition. Study 2 sought to aid in the interpretation of this possibility.

Sociability. The sociability ranking, from most social to least social, was hypothesized to be role-playing, shooting, fighting, strategy, racing, and puzzle. The results did not reflect what was hypothesized. Sociability ratings for first-person shooting games were significantly higher than the rest of the genres. However, past literature did not find correlations between first-person shooters and social skills. This difference may be due to the mechanics of first-person shooting games. In multiplayer first-person shooter games, players must communicate and work as a team with random players. This may make first-person shooter games appear to have high sociability; however, in the fast-pace environment of first-person shooters, players are limited to simple and concise messages to communicate and work as a team. It is possible that this environment, while having sociability, attracts individuals with poorer social skills who do not wish for deeper and more complex interactions with others. It is also possible that the limited options for communication in first-person shooter games does not provide a good environment for developing social skills. Unlike first-person shooting games, role-playing games have mechanics such as in-game chat and options for their avatar to depict certain emotions. This allows for a deeper and broader range of communication options. Research has suggested that these mechanisms are what makes role-playing games an environment for building social skills (Gallup & Barbara, 2017). Despite this, role-playing games were not rated to have high sociability. This may be attributed to many role-playing games having the option for solo play. It would seem the general sociability ratings do not capture enough detail to serve as a useful research indicator. Future studies might look at specific games and how the traits of specific games can affect development.

Study 2

Method

Design. Study 2 was a correlational design, which utilized an online survey to collect demographics, video game use, social play, academic performance, and metacognition. Video game use was recorded for seven video game genres: strategy, role-playing, shooting, racing, rhythm, puzzle, and fighting games. In addition, general video game use was recorded. Academic performance was recorded as cumulative GPA and metacognition was recorded using the Cognitive and Metacognitive Strategies scale (CMS). The purpose of this study was to examine whether video game use and social play can predict use of metacognitive strategies and academic performance. Study 2 was intended to be interpreted with study 1 to address possible connections between game characteristics and learning strategies and outcomes.

Participants. Participants (N = 211) were recruited from Kwantlen Polytechnic University through the university's human research participant program, SONA, and posters which included a QR code for the survey. The majority of the participants were female (n = 138, 81.70%). The participants were between the ages of 18 and 54 with a mean age of 21.81 (SD = 4.38). Most of the participants described their ethnicity as Caucasian/European (38.5%), South Asian (29.6%), or Asian (22.5%). The remainder of the participants (9.5%) described themselves as Central/South American, Middle Eastern, Eurasian, Fijian, Oceanian, or mixed. Participants ranged from 1st year students to 4th year students: First year, n = 59 (34.9%); Second year, n = 49 (29%); Third year, n = 36 (21.3%); Fourth year n = 24 (14.2%). One participant did not report their level of education.

Procedure. After the consent form, the participants were presented with the demographic questionnaire asking about their age, sex, ethnicity, level of education, and their cumulative GPA. Following the demographic questionnaire, participants were presented with the measure of cognitive and metacognitive strategies. Afterwards, the participants were given the video game use questionnaire. Lastly, the participants are asked how much of the video game time is spent playing with others.

Measures.

Video Game Use Questionnaire. The video game use questionnaire consisted of eight questions that ask for participants' video game use in an average week in the past year (VGHours). Participants reported their gaming hours for strategy, role-playing, shooting, racing, puzzle, rhythm, fighting, and their overall gaming hours. The participant responded by moving a slider ranging from 0 hours to 40 hours in one-hour increments. Participants were instructed to move the slider to 40 hours if their use exceeded 40 hours. An additional check box was available for participants who did not know their video game use. Lastly, to measure what proportion of participants' video game use was with their peers (VGSocial), participants were asked the percentage of their time they spent playing video games with others. The participants responded on a slider ranging from 0% to 100% in 1% increments.

Cognitive and Metacognitive Strategies (CMS). The CMS is a scale developed by Pintrich, Smith, García, and McKeachie (1991) and is contained within a larger questionnaire called the Motivated Strategies for Learning Questionnaire (MSLQ). Pintrich et al. (1991) designed the CMS to measure students' use of metacognitive self-regulation and various cognitive and metacognitive strategies: rehearsal, elaboration, organization, critical thinking, and metacognitive self-regulation. Rehearsal is the repetition of information. Although rehearsal influences the encoding of information, it does not make connections between learned and prior information. Elaboration allows new items to be connected in the form of paraphrasing, summarizing, creating analogies, and generative notetaking. Organization is the organization of information to be learned through strategies, such as clustering, and outlining, of main ideas. Critical thinking is the application of previous knowledge to new knowledge through critique and questioning. Metacognitive self-regulation detects behaviours very similar to that of Zimmerman's (2002) cyclical-phase model. In this scale, Pintrich et al. (1991) measured learners' ability to plan the task, monitor its progress, reflect on results, and adjust behaviour based on the results. Pintrich et al. (1991) tested the scale for its internal reliability using Cronbach's alpha. Alpha levels in the CMS range from .64 to .80 (Pintrich et al., 1991). In addition, the CMS was found to significantly correlate with academic performance. From over 375 students, Pintrich et al. (1991) found significant correlations between final grades and each of the CMS subscales with varying degrees of correlation: rehearsal (.05), elaboration (.22), organization (.17), critical thinking (.15), and metacognitive self-regulation (.30). The CMS used in this study is a revised version of the

CMS developed by Pintrich et al. (1991). The questions have been reworded for administration online in a university population. While the original CMS question would refer to a specific class the participant is currently in, revision was made so the questions refer to the participants' classes in general. For example, the question "When I study the readings for this course, I outlined the material to help me organize my thoughts." was changed to "When I study the readings for a course, I outline the material to help me organize my thoughts." Similar changes were made to the questions when necessary, so the questions reference all the participants' courses instead of a specific course. Cronbach's alpha was calculated for each subscale of CMS: rehearsal (α = .598), elaboration (α = .789), organization (α = .652), critical thinking (α = .850), and metacognitive self-regulation (α = .803).

