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The predictive role of cognitive flexibility in 21st century skills among esports players

Alp Kaan Kilci [a,*], Zekeriya Göktaş [b]

[a] Department of Sport Management, Faculty of Sport Science, Balikesir University, Balikesir, Turkey
[b] Department of Physical Education and Sport, Faculty of Sport Science, Balikesir University Balikesir, Turkey

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ABSTRACT

This paper presents the role of cognitive flexibility in predicting 21st century skills among esports players. Based on survey data collected from 591 players of esports games selected from among the ten most widely played by worldwide, the study explores how cognitive flexibility relates to key competencies such as digital literacy, innovation, leadership, and career consciousness. The research is guided by two research questions: (1) *To what extent does cognitive flexibility predict 21st century skill development in esports players?* and (2) *Does the frequency of gaming influence this prediction?* The results indicate that cognitive flexibility is a significant predictor of information technology literacy, entrepreneurial thinking, and leadership, particularly among those with higher weekly gaming frequency. However, no meaningful association was found between cognitive flexibility and critical thinking/problem-solving skills, suggesting that team-based gameplay dynamics may limit individual-level cognitive reflection. The findings highlight esports as a potent environment for developing transferable competencies and emphasize the importance of cognitive flexibility as both an outcome and enabler of skill acquisition in digital contexts. An integrative framework is proposed for understanding how gameplay experiences translate into real-world readiness. Future research should focus on designing targeted interventions to enhance cognitive flexibility within competitive gaming settings.

1. Introduction

In recent years, video games, which have become particularly popular among young people and emerging adults [1] have led to the emergence of the concept of esports; a professional and competitive gaming environment where teams or individuals compete against each other through a video game [2]. With the increasing popularity of esports, organizations featuring live sports competitions and commentary are being held under the sponsorship of major companies. These events are watched by a large audience both at the venue and through online streaming platforms such as Twitch and YouTube [3]. This shows that esports is distinct from traditional sports because it is closely linked to information and communication technologies. Extending beyond its technological infrastructure, esports offers a distinctive context for exploring diverse psychological and cognitive constructs. Previous studies focused on the cognitive demands of competitive gaming, revealing associations with enhanced attentional control [4], rapid decision-making [5], and problem-solving [6]. In parallel, the inherently social and collaborative nature of many esports titles facilitates the development of interpersonal skills, team coordination, and strategic communication, distinguishing esports as a fertile ground for investigating human performance in digital competitive contexts [7,8]. Furthermore, esports activities are connected to daily life and serve as preparation for real-world experiences. This contributes to the development of socialization, collaboration and leadership skills [1].

It should be emphasized once again that video games are not just for entertainment but also contribute to the development of various skills in players. video games highlight players' socialization, communication, and collaboration skills [9]. In particular, multiplayer online games allow individuals to socialize and interact in real time with thousands of other players [10]. These games require individuals to integrate, analyze, evaluate information, and engage in critical thinking and problem-solving, thereby helping players acquire 21st century skills that can be transferred to real-life situations [11,12]. In accordance video games games promote skills closely aligned with 21st century competencies, examining how esports environments activate specific cognitive processes has become an important focus of contemporary research.

While previous studies have demonstrated that esports can enhance

* Corresponding author at: Faculty of Sport Science-Balikesir University, Balikesir 10100, Turkey.
E-mail addresses: alpkaankilci@balikesir.edu.tr (A.K. Kilci), zgoktas@balikesir.edu.tr (Z. Göktaş).

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various mental competencies, they often lack clarity on the specific cognitive or psychological mechanisms involved and how these contribute to broader competencies such as 21st century skills. Addressing this gap, the present study highlights cognitive flexibility as a key mechanism, offering a novel framework that integrates cognitive psychology with esports. This study is expected to provide critical insights into how cognitive flexibility contributes to the development of essential life skills. Moreover, the growing importance of such skills is not limited to the context of esports; it is also reinforced by rapid technological advancements and shifting societal expectations in the digital age.

The rapid development of technology not only changes and transforms individual habits but also impacts social structures [13]. Contemporary societies are defined as "knowledge societies" [14]. These changes necessitate that individuals possess various attributes. Especially in developed countries, individuals are expected to have flexible thinking, interpersonal communication, and technological skills [15]. Today, there is a growing need for individuals who can generate new ideas and information and possess technology usage skills, highlighting the necessity for individuals to enhance their knowledge and skills to succeed [16,17]. In these developments, skills such as information technology, collaboration, communication, social responsibility, creativity, innovation, critical thinking, and problem-solving are of vital importance in the fast and continuously changing world of the 21st century. These skills enable individuals to cope with complex and uncertain situations, develop new ideas, and produce effective solutions. The literature identifies various skills that individuals must possess to succeed in life as "21st Century Skills" [18]. Recent studies suggests that esports serves as an effective context for the development of core 21st century skills, particularly collaboration [19–21], problem-solving [22], and creative thinking. Several studies have demonstrated that the dynamic and cognitively demanding nature of competitive gaming environments fosters teamwork and communication skills through sustained cooperative engagement [23]. Additionally, the requirement to devise novel strategies, adapt to unpredictable in-game situations, and approach challenges from multiple perspectives highlights the role of esports in enhancing creative thinking abilities [24]. The fast-paced, complex decision-making processes that characterize esports gameplay also promote flexible problem-solving and innovation, reinforcing the idea that such digital environments can facilitate the acquisition of transferable cognitive and social competencies relevant to contemporary academic and professional domains.