Statistical Analyses. Participants reported their average hours of playing video games in a week (gaming hours), proportion of gaming time played with others (social play, and completed the CMS. SPSS 17 was used to implement several standard multiple regression analyses. This study expected a mediation model. It was hypothesized that video game use improves metacognition and, consequently, improves GPA. To test for this, two sets of regression analyses were implemented. The first set of regressions addressed the hypothesis that video games would improve learners' metacognitive capacity. Five regression analyses were done to determine if gaming hours and social play served as good predictors for each subscale of Rehearsal, Elaboration, Organization, Critical Thinking, and Metacognitive Self-Regulation. The second set of regressions was conducted to test for the mediation model. The first regression was a forced-entry method multiple regression analysis with gaming hours and social play as predictors of GPA. The second regression was conducted with gaming hours, social play, and CMS as predictors of GPA. The two regression models were compared to see if the inclusion of the CMS reduced the predictability of video game use. A reduction in predictability of gaming hours and social play would have supported the mediation model.

Results

Addressing missing data. Data were collected from 211 participants. Two participants were missing data from the video game use questionnaire, as such they were excluded. For participants who had missing data for one or two questions in the video game use questionnaire, it could be inferred that participants who reported 0 hours of total gaming hours would not have played games in any genre. Therefore, available gaming hours in the seven genres were summed and compared to their total gaming hours. If the difference was

1 or 0, the missing values were replaced with zero. Little's MCAR test was run to ensure that listwise deletion was appropriate. The result indicated that the data were not missing completely at random, chi-square = 317.23, $df = 84$, $p < .001$. Further analysis indicated that most of the missing data was from social play ($n = 39$, 18.7% of total sample). The variable with the second most number of missing data was gaming hours for puzzle games ($n = 3$, 1.4% of total sample). Listwise deletion was not implemented. Instead, multiple imputation, then deletion of dependent variables was used to generate the missing data, as recommended by von Hippel (2007). All independent and dependent variables were used as predictors for the missing data. Cases with missing GPA data were deleted after imputation of the other missing data. Variables used in the imputation process were the gaming hours of the seven genres, gaming hours for all video games, and the seven CMS subscales. Twenty imputations were done at default settings on SPSS 17. Analyses was run on the average of all twenty imputations.

Tests of Assumptions. Assumptions of multiple regressions were tested prior to the regression analyses. There was independence of residuals, as assessed by Durbin-Watson statistic (2.13). A visual inspection of a scatter plot of the standardized residuals against the standardized predicted values showed adherence to assumptions of linearity and homoscedasticity. Multicollinearity was assessed by examining Pearson's correlations and the tolerance values. There were no correlation coefficients above .7 and no tolerance values less than .1, therefore no violation of multicollinearity was present. Outliers were determined using standardized residuals, Mahalanobis' distance, Leverage values, and Cook's distance. Standardized residuals did not indicate any outliers. However, Mahalanobis' distance and Leverage values indicated 12 multivariate outliers. Inspection of Cook's distance of these values indicated that the values were not significantly influential. The outliers were kept for the remainder of the analysis. Lastly, the assumption of normality of distribution was met, as assessed by visual inspection of the histogram of standardized residuals. However, inspection of individual distributions revealed that most female participants reported playing 0 hours of video games. This results in a positively skewed distribution of gaming hours in the female population. Gaming hours was compared between men and women. The difference did not significantly affect the results. Therefore, data from both men and women were analysed together.

Predicting metacognition. A series of standard multiple regressions were run using gaming hours of the seven genres, gaming hours for all video games, and social play to predict each subscale of the CMS: rehearsal, elaboration, organization, critical thinking, and metacognitive self-regulation. These analyses addressed the relationship between gaming hours, social play, and metacognition. The means and standard deviations of gaming hours, social play, and CMS scores are displayed in Table 3. The *B* values can be seen in Tables 4-8.

For Rehearsal, the overall regression was significant, $F(10, 198) = 1.97$, $p = .039$, $R^2 = .09$. Two significant predictors were found: gaming hours of strategy games and social play (Table 4).

For Elaboration, the overall regression was significant, $F(10, 198) = 3.68$, $p < .001$, $R^2 = .16$. There were four significant predictors: gaming hours of strategy games, gaming hours of first-person shooter games, gaming hours of fighting games, and gaming hours of rhythm games (Table 5).

For Organization, the overall regression was significant, $F(10, 198) = 2.27$, $p = .016$, $R^2 = .10$. Gaming hours of strategy games was a significant predictor (Table 6).

For Critical Thinking, the overall regression was significant, $F(10, 198) = 4.49$, $p < .001$, $R^2 = .19$. There were four significant predictors: sex (female), gaming hours of first-person shooter games, gaming hours of fighting games, and social play (Table 7).

For Metacognitive Self-regulation the model was significant, $F(10, 198) = 2.80$, $p = .003$, $R^2 = .12$. There were two significant predictors: sex and gaming hours for rhythm games (Table 8).

The power of these models ranged from .718 to .880, as assessed by post hoc power analyses.

Predicting GPA. Two standard multiple regressions were conducted. The hypothesis predicted that GPA would be predicted by gaming hours and social play mediated via metacognition. The predicted relationship was curvilinear; however, the data did not violate the assumption of linearity which suggests that the relationship is indeed linear. A forced-entry multiple regression was conducted to test the mediation model. The first regression contained gaming hours and social play as predictors for GPA. The second regression was run using gaming hours, social play, and CMS as predictors of GPA. The second regression was compared to the first. A decrease in the predictive power of gaming hours and social play after introducing CMS would be evidence support the mediation model. The summary of the mentioned variables can be found in Table 9.

Looking at the first regression, the overall regression was significant, $F(10, 183) = 2.62$, $p = .005$, $R^2 = .13$. However, there were no significant predictors (see Table 10).

The second regression was run with gaming hours of the seven genres, gaming hours for all video games, social play, and CMS. The overall regression was significant, $F(15, 178) = 2.56$, $p = .002$, $R^2 = .178$. However, there were no significant predictors (see Table 11).

The power for these models were .833 and .913 respectively.

Discussion

GPA. The overall mediation model predicted that video gaming hours would demonstrate a curvilinear relationship with GPA. In addition, it was expected that social play would have a positive relationship with GPA. Both relationships were expected to be mediated by metacognition. The regression analyses suggested that metacognition was not a mediator for video game use or social play. Looking at the analyses, it seems that video game use, social play, and metacognition together can predict academic performance. However, each individual predictor was not significant by itself. This makes it hard to discern the direction of the predictions for video game use and social play. Interestingly, the individual CMS scores were also unable to significantly predict academic performance. It is possible that while metacognition does predict cognitive and metacognitive strategy use in SRL, other scales examining various aspects of SRL are needed to predict academic performance.