Cognitive flexibility is defined as an individual's ability to restructure knowledge in an adaptable manner according to changing conditions [25]. In the 21st century, individuals are expected to question problems and evaluate events from different perspectives in response to changing circumstances. The "cognitive" aspect of cognitive flexibility refers to the retrieval of prior knowledge from memory during the acquisition of information, while "flexibility" refers to the ability to apply this knowledge flexibly in diverse situations [26]. Thus, cognitive flexibility is considered to play a significant role in the development of such skills. In this context, cognitive flexibility is an important attribute that helps individuals perform multiple tasks and find new, adaptable solutions to changing demands [27]. The ability to modify previous beliefs or habits in line with objectives indicates cognitive flexibility. Difficulties in changing habits and beliefs may stem from a lack of cognitive flexibility or responsiveness. Individuals who are not cognitively flexible often struggle when activities or processes change and fail to adapt to new situations. In summary, cognitive flexibility can be defined as the ability to devise the most suitable solutions to changing circumstances and problems while adapting to new situations. Given its role in adapting to dynamic and complex environments, cognitive flexibility becomes particularly relevant in performance domains such as esports.

Therefore, the cognitive skills and levels of flexibility of esports athletes are critically important. With the recent increase in the popularity of esports, which encompasses the struggle of strategy, reflexes, and intelligence in a virtual world, athletes are expected to possess a significant hand-eye-brain coordination similar to that required in sports such as football, basketball, and tennis [28]. Moreover, considering that players need to rapidly adapt to the constantly changing conditions within the game and find solutions to immediate problems, it is believed that high cognitive abilities and the maintenance of elevated levels of flexibility will be decisive factors in sustaining their success. Additionally, esports provide an environment that contributes to the development of 21st century skills such as critical thinking, problem-solving, and collaboration, thereby enabling an effective transfer of these skills from the virtual world to real-life applications.

In conclusion, investigating the effects of cognitive flexibility levels of esports athletes on the skills necessary for the 21st century, often referred to as the information technology age, is becoming increasingly important in today's dynamic world. As a result of rapid changes and transformations occurring on a global scale, societies aim to cultivate individuals with competencies known as 21st century skills to play an active role on the global stage [13]. Individuals must be proficient in areas such as technology use, collaborative work, effective communication, digital literacy, problem-solving, and critical thinking [29,30]. These skills are defined as 21st century skills and play a critical role in enabling individuals to achieve success. As a dynamic and interactive domain, esports offer a rich environment for the development of 21st century skills such as particularly critical thinking, adaptability, teamwork, collaboration, and rapid problem-solving—by engaging individuals in fast-paced decision-making and complex strategic interactions.

Although existing studies have emphasized the benefits of gaming for social and cognitive development, research specifically addressing the relationship between esports and 21st century skills remains scarce. Previous studies focusing on esports have predominantly highlighted positive outcomes such as improved decision-making [5,31], faster reaction times [32–34], and enhanced cognitive control [35]. Despite the growing academic interest in esports and cognitive performance, an integrated understanding of how cognitive flexibility contributes to the development of 21st century skills within this context is noticeably lacking in the literature. In particular, there is a lack of empirical research that systematically examines the intersection of cognitive flexibility, esports participation, and 21st century competencies within a unified framework. These observations point to the importance of investigating how cognitive flexibility, may serve as bridges between esports participation and real-world skill acquisition.

While the existing literature offers preliminary insights into the potential of esports to foster various 21st century skills, a substantial gap remains in understanding the specific cognitive mechanisms underlying this development. In particular, there is a lack of empirical research directly examining how cognitive flexibility relates to the acquisition of core 21st century competencies such as critical thinking, collaboration, and problem-solving within esports contexts. Although prior studies have emphasized the benefits of gaming on social and cognitive development, they often fall short of integrating these constructs into a unified explanatory framework. Therefore, this study aims to address this gap by empirically investigating the predictive role of cognitive flexibility in the development of 21st century skills among esports athletes, thereby offering a novel contribution to the emerging discourse at the intersection of digital performance, cognition, and real-world skill transfer.

This study explores the extent to which cognitive flexibility predicts the development of 21st century competencies within the distinctive performance context of esports. In recent years, esports has emerged as a prominent platform where individuals cultivate critical thinking, problem-solving, and collaborative skills, which are widely recognized as fundamental components of the 21st century skillset and are actively practiced in competitive gaming environments. Previous studies in this field provides compelling evidence for the contribution of esports

participation to the enhancement of these competencies [36–39]. Against this backdrop, the present study poses the following research questions (RQ):

RQ 1: *To what extent does cognitive flexibility influence the acquisition and development of 21st century skills among esports athletes?*

RQ 2: *To what extent does gaming frequency affect the prediction of 21st century skill development by cognitive flexibility among esports athletes?*

By conceptualizing cognitive flexibility as a central cognitive predictor, this study introduces an integrative framework that elucidates how sports may support the transfer of domain-specific experiences into broader real-life competencies, thereby addressing a critical gap in the literature at the intersection of esports, adaptive cognition, and future-oriented skills development.

2. Methods

2.1. Theoretical Framework

In this study, cognitive flexibility was determined as a predictor of 21st century skills, based on the premise that multifaceted competencies such as critical thinking, problem solving, creativity, collaboration, self-management, and digital literacy are closely associated with key components of cognitive flexibility, including adaptability to changing conditions, the generation of alternative solutions, and the evaluation of multiple perspectives.

2.2. Data Collection

The data were collected through online surveys distributed across online gaming communities. The player group in this study consists of individuals who actively participate in e-sports games that are associated with different cognitive and social skill areas and stand out in the literature with these aspects. The games included in the study were purposively selected based on two main criteria: being among the top ten most played esports games on a global scale [40] and having a high level of accessibility for the participants. This selection both strengthens the ecological validity of the study and supports the theoretical grounding of the cognitive and social dimensions examined. Within these games, *CS:GO* is linked to the activation and maintenance of cognitive systems [41]; *PUBG* promotes social interaction, collaboration, and strategic thinking [42]; *League of Legends* is notable for its contribution to the development of cognitive flexibility [5]; *Dota 2* is associated with enhanced decision-making and cognitive development [43]; *Valorant* emphasises tactical thinking, teamwork, and coordination [44]; and *World of Warcraft* supports the cultivation of leadership and team collaboration skills [24]. This approach aims to effectively reach the target audience and ensure an adequate sample size. Such a strategy provides a more accurate sampling framework, thereby enhancing the reliability of subsequent data analysis [45]. At the beginning of the survey, participants were informed about the estimated duration of the survey (4–6 min) and were provided with information regarding the voluntary nature of their participation as well as assurances about the protection of their anonymity and confidentiality. All participants were informed about the procedures and each provided written informed consent to take part in the study.

2.3. Ethic

The Ethics Committee of Balıkesir University approved all procedures of this study (GOA 2020/11-11: Decision Number:2020/200). The study protocol aligns with the most recent version of the Declaration of Helsinki.

2.4. Participants

Participants consisted of 84.3 % (n = 498) males and 15.7 % (n = 93) females. In terms of age distribution, 44.7 % (n = 264) were in the 18–20 age range, 23.9 % (n = 141) were aged 21–23, 9.6 % (n = 57) were between 24–26, and 21.8 % (n = 129) were 27 years or older. Regarding educational background, 19.8 % (n = 117) were high school graduates, 66 % (n = 390) held a bachelor's degree, and 14.2 % (n = 84) had completed postgraduate education. In terms of gaming preferences, 14.7 % (n = 87) played CS:GO, 20.8 % (n = 123) played League of Legends, 2.5 % (n = 15) played DOTA 2, 16.2 % (n = 96) played PUBG, 17.8 % (n = 105) played Valorant, 11.7 % (n = 69) played World of Warcraft, and 16.2 % (n = 96) participated in other esports games. As for daily gaming time, 17.9 % (n = 105) played less than 1 h per day. Additionally, 38.1 % (n = 225) played between 1–3 h, 29.9 % (n = 177) played between 3–5 h, and 14.2 % (n = 84) played for more than 5 h. Regarding weekly gaming frequency, 9.1 % (n = 52) played once a week. Furthermore, 7.1 % (n = 42) played twice a week, 10.7 % (n = 63) played three times a week, 11.2 % (n = 66) played four times a week, 14.2 % (n = 84) played five times a week, 11.1 % (n = 66) played six times a week, and 36.5 % (n = 216) played every day.

Participants were divided into two groups as '1–3 days' and '4–7 days' according to their weekly game playing frequency. This classification was made to determine the intensity of game playing behaviour in order to answer the 2nd RQ of the study. Individuals who play games 4 or more days a week were considered as intensive gamers since they participate in these games more than half of the week. In the literature, it has been reported that individuals with a weekly playing time of 22 h or more play games for more than 3 h on average daily and that these individuals are classified as regular and intense gamers [46–49]. Similarly, in a study conducted by Fernández-Arias et al. [50], it was reported that the weekly frequency of regular gamers was more than 3 days on average. Game playing behaviour of 3 h or more per day indicates that the game activity is spread over more than half of the week, and this coincides with the classification of the participants in the '4–7 days' group in our study. Therefore, the fact that individuals who play games 4 days a week or more are considered as a separate category reflects the intensity in gaming behaviour, consistent with previous research.

2.5. Measurements

Based on the research objectives and a review of the relevant literature, this study was conducted using appropriate measurement tools. In the study, cognitive flexibility was measured with the widely used Cognitive Flexibility Scale, whose validity and reliability have been repeatedly validated in the literature. The scale was specifically designed to measure an individual's ability to adapt to changing conditions, generate alternative solutions and evaluate different perspectives, and has been successfully used in e-sports research where cognitive performance and mental skills are important [51,52]. In this context, the measure used in this study was considered an appropriate and valid choice based on both theoretical foundations and previous empirical findings.

The Cognitive Flexibility Scale (CFS); developed by Martin and Rubin [53] and adapted into Turkish by Çelikkaleli [54], was utilized to measure participants' levels of cognitive flexibility. This scale consists of 12 items under a single dimension. The Turkish validity and reliability study of the scale resulted in an internal consistency coefficient of 0.74. The test–retest correlation coefficient of the measurement tool was found to be 0.98, while the split-half reliability of the scale was obtained as 0.77.