From the results, it seems that video game use and social play were unable to predict academic performance by themselves. This is interesting because past research has found negative effects and positive effects from video games (Elson & Ferguson, 2014; Granic et al., 2014). Past research has found that video games, socialization, and metacognition would affect an individual's academic performance (Adachi & Willoughby, 2013; Eichenbaum et al., 2014; Lehenbauer-Baum & Fohringer, 2015). However, the results were unable to detect those effects. A possible explanation is that while the data did not violate standards of multicollinearity, the predictor variables do correlate to a certain extent. Graham (2003) found that even low levels of multicollinearity can affect the results of a multiple regression analysis. Since the forced-entry multiple regression does not take shared variance into account, it is possible that the effects were masked due to multicollinearity. This implies that all the variables are correlated to a certain extent. It may be unsurprising that a participant who plays one genre of video games may also play a different genre. Looking at Pearson correlations between the variables, it is apparent that many of the gaming hours for one genre are correlated with gaming hours for another genre and with social play, with correlations as high as .617. Similarly, CMS subscales seem to also correlate with other CMS subscales, with correlations as high as .665. In addition, results from this study hint at a relationship among video game use, social play, and metacognition.

Metacognition. Gaming hours of the seven video game genres, total gaming hours, and social play were used to predict various studying strategies: rehearsal, elaboration, organization, critical thinking, and metacognitive self-regulation. The overall regression for all the regression models was significant. While the effects of individual predictors are small, these results seem to differ from past research. Gabbiadini and Greitmeyer (2017) found that strategy games were correlated with self-regulation. Fighting games were associated with aggression and depression, variables that could distract students from their learning (Fischer et al., 2012; Lehenbauer-Baum & Fohringer, 2015; Lemola et al., 2011).

Adachi and Willoughby (2014) found that strategy games and role-playing games predicted improvements in problem solving skills. Gaming hours for genres, such as strategy, rhythm, and shooting games predicted decreases in using certain studying strategies. However, the coefficients for those genres did not exceed .04. In addition, fighting and role-playing games predicted use of critical thinking and metacognitive self-regulation respectively. However, coefficients for those genres were no higher than .05. The data indicate that gaming hours had little impact on students' implementation of studying strategies. Learners would have to play over 20 hours of video game a week to influence study strategies by a single standard deviation.

Similar results were found for social play. In accordance with Ryan et al. (2001) and Zimmerman (2002) it was expected that social play would predict increases in CMS subscales. Dissimilar to what was expected, social play significantly predicted decreases in rehearsal and critical thinking. Again, the effects were small, with coefficients ranging from -.005 to -.007. Power analyses revealed that the data had sufficient power to detect effects, ranging from .780 to .838. Therefore, the results were not due to low power. A possible explanation for these results is multicollinearity. Although not enough to violate multicollinearity, correlations among the predictors may have masked each other's effects. This interpretation suggests that the effects of video games are not weak and may strongly contradict previous literature.

General Discussion

In summary, it was expected that video games rated high in complexity would best improve metacognition. However, the genre with the highest complexity rating predicted decreases in the metacognitive skills of rehearsal, elaboration, and organization. On the other hand, fighting games, rated as less complex than strategy and role-playing games, predicted increases in elaboration and critical thinking. Sociability ratings revealed little about the relationship between video game use and metacognition. Fighting and role-playing games, which had average sociability ratings, were found to significantly predict the use of elaboration, critical thinking, and metacognitive self-regulation. Other genres predicted decreases in various study strategies.

Complexity and sociability ratings were expected to describe the relationship among video game use, metacognition, and academic achievement. However, this was not the case. While the regression models were significant, the individual predictors were not significant or had low predictive power. It does not indicate that video game use, social play, and metacognition are strong predictors of GPA. One interpretation of these results is that video game use, social play, and metacognition have little effect on academic performance, as measured by GPA. However, that does not exclude video games as potential contributors to academic performance. Past research has found some effect, so it is possible that, under certain conditions, video games do have an impact on players. These mixed results speak for the nature of learning. Learning is a complex process, and much is still unknown. It is unlikely that video games are the factors that tilt the scale between academic success and failure. The mixed results in video game literature is evidence of that.

Limitations

This study had several limitations. The study utilized a survey that was administered through online data collection software. Although online surveys are efficient, they also produce extraneous variables that are hard to control. These can be seen in some of the logical inconsistencies in survey responses. For example, participants who report 0 hours of playing video games in total also reported playing some video games in specific genres. Usually, participants are not actively recording their video game use. A more difficult task of reporting video game use for certain genres may be too specific for many participants. In addition, video game genres can be a subjective classification. Multiple video games can embody multiple genres or only contain certain elements from genres. While many video games have recognized genres, similar classification systems for these games cannot be guaranteed from participants. Another limitation with the study is the design of the video game use questionnaire. In addition to answering the number of hours participants play a week, a box was included for participants to indicate that they do not know their average hours. While this is a convenient option for participants, this increases the chances of encountering missing data. A rough estimate from the participant was likely more accurate than imputed data.

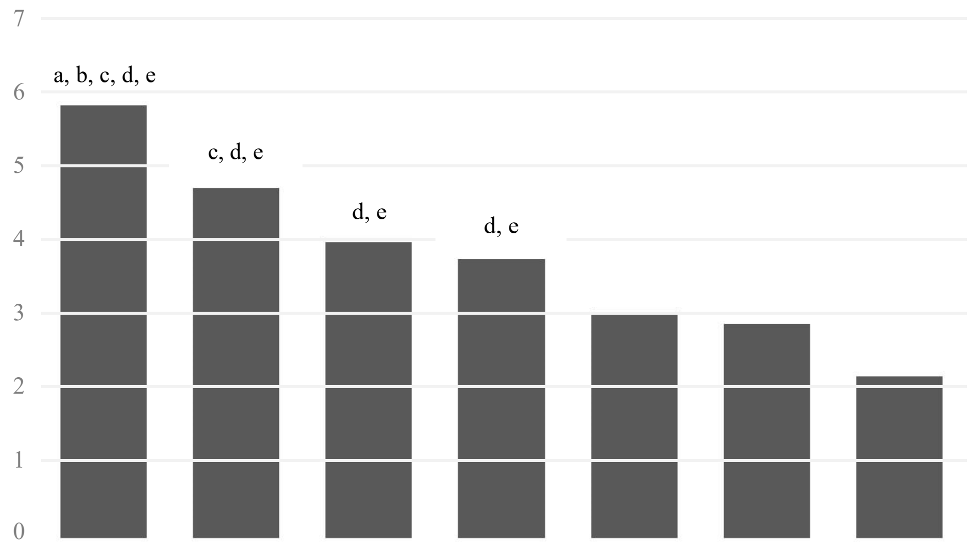
Future Research

At this point, much is still unknown about the effects of video games. While video game use can contribute to a certain extent, it does not seem to be the determining factor for learning behaviour. Dividing video games by genres may not be the best way to approach future research because the categories may be too broad to detect the effects of video games. Future research could benefit from more detailed descriptions of video game characteristics. This can come from more qualitative research that asks participants to describe aspects of video games to compile a distinguishing set of characteristics.