Multidimensional 21st Century Skills Scale: Developed by Çevik and Şentürk [13] was used to measure 21st century skills. The scale comprises 41 items across 5 dimensions: information and technology literacy skills, critical thinking and problem-solving skills, entrepreneurship and innovation skills, social responsibility and leadership skills, and career consciousness skills. esports gaming playing time. The Turkish validity and reliability study of the scale resulted in a Cronbach's alpha coefficient of 0.86. The reliability coefficient for the first sub-dimension was

0.84, for the second sub-dimension it was 0.79, for the third sub-dimension it was 0.76, for the fourth sub-dimension it was 0.73, and for the fifth sub-dimension it was 0.75. In light of these findings, it can be concluded that the reliability of the scale falls within acceptable limits. Additionally, the control variables of the study included gender, age, educational background, daily and weekly esports gaming frequency.

2.6. Statistical Analysis

The analysis of the scale forms used in the study was conducted using SPSS 25.0 software. The data obtained online were initially recorded in Excel format and then transferred to the SPSS program for the removal of missing and outlier data, followed by relevant analyses on the raw data. To determine whether the data exhibited a normal distribution, the skewness and kurtosis values were examined. It was found that these values ranged between + 1.5 and −1.5, indicating that the data exhibited a normal distribution [55]. Additionally, all constructs met the criteria for Cronbach's alpha coefficients (>0.85) (Table 1). Previous studies have reported that all scales used in this research demonstrate acceptable levels of reliability and validity. For the data determined to display a normal distribution, percentage, frequency, and correlation and simple linear regression analyses were performed in line with the study's objectives. Correlation and regression effect sizes between 0.10 and 0.29 indicate a small effect, those between 0.29 and 0.49 indicate a medium effect, and those between 0.50 and 1.00 indicate a large effect [56,57]. Additionally, the Durbin-Watson statistic used to assess autocorrelation in regression analysis is expected to be within the range of + 1.5 to + 2.5 [58]. The Durbin-Watson values for all identified regression models are within the acceptable range indicated in the literature (1.66; 2.50).

3. Results

This section of the study presents the findings that emerged from the statistical analyses of the data.

3.1. The Relationship Between Cognitive Flexibility and Multidimensional 21st Century Skills

According to the correlation analysis conducted (Table 2) between the scores obtained by esports athletes from the Cognitive Flexibility Scale and the scores from the Multidimensional 21st Century Skills Scale and its sub-dimensions, there was a statistically significant positive relationship between cognitive flexibility and the sub-dimension of information technology literacy skills ($p < 0.001$; $r = 0.39$). Additionally, a statistically significant positive relationship was found between cognitive flexibility and the sub-dimension of entrepreneurship and innovation skills ($p < 0.001$; $r = 0.44$), as well as between cognitive flexibility and the sub-dimension of social responsibility and leadership skills ($p < 0.001$; $r = 0.32$). There was also a statistically significant positive relationship between cognitive flexibility and the sub-dimension of career consciousness skills ($p < 0.001$; $r = 0.22$) and between cognitive flexibility and the overall multidimensional 21st century skills ($p < 0.001$; $r = 0.40$). However, no statistically significant relationship was found between cognitive flexibility and the sub-dimension of critical thinking and problem-solving skills ($p > 0.05$; $r = -0.03$).

Table 1
Validity and Reliability Analyses for Scales and Sub-Dimensions.

Scales and Sub-Dimensions	Cronbach's Alpha	Skewness	Kurtosis
Knowledge and Technology Literacy Skills	0.88	−0.81	0.89
Critical Thinking and Problem Solving Skills	0.79	−1.39	0.84
Entrepreneurship and Innovation Skills	0.87	−0.23	0.08
Social Responsibility and Leadership Skills	0.79	−0.50	−0.05
Career Consciousness	0.79	−0.95	−0.15
Multidimensional 21th Century Skills Scale	0.91	−0.44	0.38
Cognitive Flexibility Scale	0.86	0.37	1.41

Table 2
Correlation Analysis Results Between Cognitive Flexibility and 21st Century Skills with Sub-Dimensions.

Variables		*r*	p
Cognitive Flexibility	Knowledge and Technology Literacy Skills	0.39	0.00***
	Critical Thinking and Problem Solving Skills	−0.03	0.39
	Entrepreneurship and Innovation Skills	0.44	0.00***
	Social Responsibility and Leadership Skills	0.32	0.00***
	Career Consciousness Skills	0.22	0.00***
	21th Century Skills	0.40	0.00***

*** $p < 0.001$.

3.2. Esport Players' Cognitive Flexibility Levels and Impact on 21st Century Skills Based on Increased Gaming Frequency

To investigate the predictive capacity of cognitive flexibility levels concerning 21st century skills among esports athletes based on their weekly gaming durations, a simple linear regression analysis was performed. The results reveal that the second regression model is statistically significant, whereas the first model fails to achieve statistical significance (Table 2). The group with a weekly gaming duration of 1–3 days ($F_{(1,157)=}3.76$; $p > 0.05$; $\beta = 0.15$) demonstrated a positive but non-significant effect of cognitive flexibility on 21st century skills. Conversely, the group with a weekly gaming duration of 4–7 days ($F_{(1,43)=}126.14$; $p < 0.001$; $\beta = 0.47$) showed that cognitive flexibility significantly and positively predicts their 21st century skills. It was found that the group gaming 1–3 days accounts for 2 % of the effect of cognitive flexibility on 21st century skills, while the group gaming 4–7 days explains 22 % of this relationship (Table 3).