In addition, future research needs to address potential issues with multicollinearity. The results from this study suggested that playing certain video games is correlated with playing other games. Future studies could benefit from introducing more controlled environments where participants are assigned training sessions where they play certain video games for different amounts of time. It would be interesting to see how this intervention would affect players over multiple sessions.

Lastly, about 15 participants reported playing 40 hours of video games, which is almost six hours a day, every day of the week. Due to the small population, this study was unable to examine these participants separately. However, it may be interesting to explore the effects of gaming in this population of avid gamers. This can contribute to research regarding internet gaming disorder.

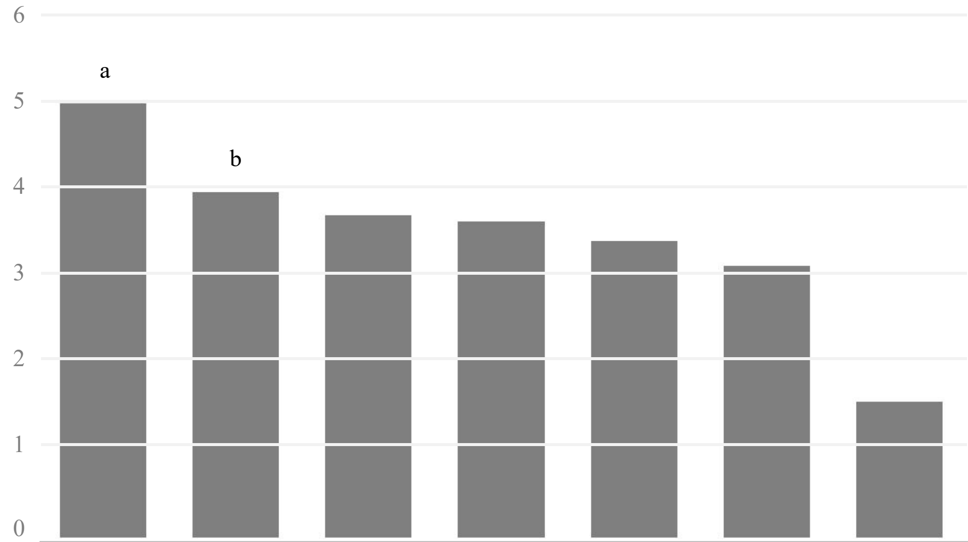
Figures and Tables



	Strategy	RPG	Fighting	Puzzle	Shooter	Rhythm	Racing
Mean	5.89	4.76	4.03	3.80	3.06	2.91	2.21
Std. Deviation	1.13	1.26	1.82	1.49	1.10	1.43	0.93

Figure 1. Means and standard deviations of complexity rating. RPG = RPG game; Fighting = Fighting game; Shooter = First-person shooting game. All genres are significantly different from Racing.

[a]Significantly different from RPG
[b]Significantly different from fighting
[c]Significantly different from puzzle
[d]Significantly different from shooter
[e]Significantly different from rhythm



	Shooting	Fight	Rhythm	RPG	Race	Strategy	Puzzle
Mean	5.06	4.03	3.76	3.68	3.46	3.17	1.59
Std. Deviation	1.51	1.46	2.05	2.08	1.81	1.39	0.94

Figure 2. Means and standard deviations of sociability rating note. RPG = RPG game; Fight = Fighting game; Shooting = First-person shooting game. All genres are significantly different from Puzzle games.

[a]Significantly different from all other genres

[b]Significantly different from strategy

Table 1. *Complexity Score Pairwise Comparison*

Genre	Genre	Mean Difference	Std. Error	Sig
Strategy (5.89)	RPG (4.76)	1.13	.18	.000
	Fight (4.03)	1.86	.21	.000
	Puzzle (3.80)	2.09	.17	.000
	Shoot (3.06)	2.82	.17	.000
	Rhythm (2.91)	2.97	.21	.000
	Race (2.21)	3.68	.14	.000
RPG (4.76)	Fight (4.03)	0.73	.23	.053
	Puzzle (3.80)	0.96	.20	.000
	Shoot (3.06)	1.69	.18	.000
	Rhythm (2.91)	1.85	.21	.000
	Race (2.21)	2.55	.16	.000
Fight (4.03)	Puzzle (3.80)	0.23	.26	1.000
	Shoot (3.06)	0.96	.25	.004
	Rhythm (2.91)	1.12	.26	.001
	Race (2.21)	1.82	.20	.000
Puzzle (3.80)	Shoot (3.06)	0.73	.23	.036
	Rhythm (2.91)	0.89	.20	.001
	Race (2.21)	1.59	.19	.000
Shoot (3.06)	Rhythm (2.91)	0.15	.20	1.000
	Race (2.21)	0.86	.15	.000
Rhythm (2.91)	Race (2.21)	0.71	.19	.006

Note. RPG = RPG game; Fight = Fighting game; Shoot = First-person shooting game

Table 2. *Sociability Rating Pairwise Comparison*

Genre	Genre	Mean Difference	Std. Error	Sig
Shooting (5.06)	Fight (4.03)	1.03	.23	.001
	Rhythm (3.76)	1.30	.31	.001
	RPG (3.68)	1.38	.30	.001
	Race (3.46)	1.61	.28	.000
	Strategy (3.17)	1.89	.20	.000
	Puzzle (1.59)	3.47	.23	.000
Fight (4.03)	Rhythm (3.76)	0.27	.28	1.000
	RPG (3.68)	0.35	.33	1.000
	Race (3.46)	0.58	.26	.569
	Strategy (3.17)	0.86	.25	.020
	Puzzle (1.59)	2.44	.20	.000
Rhythm (3.76)	RPG (3.68)	0.08	.38	1.000
	Race (3.46)	0.30	.26	1.000
	Strategy (3.17)	0.59	.28	.857
	Puzzle (1.59)	2.17	.27	.000
RPG (3.46)	Race (3.46)	0.23	.34	1.000
	Strategy (3.17)	0.52	.31	1.000
	Puzzle (1.59)	2.09	.28	.000
Race (3.68)	Strategy (3.17)	0.29	.26	1.000
	Puzzle (1.59)	1.86	.24	.000
Strategy (3.17)	Puzzle (1.59)	1.58	.20	.000

Note. RPG = RPG game; Fight = Fighting game; Shooting = First-person shooting game

Table 3. *Mean and Standard Deviation of GPA with VGHours, VGSocial, and CMS*

	Mean	*SD*	Minimum	Maximum	N
Strategy[a]	4.07	8.70	0	40	194
Shoot[a]	3.73	8.76	0	40	194
RPG[a]	6.52	11.33	0	40	194
Racing[a]	4.73	8.18	0	40	194
Puzzle[a]	8.21	10.97	0	40	194
Fight[a]	3.42	8.00	0	40	194
Rhythm[a]	4.23	8.02	0	40	194
Total[a]	10.36	12.89	0	40	194
VGSocial	33.02	33.10	0	100	194
Rehearsal	5.32	1.09	1	7	194
Elaboration	5.06	1.15	1	7	194
Organization	4.73	1.22	1	7	194
Critical	4.11	1.35	1	7	194
Metacog	4.51	0.95	2	7	194
GPA	3.10	0.57	1.17	4.17	194

Note. RPG = RPG game; Fight = Fighting game; Shoot = First-person shooting game; VGSocial = Proportion of video game play with others, social play.

[a]Values are hours per week

Table 4. *Multiply Imputed Multiple Regression Predicting Rehearsal*

	Coefficients				
Predictor	*B*	*SE**B*	β	*T*	95% CI for *B*
(Constant)	5.27	.47		11.17***	[4.34, 6.20]
Sex	0.18	.24	.06	0.78	[-0.28, 0.65]
Strategy	-0.03	.01	-.28	-2.30*	[-0.05, -0.00]
Shoot	0.00	.01	.02	0.19	[-0.02, 0.03]
RPG	-0.01	.01	-.05	-0.57	[-0.02, 0.01]
Racing	0.01	.01	.10	1.01	[-0.01, 0.04]
Puzzle	-0.02	.01	-.18	-1.96	[-0.04, 0.00]
Fight	0.00	.01	.03	0.30	[-0.02, 0.03]
Rhythm	0.00	.01	-.00	-0.05	[-0.02, 0.02]
Total	0.01	.01	.09	0.94	[-0.01, 0.03]
VGSocial	-0.01	.00	-.16	-2.07*	[-0.01, 0.00]

Note. Model summary: $F(10, 198) = 1.97$, $p = .039$, $R^2 = .09$. RPG = RPG game; Fight = Fighting game; Shoot = First-person shooting game; VGSocial = Proportion of video game play with others, social play.
*$p < .05$ **$p < .01$ ***$p < .001$

Table 5. *Multiply Imputed Multiple Regression Predicting Elaboration*

	Coefficients				
Predictor	*B*	SE_B	β	*T*	95% CI for *B*
(Constant)	5.75	.48		12.01***	[4.80, 6.69]
Sex	-0.32	.24	-.11	-1.35	[-0.79, 0.15]
Strategy	-0.03	.01	-.23	-2.66**	[-0.05, 0.01]
Shoot	-0.03	.01	-.22	-2.26*	[-0.05, -0.00]
RPG	0.01	.01	.07	0.88	[0.01, 0.02]
Racing	-0.01	.01	-.06	-0.60	[-0.03, 0.02]
Puzzle	0.01	.01	.12	1.43	[-0.01, 0.03]
Fight	0.03	.02	.23	2.27*	[-0.00, 0.06]
Rhythm	-0.04	.01	-.30	-3.65***	[-0.07, 0.02]
Total	0.01	.01	.11	1.17	[-0.01, 0.03]
VGSocial	0.00	.00	.01	-0.18	[-0.01, 0.01]

Note. Model summary: $F(10, 198) = 3.68$, $p < .001$, $R^2 = .16$. RPG = RPG game; Fight = Fighting game; Shoot = First-person shooting game; VGSocial = Proportion of video game play with others, social play.
*$p < .05$ **$p < .01$ ***$p < .001$

Table 6. *Multiply Imputed Multiple Regression Predicting Organization*

		Coefficients			
Predictor	*B*	*SE_B*	β	*T*	95% CI for *B*
(Constant)	5.18	.52		9.90***	[4.15, 6.21]
Sex	-0.14	.26	-.04	-0.52	[-0.65, 0.38]
Strategy	-0.03	.01	-.20	-2.24*	[-0.05, -0.00]
Shoot	-0.03	.01	-.19	-1.87	[-0.05, 0.00]
RPG	0.00	.01	-.03	-0.30	[-0.02, 0.02]
Racing	0.01	.02	.05	0.49	[-0.02, 0.04]
Puzzle	0.01	.01	.07	0.81	[-0.01, 0.03]
Fight	0.02	.02	.22	1.21	[-0.01, 0.05]
Rhythm	-0.01	.01	-.09	-1.04	[-0.04, 0.01]
Total	0.01	.01	.08	0.85	[-0.01, 0.03]
VGSocial	-0.01	.00	-.14	-1.86	[-0.01, 0.00]

Note. Model summary: $F(10, 198) = 2.27$, $p = .016$, $R^2 = .10$. RPG = RPG game; Fight = Fighting game; Shoot = First-person shooting game; VGSocial = Proportion of video game play with others, social play.
$^*p < .05$ $^{**}p < .01$ $^{***}p < .001$

Table 7. *Multiply Imputed Multiple Regression Predicting Critical Thinking*

		Coefficients			
Predictor	*B*	*SE_B*	β	*T*	95% CI for *B*
(Constant)	6.42	.55		11.68***	[5.34, 7.50]
Sex	-1.18	.27	-.33	-4.31***	[-1.72, -0.64]
Strategy	-0.00	.01	-.02	-0.22	[-0.03, 0.02]
Shoot	-0.03	.01	-.21	-2.20*	[-0.06, -0.00]
RPG	0.00	.01	.03	0.40	[-0.02, 0.02]
Racing	-0.02	.02	-.15	-1.58	[-0.06, 0.01]
Puzzle	0.02	.01	.12	1.42	[-0.01, 0.04]
Fight	0.05	.02	.28	2.80**	[0.01, 0.08]
Rhythm	-0.02	.01	-.13	-1.62	[-0.08, 0.01]
Total	0.01	.01	.11	1.13	[-0.14, 0.03]
VGSocial	-0.01	.00	-.17	-2.43*	[-0.11, -0.00]