3.3. Esport Players' Cognitive Flexibility Levels and Impact on Information Knowledge and Technology Literacy Skills Based on Weekly Gaming Frequency

To determine whether cognitive flexibility levels among esports athletes are a significant predictor of information technology literacy skills based on their weekly gaming durations, a simple linear regression analysis was conducted. The results indicate that both the first and second regression models are significant (Table 4). In the group with a weekly gaming frequency of 1–3 days, cognitive flexibility positively and significantly predicted information technology literacy skills ($F_{(1,157)} = 5.25$; $p < 0.05$; $\beta = 0.18$). Similarly, in the group with a weekly gaming frequency of 4–7 days, cognitive flexibility also positively and significantly predicted information technology literacy skills ($F_{(1,43)} = 140.24$; $p < 0.001$; $\beta = 0.49$). It was found that the group gaming 1–3 days accounted for 3 % of the effect of cognitive flexibility on information technology literacy skills, while the group gaming 4–7 days explained 24 % of this relationship.

3.4. Esport Players' Cognitive Flexibility Levels and Impact on Critical Thinking and Problem Solving Skills Based on Weekly Gaming Frequency

To predictive role of cognitive flexibility levels on critical thinking and problem-solving skills among esports athletes based on their weekly gaming duration, a simple linear regression analysis was conducted. The

Table 3
Regression Analysis of Esport Players' Cognitive Flexibility Levels as Predictors of 21st Century Skills Based on Weekly Gaming Frequency.

Model	Weekly Gaming Frequency	R	R^2	Variable	B	S.D.	f	β	t	p	Durbin Watson
1	1–3 days	0.15	0.02	Constant	137.25	0.30	3.76	0.15	1.94	0.05	1.86
				Cognitive Flexibility	0.59						
2	4–7 days	0.47	0.22	Constant	64.07	0.21	126.14	0.47	11.23	0.00***	1.88
				Cognitive Flexibility	2.41						

Dependent Variable: 21th Century Skills; ***p < 0.001.

Table 4
Regression Analysis of Esport Players' Cognitive Flexibility Levels as Predictors of Knowledge and Technology Literacy Skills Based on Weekly Gaming Frequency.

Model	Weekly Gaming Frequency	R	R^2	Variable	B	S.S.	f	β	t	p	Durbin Watson
1	1–3 days	0.18	0.03	Constant	46.78	0.14	5.25	0.18	2.29	0.02*	1.77
				Cognitive Flexibility	0.33						
2	4–7 days	0.49	0.24	Constant	19.69	0.08	140.24	0.49	11.84	0.00***	1.85
				Cognitive Flexibility	1.03						

Dependent Variable: Knowledge and Technology Literacy Skills; ***p < 0.001; *p < 0.05.

results indicate that the first regression first model demonstrates statistical significance whereas the second model does not. (Table 5). In the group with a weekly gaming frequency of 1–3 days, cognitive flexibility was found to significantly and negatively predict critical thinking and problem-solving skills ($F_{(1,157)} = 25.58$; $p < 0.001$; $\beta = -0.37$). Conversely, in the group with a weekly gaming frequency of 4–7 days, the cognitive flexibility level exhibited a negative effect on critical thinking and problem-solving skills, although this effect was not statistically significant ($F_{(1,43)} = 2.37$; $p > 0.05$; $\beta = -0.07$). It was found that the group gaming 1–3 days in a week explained 14 % of the variance in the impact of cognitive flexibility on critical thinking and problem-solving skills whereas the group gaming 4–7 days in a week did not explain any variance in this relationship.

3.5. Esport Players' Cognitive Flexibility Levels and Impact on Entrepreneurship and Innovation Skills Based on Weekly Gaming Frequency

To cognitive flexibility levels among esports athletes serve as significant predictors of entrepreneurship and innovation skills based on their weekly gaming durations, a simple linear regression analysis was used. The results indicate that both the first and second regression models are statistically significant (Table 6). In the group with a weekly gaming frequency of 1–3 days ($F_{(1,157)} = 24.50$; $p < 0.001$; $\beta = -0.36$), cognitive flexibility was found to significantly and positively predict entrepreneurship and innovation skills. Similarly, in the group with a weekly gaming frequency of 4–7 days ($F_{(1,43)} = 105.70$; $p < 0.001$; $\beta = -0.44$), cognitive flexibility also significantly and positively predicted entrepreneurship and innovation skills. It was determined that the group gaming 1–3 days in a week explained for 13 % of the variance in the effect of cognitive flexibility on entrepreneurship and innovation skills, while the group gaming 4–7 days in a week explained 19 % of this effect.

3.6. Esport Players' Cognitive Flexibility Levels and Impact on Social Responsibility and Leadership Skills Based on Weekly Gaming Frequency

To determine whether cognitive flexibility levels among esports athletes serve as significant predictors of social responsibility and leadership skills based on their weekly gaming durations, a simple linear regression analysis was used. The indicate that the second regression model demonstrates statistical significance, whereas the first model does not reach statistical significance (Table 7). In the group with a weekly gaming frequency of 1–3 days ($F_{(1,157)} = 3.04$; $p > 0.05$; $\beta = 0.13$), cognitive flexibility was found to positively impact to social responsibility and leadership skills; however, this effect was not statistically significant. Conversely, in the group with a weekly gaming frequency of 4–7 days ($F_{(1,43)} = 65.92$; $p < 0.001$; $\beta = 0.36$), cognitive flexibility significantly and positively predicted social responsibility and leadership skills. It was determined that the group gaming 1–3 days in a week explained for 1 % of the variance in the effect of cognitive flexibility on information technology literacy skills and the group gaming 4–7 days in a week explained 13 % of the variance in the impact of cognitive flexibility on social responsibility and leadership skills.

3.7. Esport Players' Cognitive Flexibility Levels and Impact on Career Consciousness Skills Based on Weekly Gaming Frequency

To cognitive flexibility levels among esports athletes are significant predictors of career consciousness skills based on their weekly gaming durations, a simple linear regression analysis was conducted. The results indicate that the second regression model is statistically significant while the first model does not exhibit statistical significance (Table 8). In the group with a weekly gaming duration of 1–3 days ($F_{(1,157)} = 1.07$; $p > 0.05$; $\beta = 0.08$), cognitive flexibility was found to have a positive effect on career consciousness skills; however, this effect was not statistically significant. Conversely, in the group with a weekly gaming duration of 4–7 days ($F_{(1,43)} = 36.52$; $p < 0.001$; $\beta = 0.28$), cognitive flexibility significantly and positively predicted career skills. It was observed that the group gaming 1–3 days in a week explained no variance in the effect of cognitive flexibility on career consciousness skills, whereas the group gaming 4–7 days explained 7 % of the variance in this relationship.

Table 5
Regression Analysis of Esport Players' Cognitive Flexibility Levels as Predictors of Critical Thinking and Problem Solving Skills Based on Weekly Gaming Frequency.

Model	Weekly Gaming Frequency	R	R^2	Variable	B	S.S.	f	β	t	p	Durbin Watson
1	1–3 days	0.37	0.14	Constant	39.48	3.12	25.58	−0.37	−5.05	0.00***	2.50
				Cognitive Flexibility	−0.36						
2	4–7 days	0.07	0.00	Constant	27.86	2.56	2.37	−0.07	−1.54	0.12	2.33
				Cognitive Flexibility	−0.09						

Dependent Variable:: Critical Thinking and Problem Solving Skills; ***p < 0.001.

Table 6
Regression Analysis of Esport Players' Cognitive Flexibility Levels as Predictors of Entrepreneurship and Innovation Skills Based on Weekly Gaming Frequency.

Model	Weekly Gaming Frequency	R	R^2	Variable	B	S.S.	f	β	t	p	Durbin Watson
1	1–3 days	0.36	0.13	Constant	15.69	0.09	24.50	0.36	4.95	0.00***	1.66
				Cognitive Flexibility	0.47						
2	4–7 days	0.44	0.19	Constant	−2.32	0.09	105.70	0.44	10.28	0.00***	1.95
				Cognitive Flexibility	0.02						

Depentdent Variable: Entrepreneurship and Innovation Skills; ***$p < 0.001$.

Table 7
Regression Analysis of Esport Players' Cognitive Flexibility Levels as Predictors of Social Responsibility and Leadership Skills Based on Weekly Gaming Frequency.

Model	Weekly Gaming Frequency	R	R^2	Variable	B	S.S.	f	β	t	p	Durbin Watson
1	1–3 days	0.13	0.01	Constant	11.37	0.04	3.04	0.13	1.74	0.08	2.24
				Cognitive Flexibility	0.08						
2	4–7 days	0.36	0.13	Constant	5.12	0.03	65.92	0.36	8.11	0.00***	1.94
				Cognitive Flexibility	0.25						

Dependent Variable: Social Responsibility and Leadership Skills; ***$p < 0.001$.

Table 8
Regression Analysis of Esport Players' Cognitive Flexibility Levels as Predictors of Career Consciousness Skills Based on Weekly Gaming Frequency.

Model	Weekly Gaming Frequency	R	R^2	Variable	B	S.S.	f	β	t	p	Durbin Watson
1	1–3 days	0.08	0.00	Constant	23.92	0.06	1.07	0.08	1.03	0.30	2.43
				Cognitive Flexibility	0.06						
2	4–7 days	0.28	0.07	Constant	13.71	0.04	36.52	0.28	6.04	0.00***	1.79
				Cognitive Flexibility	0.29						

Dependent Variable: Career Consciousness Skills; ***$p < 0.001$.

4. Discussions

In accordance with the aim of this study, which was to examine how cognitive flexibility contributes to the development of 21st century skills in e-sports players, previous research also highlights the positive cognitive outcomes associated with video game experience. Previous studies reveal the positive effect of esports on cognitive flexibility, with increasing evidence that the experience of playing esport games can improve cognitive control skills. Colzato et al. [59] reported that individuals who play video games (VGPs) show superior performance on cognitive control tasks compared to individuals who do not play video games, and this may be due either to the fact that the gaming experience improves cognitive flexibility or that VGPs use these skills more intensively while playing games. As a matter of fact, in the context of esports, the necessity for players to switch between a large number of tasks and make quick decisions during the game necessitates the constant activation of cognitive flexibility. Such situations are similar to the necessity to switch between activities that individuals encounter in daily life or to adapt quickly to new conditions. The observation that cognitive flexibility in VGPs significantly predicts performance on relatively structured diagnostic measures of this skill [60] supports the view that gaming experience improves cognitive flexibility. This view is in line with experimental studies showing that individuals who play games for a certain period of time exhibit higher performance on various cognitive measures compared to control groups [61–63]. These findings suggest that esports is not only a recreational activity, but also offers a functional environment for the development of cognitive flexibility.