Note. Model summary: $F(10, 198) = 4.49$, $p < .001$, $R^2 = .19$. RPG = RPG game; Fight = Fighting game; Shoot = First-person shooting game; VGSocial = Proportion of video game play with others, social play.
$^*p < .05$ $^{**}p < .01$ $^{***}p < .001$

Table 8. *Multiply Imputed Multiple Regression Predicting Metacognitive Self-regulation*

	Coefficients				
Predictor	*B*	*SE*$_B$	β	*T*	95% CI for *B*
(Constant)	5.89	.40		14.59***	[5.09, 6.68]
Sex	-0.66	.20	-.26	-3.26**	[-1.05, -0.26]
Strategy	-0.01	.01	-.10	-1.15	[-0.03, 0.01]
Shoot	-0.01	.01	.06	-0.55	[-0.03, 0.02]
RPG	0.01	.01	.13	1.48*	[-0.00, 0.03]
Racing	0.01	.01	.07	0.69	[-0.01, 0.03]
Puzzle	0.01	.01	.10	1.08	[-0.01, 0.02]
Fight	0.01	.01	.10	0.91	[-0.01, 0.04]
Rhythm	-0.02	.01	-.17	-2.03*	[-0.04, 0.00]
Total	-0.01	.01	-.16	-1.68	[-0.03, 0.00]
VGSocial	-0.00	.00	-.12	-1.55	[-0.01. 0.00]

Note. Model summary: $F(10, 198) = 2.80$, $p = .003$, $R^2 = .12$. RPG = RPG game; Fight = Fighting game; Shoot = First-person shooting game; VGSocial = Proportion of video game play with others, social play.
*$p < .05$ **$p < .01$ ***$p < .001$

Table 9. *Mean and Standard Deviation of GPA with VGHours, VGSocial, and CMS*

	Mean	*SD*	Minimum	Maximum	*N*
Strategy[a]	4.07	8.70	0	40	194
Shoot[a]	3.73	8.76	0	40	194
RPG[a]	6.52	11.33	0	40	194
Racing[a]	4.73	8.18	0	40	194
Puzzle[a]	8.21	10.97	0	40	194
Fight[a]	3.42	8.00	0	40	194
Rhythm[a]	4.23	8.02	0	40	194
Total[a]	10.36	12.89	0	40	194
VGSocial	33.02	33.10	0	100	194
Rehearsal	5.32	1.09	1	7	194
Elaboration	5.06	1.15	1	7	194
Organization	4.73	1.22	1	7	194
Critical	4.11	1.35	1	7	194
Metacog	4.51	0.95	2	7	194
GPA	3.10	0.57	1.17	4.17	194

Note. RPG = RPG game; Fight = Fighting game; Shoot = First-person shooting game; VGSocial = Proportion of video game play with others, social play.
[a]Values are hours per week

Table 10. *Multiply Imputed Multiple Regression Predicting GPA with VGHours and VGSocial*

	Coefficients				
Predictor	*B*	SE_B	*β*	*T*	95% CI for *B*
(Constant)	3.28	.25		13.24***	[2.79, 3.77]
Sex	-0.08	.12	-0.06	-0.68	[-0.33, 0.16]
Strategy	-0.01	.01	-0.09	-1.00	[-0.02, 0.01]
Shoot	-0.00	.01	-0.02	-0.23	[-0.02, 0.01]
RPG	0.01	.01	0.12	1.35	[-0.00, 0.02]
Racing	-0.01	.01	-0.07	-0.75	[-0.02, 0.01]
Puzzle	-0.00	.01	-0.04	-0.44	[-0.01, 0.01]
Fight	-0.01	.01	-0.17	-1.54	[-0.03, 0.00]
Rhythm	-0.01	.01	-0.15	-1.77	[-0.03, 0.00]
Total	0.01	.01	0.11	1.09	[-0.00, 0.01]
VGSocial	0.00	.00	0.07	0.86	[-0.00, 0.00]

Note. Model summary: $F(10, 183) = 2.62$, $p = .005$, $R^2 = .13$. RPG = RPG game; Fight = Fighting game; Shoot = First-person shooting game; VGSocial = Proportion of video game play with others, social play.
$^*p < .05$ $^{**}p < .01$ $^{***}p < .001$

Table 11. *Multiply Imputed Multiple Regression Predicting GPA with VGHours, VGSocial, and CMS*

	Coefficients				
Predictor	*B*	SE_B	*β*	*T*	95% CI for *B*
(Constant)	2.55	.39		6.51***	[1.78, 3.32]
Sex	0.02	.13	-0.01	-0.15	[-0.28, 0.24]
Strategy	-0.01	.01	-0.07	-0.70	[-0.02, 0.01]
Shoot	0.00	.01	0.02	0.23	[-0.01, 0.02]
RPG	0.00	.01	0.08	0.90	[-0.01, 0.01]
Racing	-0.01	.01	-0.07	-0.71	[-0.02, 0.01]
Puzzle	-0.00	.01	-0.08	-0.88	[-0.01, 0.01]
Fight	-0.02	.01	-0.20	-1.82	[-0.03, 0.00]
Rhythm	-0.01	.01	-0.09	-1.01	[-0.02, 0.01]
Total	0.01	.01	0.12	1.17	[-0.00, 0.02]
VGSocial	0.00	.00	0.06	0.74	[-0.00, 0.00]
Rehearsal	-0.02	.04	-0.05	-0.56	[-0.11, 0.06]
Elaboration	0.09	.06	0.18	1.60	[-0.02, 0.21]
Organization	0.00	.04	-0.00	-0.01	[-0.09, 0.09]
Critical	-0.01	.04	-0.02	-0.21	[-0.09, 0.07]
Metacog	0.07	.07	0.11	1.05	[-0.06, 0.20]

Note. Model summary: $F(15, 178) = 2.56$, $p = .002$, $R^2 = .18$. RPG = RPG game; Fight = Fighting game; Shoot = First-person shooting game; VGSocial = Proportion of video game play with others, social play; Critical = Critical thinking; Metacog = Metacognitive self-regulation.
$^*p < .05$ $^{**}p < .01$ $^{***}p < .001$

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Appendix A: Consent form for study 1

Informed Consent

Title of Research Project: Rating of sociability and complexity of videogame genre

Principal Investigator: Shih-Chieh, Chen
Supervisor: Dr. Jocelyn Lymburner

Voluntary participation:
Your participation in this research project is completely voluntary. You have the right to withdraw from the research study at any point during your session. If you choose to do so we will not use your data for our research. If you have any questions, you may email the researcher listed below.