The increase in cognitive flexibility levels among esports athletes indicates a corresponding enhancement in their 21st century skills. These results support the direct proportional increase between cognitive flexibility and 21st century skills. In this context the existing literature also reinforces our findings. Spiro et al. [64] emphasize that cognitive flexibility can guide the development of 21st century skills. Similarly Idawati et al. [65] state that cognitive flexibility plays a significant role in dealing with innovations and sudden changes during learning and teaching processes as well as in acquiring 21st century skills. These studies are consistent with the results obtained in our research and highlight the positive impact of cognitive flexibility on 21st century skills. In the rapidly evolving information age individuals must possess the ability to evaluate various solutions in the situations they encounter and develop the awareness necessary to adapt. Therefore the presence of a positive relationship between cognitive flexibility and 21st century skills can aid individuals in meeting these essential requirements.

Cognitive flexibility levels among esports athletes significantly contribute to the enhancement of information technology literacy, which is regarded as a crucial sub-dimension of 21st century skills. This includes competencies such as digital tool usage, media literacy, and information management. This finding highlights the positive impact of cognitive flexibility on various aspects of information technology literacy. The rapid technological advancements of today necessitate individuals who can adapt to innovations, use technology effectively, and develop innovative solutions to technological challenges. In this context, technology literacy skills, which encompass understanding the importance of technology and recognizing related issues, are interrelated with cognitive flexibility [66]. Salomon [67] [] stated that technology enhances cognitive skills while Pea [68] noted that computer systems improve children's cognitive abilities and Greenfield [69] emphasized that computer games support analytical skills. Tiatri et al. [70] highlighted the ability of programs incorporating technology to enhance cognitive competence. Literature frequently references studies demonstrating that computer-based video games enhance cognitive skills [36,71–76]. The parallelism between esports athletes' cognitive flexibility levels and their information and technology literacy skills can be attributed to the nature of esports requiring players to possess advanced computer and software utilization skills.

The absence of a relationship between the cognitive flexibility levels of individuals participating in esports and their critical thinking and problem-solving skills may result from the limitations inherent in the measurement framework of these constructs. Esports prioritize communication and coordination skills among players, thereby fostering adherence to team strategies over individual critical thinking processes. Moreover, these games often necessitate the repetition of specific

strategies and routines, which may orient players toward problem-solving strategies while marginalizing critical thinking. The exigencies of rapid reactions and quick decision-making inherent in the esports environment can further constrain the development of deeper critical thinking processes. Cognitive flexibility, defined as the capacity to reorganize strategies in response to novel and unexpected circumstances, represents a crucial construct that influences the problem-solving process and awareness of problem contexts through the generation of alternative solutions [77]. A comprehensive review of the literature reveals a substantial body of research indicating that cognitive flexibility exerts a positive influence on problem-solving abilities [78–82]. Furthermore, Adachi et al. [6] and Bavelier et al. [83] assert that participation in video games facilitates cognitive development and enhances problem-solving skills. Nonetheless, within the context of esports, this developmental potential may not be fully operationalized due to the demands for rapid responses and reliance on predetermined strategies. Consequently, this dynamic may lead players to concentrate on swift and efficient solutions rather than engaging in comprehensive analysis and reflection, thereby restricting opportunities for critical thinking and creative problem-solving.

The ability of people with high cognitive flexibility to categorize ideas and concepts in various ways and establish relationships between these categories [84,85] suggests a positive relationship between esports athletes' cognitive flexibility levels and their entrepreneurship and innovation skills. The literature includes several studies indicating that individuals with high cognitive flexibility make significant contributions to entrepreneurial and innovative thinking processes [86–93]. This finding implies the necessity for esports athletes to develop innovative ideas and think differently during competitions to remain effective against their rivals. Therefore, the results of this research clearly demonstrate that esports athletes require innovative thinking processes to utilize their cognitive flexibility effectively and attain a strategic advantage, thereby fostering their development in this area.

Cognitive flexibility is believed to enhance leadership and social responsibility skills. The ability of leaders to generate creative and practical solutions to complex problems is a reflection of intelligence and constitutes a crucial attribute that enables leaders to process complex information swiftly and effectively, thereby strengthening their problem-solving capabilities and laying the foundation for effective leadership [94–97]. In this context, creative thinking and strategic decision-making are considered critical components of leadership success. Furthermore, the literature contains numerous studies that indicate the positive impact of cognitive flexibility on leadership skills [98,99]. These findings are consistent with the results of our research and underscore the importance of cognitive flexibility in leadership. Esports, through team-based activities, enhances strategic thinking, rapid decision-making, and intra-team coordination, thereby fortifying leadership skills. Additionally, through role distribution and social interactions, esports cultivates social responsibility and empathy. Esports events reinforce social responsibility awareness by encouraging participants to engage in community projects, thus significantly contributing to the development of leadership and social responsibility.

There several reasons for the positive relationship between the cognitive flexibility levels of esports athletes and their career consciousness skills. Cognitive flexibility enhances the ability of athletes to adapt to rapidly changing game scenarios and strategies, thereby aiding their ability to adjust to evolving conditions and opportunities in their careers. Their skills in solving problems encountered during gameplay and developing innovative strategies can also prove effective in career planning and management. Furthermore, cognitive flexibility increases the capacity to learn new information quickly and to integrate innovative perspectives into existing knowledge, enabling athletes to better assess career opportunities and shape their goals. The ability to make fast and flexible decisions provides advantages in both gameplay and strategic choices along their career paths. The combination of these factors may significantly contribute to the relationship between cognitive flexibility and career skills among esports athletes. In the literature, Muja et al. [100] state that solving complex problems enhances individuals' self-efficacy and boosts their confidence, which influences their career goal setting. Similarly, Pérez-López et al. [101] emphasize that self-efficacy, innovative thinking, and entrepreneurial skills positively affect individuals' career planning. Yükçü and Kaplanoğlu [102] also indicate that esports offer various employment opportunities not only in computer-related fields but across a wide range of areas. These findings demonstrate that the contributions of esports to career development are multifaceted.

5. Limitations

Despite the valuable findings presented in this study, several limitations need to be considered in order to strengthen the results and guide future research. First, while the sample size may be adequate for initial insights, it may not fully represent the broader esports population. Variations in esports disciplines, player demographics, and regional differences can impact cognitive flexibility levels and the development of 21st century skills. While this research highlights the benefits of cognitive flexibility in the realm of esports, it does not comprehensively examine potential challenges or negative aspects associated with high cognitive flexibility, such as decision fatigue or overthinking during fast-paced gameplay. Future studies may focus on these nuances to gain a broader understanding of the role of cognitive flexibility. These limitations underscore the importance of investigating the relationship between cognitive flexibility and core skills in esports, suggesting that future research employing diverse methodologies and longitudinal approaches could further illuminate this intriguing area of study.

6. Conclusions

The results of this study indicate that cognitive flexibility is a significant area of development and that the esports environment supports the full realization of this potential. Esports contribute to the strengthening of cognitive flexibility by equipping individuals with skills such as quick decision-making, strategic thinking, and teamwork. In this context, as esports athletes enhance their problem-solving abilities, the dynamic nature of the games also facilitates the development of critical thinking and innovative approaches. Notably, cognitive flexibility has been shown to play a critical role in the development of essential competencies such as 21st century skills and career consciousness. The findings suggest that cognitive flexibility positively influences individuals' strategic thinking, problem-solving, and communication skills, thereby aiding in the formulation of overarching career goals. Moreover, the enhancement of information technology literacy through esports facilitates individuals' adaptation to innovations in today's rapidly changing digital landscape. However, considering that individual critical thinking may not be prioritized in esports and that actions are often driven by team dynamics, opportunities for in-depth analysis and reflection may be limited. Ultimately, the contributions of esports to the development of leadership and social responsibility skills empower individuals to adopt innovative, flexible, and proactive approaches not only in the gaming arena but also in their career advancement. Future research could explore how strategies for enhancing cognitive flexibility can be more effectively implemented in esports, thereby further supporting these findings.

CRediT authorship contribution statement

Alp Kaan Kilci: Writing – review & editing, Writing – original draft, Validation, Methodology, Investigation, Formal analysis, Data curation. **Zekeriya Göktaş:** Conceptualization, Writing – review & editing, Supervision.

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Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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Data availability

Data will be made available on request from corresponding author.

References

[1] Kottama NR, Sebastian N, Adrianto HA, Harefa J, Chowanda A. The Mobile Life Simulator for Introducing the Career as a Professional Player in E-Sport. Procedia Comput Sci, vol. 179, Elsevier B.V.; 2021, p. 656–61. DOI: 10.1016/j.procs.2021.01.052.

[2] Jonasson K, Thiborg J. Electronic sport and its impact on future sport. Sport in Society Cultures, Commerce, Media, Politics 2010;13:287–99. DOI: 10.1080/17430430903522996.

[3] T.L. Taylor, Raising the Stakes: E-Sports and the Professionalization of Computer gaming, 1st ed., The MIT Press, London, 2012.

[4] M. Poppelaars, A. Lichtwarck-Aschoff, M. Kleinjan, I. Granic, The impact of explicit mental health messages in video games on players' motivation and affect, Comput. Human Behav. 83 (2018) 16–23, https://doi.org/10.1016/J.CHB.2018.01.019.

[5] C. Valls-Serrano, C. de Francisco, E. Caballero-López, A. Caracuel, Cognitive flexibility and decision making predicts expertise in the MOBA esport, league of legends, SAGE Open 12 (2022), 10.1177/21582440221142728/SUPPL_FILE/SJ-DOCX-1-SGO-10.1177_21582440221142728.DOCX.

[6] P.J.C. Adachi, T. Willoughby, More than just fun and games: the longitudinal relationships between strategic video games, self-reported problem solving skills, and academic grades, J. Youth Adolesc. 42 (2013) 1041–1052, https://doi.org/10.1007/S10964-013-9913-9/FIGURES/3.

[7] M. Wagner, in: On the Scientific Relevance of e-Sports, CSREA Press, Las Vegas, 2006, pp. 437–442.

[8] Dongsheng Y, Xiaohang Y, Daofeng K. The present situation and development trend of E-sports games in China. Proceedings of the 2011 International Conference on Future Computer Science