This informed consent page explains the research study you are being asked to join. Please review this page carefully.

Purpose of Research Project: The purpose of this project is to see if genres of video games can be categorized into characteristics. This is the first study to a series of two studies. The details of the study can be found at the end of this survey. Additionally, you may email the principal investigator if you have any questions.

Procedures: If you choose to participate today, we will ask you to fill out a questionnaire. Asking you to rate various characteristics of your gaming. The task will take no more than 5 mins.

Risks of harm/Discomforts/Inconvenience: This study is considered "minimal risk," there are no anticipated risks of harm, discomfort, or inconvenience.

Benefits: This project will help us further characterize video games and potentially attribute those characteristics to cognitive effects.

Confidentiality: We will encrypt all the data received and only researchers who are involved in the study will have access to the data files. Your name will not be associated with the data in any way.

Persons to Contact: If you have any other questions about the study, you should contact the principal investigator, Shih-Chieh (Jack), Chen at jack.chen4@email.kpu.ca. Once you have read this document, please press continue if you agree to take part in the study. By consenting, participants have not waived any rights to legal recourse in the event of research-related hardship.

Appendix B: Consent form for study 2

Informed Consent

Title of Research Project: Bridging the gap between learning and fun: Relationship between videogaming use and self-regulated learning

Principal Investigator: Shih-Chieh, Chen
Supervisor: Dr. Jocelyn Lymnburner

Application #

Voluntary participation:
Your participation in this research project is completely voluntary. You have the right to withdraw from the research study at any point during your session. If you choose to do so and we will not use your data for our research. Even if you do not want to join the study or if you withdraw from the study, you will still receive the same quality of instruction, benefits, and opportunities. Your decision also will not jeopardize your grades or studies. You should email principal investigator listed below any questions you may have about this research study. You may ask him/her questions in the future if you do not understand something that is being done.

This informed consent page explains the research study you are being asked to join.
Please review this page carefully.

Purpose of Research Project: The purpose of this study is to examine the effects of video games on learning. Specifically, a student's ability to regulate their own learning, coined self-regulated learning. Metacognition, or the ability to regulate cognition and knowledge about cognition, have been linked to important aspects of self-regulated learning. We wish to look at seven genres of video games (strategy, RPG, shooting, puzzle and fighting games) to see if games that require planning (strategy, RPG) would benefit metacognition. Also, we like to see if strategy, and RPG games affect metacognition different from shooting, puzzle, and fighting games.

Procedures: If you choose to participate today, we will ask you to fill out some questionnaires. There will be questions regarding your demographics, gaming habits and studying habits. You'll have the option to skip any of these questionnaires. Lastly, we will as for your in-game identification for four different games: Overwatch, Starcraft 2, and League of Legends. If you do not play these games, or do not wish to share your in-game identification, you'll have the option to skip any of the questions. The task will take no more than 30 mins.

Risks of harm/Discomforts/Inconvenience: This study is considered "minimal risk," there are no anticipated risks of harm, discomfort or inconvenience.
Benefits: There are broader societal and academic benefit that stem from your participation in this research. Video games are a past time for many individuals. It is important to understand the benefits and harm that video games can have on others. This finding is

especially important for developing children because they are at an important stage of their development and many play video games as a form of leisure. The results can contribute to programs that maximizes the benefits and reduces the harms commercial video game has on individuals. To thank you for your participation, you will receive 0.5% bonus marks for a course through the KPU Psychology Participant pool. Only courses that are part of the Pool are eligible to receive credits. Also, you will be entered into a draw for a 50$ gift visa gift card.

Confidentiality: We will encrypt all the data received and only researchers who are involved in the study will have access to the data files. Your name will not be associated with the data in any way.

Persons to Contact: If you want to talk to anyone about this research study because you think you have not been treated fairly or think you have been hurt by joining the study, or you have any other questions about the study, you should contact the principal investigator, Shih-Chieh (Jack), Chen at jack.chen4@email.kpu.ca.

Once you have read this document, please press continue if you agree to take part in the study. By consenting, participants have not waived any rights to legal recourse in the event of research-related hardship.

Appendix C: Participant rating of genre complexity

Questions

1) How complex would you rate a typical strategy game (StarCraft, Command and Conquer, Civilization)?
2) How complex would you rate a typical shooter game (Counterstrike, Half-life, Doom, Team Fortress)?
3) How complex would you rate a typical role-playing (RPG) game (The Elder Scrolls, The Witcher, World of Warcraft, Final Fantasy)?
4) How complex would you rate a typical racing game (Need for Speed, Gran Turismo, Super Mario Kart, Forza Motorsport)?
5) How complex would you rate a typical puzzle game (Tetris, Portal, Limbo, Candy Crush, Bejeweled)?
6) How complex would you rate a typical fighting game (King of Fighters, Street Fighter, Injustice, Tekken, Mortal Kombat)?
7) How complex would you rate a typical rhythm game (Dance Dance Revolution, Guitar Hero)?

Possible responses

N/A	1	2	3	4	5	6	7
Don't Know	Not Complex			Moderately Complex			Very Complex

8) How would you rate the extent of social interaction of a typical strategy game (StarCraft, Command and Conquer, Civilization)?
9) How would you rate the extent of social interaction of a typical strategy game (StarCraft, Command and Conquer, Civilization)?
10) How would you rate the extent of social interaction of a typical role-playing (RPG) game (The Elder Scrolls, The Witcher, World of Warcraft, Final Fantasy)?
11) How would you rate the extent of social interaction of a typical racing game (Need for Speed, Gran Turismo, Super Mario Kart, Forza Motorsport)?
12) How would you rate the extent of social interaction of a typical puzzle game (Tetris, Portal, Limbo, Candy Crush, Bejeweled)?
13) How would you rate the extent of social interaction of a typical fighting game (King of Fighters, Street Fighter, Injustice, Tekken, Mortal Kombat)?
14) How would you rate the extent of social interaction of a typical rhythm game (Dance Dance Revolution, Guitar Hero)?

Possible responses

N/A	1	2	3	4	5	6	7
Don't Know	Non-Social			Moderately Social			Social

Appendix D: Demographics Questionnaire

1. Age:

2. Sex:
    a. Male
    b. Female
    c. Something else, specify:__________

3. Ethnicity:
    a. Caucasian/European
    b. Indigenous (First Nations, Inuit, Metis, Native American)
    c. Asian
    d. South Asian
    e. African
    f. Middle Eastern
    g. Central/South American
    h. Something else, specify:_________
4. Level of Education:
    a. 1 – 1st year undergraduate
    b. 2 – 2nd year undergraduate
    c. 3 – 3rd year undergraduate
    d. 4 – 4th year undergraduate
    e. 5 – Graduate school

5. What is your cumulative GPA?

Appendix E: Video game Use Questionnaire

1) Recently, how many hours did you spend playing strategy games (StarCraft, Command and Conquer, Civilization) per week on average?
2) Recently, how many hours did you spend playing first-person shooter (Counterstrike, Half-life, Doom, Team Fortress) games per week on average?
3) Recently, how many hours did you spend playing role-playing games (The Elder Scrolls, The Witcher, World of Warcraft, Final Fantasy) per week on average?
4) Recently, how many hours did you spend playing racing games (Need for Speed, Gran Turismo, Super Mario Kart, Forza Motorsport) per week on average?
5) Recently, how many hours did you spend playing puzzle games (Tetris, Portal, Limbo, Candy Crush, Bejeweled) per week on average?
6) Recently, how many hours did you spend playing fighting games (King of Fighters, Street Fighter, Injustice, Tekken, Mortal Kombat) per week on average?
7) Recently, how many hours did you spend playing rhythm games (Dance Dance Revolution, Guitar Hero) per week on average?
8) Recently, how many hours did you spend playing video games per week on average?

<u>Possible responses</u>

Participants respond on a slider ranging from 0 to 40 hours in 1 hour increments. Particpants are instructed to slide the slider to 40 if they play for more than 40 hours a week.

9) Across all videogame genres, about what precentage of your videogame playtime is played with others?

<u>Possible responses</u>

Participant respond on a slider ranging from 0 to 100 in 1 unit increments. Participants have a Not Applicable option.

Appendix F: MSLQ’s Learning Strategy Scale

MSLQ Learning Strategies Scale

The final score is the mean of all the questions

1. When I study the readings for a course, I outline the material to help me organize my thoughts.
2. During class time I often miss important points because I'm thinking of other things. (REVERSED)
3. When reading for a course, I make up questions to help focus my reading.
4. I often find myself questioning things I hear or read in a course to decide if I find them convincing.
5. When I study for a class, I practice saying the material to myself over and over.
6. When I become confused about something I'm reading for a class, I go back and try to figure it out.
7. When I study for a course, I go through the readings and my class notes and try to find the most important ideas.
8. If course materials are difficult to understand, I change the way I read the material.
9. When studying for a class, I read my class notes and the course readings over and over again.
10. When a theory, interpretation, or conclusion is presented in class or in the readings, I try to decide if there is good supporting evidence.
11. I make simple charts, diagrams, or tables to help me organize course material.
12. I treat course materials as a starting point and try to develop my own ideas about it.
13. When I study, I pull together information from different sources, such as lectures, readings, and discussions.
14. Before I study new course material thoroughly, I often skim it to see how it is organized.
15. I ask myself questions to make sure I understand the material I have been studying in a class.
16. I try to change the way I study in order to fit the course requirements and instructor's teaching style.
17. I often find that I have been reading for class but don't know what it was all about. (REVERSED)
18. I memorize key words to remind me of important concepts.
19. I try to think through a topic and decide what I am supposed to learn from it rather than just reading it over when studying.

20. I try to relate ideas in one subject to those in other courses whenever possible.

21. When I study for a course, I go over my class notes and make an outline of important concepts.

22. When reading for a class, I try to relate the material to what I already know.

23. I try to play around with ideas of my own related to what I am learning in a course.

24. When I study for a course, I write brief summaries of the main ideas from the readings and the concepts from the lectures.

25. I try to understand the material in a class by making connections between the readings and the concepts from the lectures.

26. Whenever I read or hear an assertion or conclusion in class, I think about possible alternatives.

27. When studying for a course, I make lists of important terms and memorize the lists.

28. When studying for a course I try to determine which concepts I don't understand well.

29. When I study for a class, I set goals for myself in order to direct my activities in each study period.

30. If I get confused taking notes in class, I make sure I sort it out afterwards.

31. I try to apply ideas from course readings in other class activities such as lecture and discussion.

<u>Possible Responses</u>

1	2	3	4	5	6	7
Not at all true of me						Very true of me

Appendix G: Debriefing form for study 1

Thank you for your participation today. We really appreciate your involvement in the study. This form will provide background information on the study that we are conducting today.

In your task, you rated a number of gaming genres on their complexity. The purpose of this survey was to see if we can establish some order of complexity among the different genres. We theorize that playing video game of genres that are more complex can improve an individual's metacognition, the ability to regulate cognition and knowledge about cognition. This in turn can improve an individual's ability to self-regulated their learning which have shown to improve people's academic performance. We also hypothesize that over use of any genre of video game can negatively affect an individual's academic performance. In a follow up study, we will be measuring peoples amount of video game use and their metacognitive abilities to attempt to unravel these questions.

If you have any questions or concerns regarding the study, feel free to e-mail Shih-Chieh (Jack), Chen at jack.chen4@email.kpu.ca.

If you would like to receive that results regarding the study, please enter your email below:

Appendix H: Debriefing form for study 2

Thank you for your participation today. We really appreciate your involvement in the study. This form will provide background information on the study that we are conducting today.

In your task, you answered a number of questions. Other than the demographic questions, some of those questions were used to determine the amount of your video game use. The other questions were to assess your metacognition, or the ability to regulate cognition and knowledge about cognition. In a previous study, we asked participants to rate a number of video game genres on their complexity rating. The purpose of this was to see if we can establish some order of complexity among the different genres. We theorize that playing video game of genres that are more complex can improve an individual’s metacognition, the ability to regulate cognition and knowledge about cognition. This in turn can improve an individual’s ability to self-regulated their learning which have shown to improve people’s academic performance. We also hypothesize that over use of any genre of video game can negatively affect an individual’s academic performance. In a follow up study, we will be measuring peoples amount of video game use and their metacognitive abilities to attempt to unravel these questions.

If you have any questions or concerns regarding the study, feel free to e-mail Shih-Chieh (Jack), Chen at jack.chen4@email.kpu.ca.

If you would like to receive that results regarding the study, please enter your email below: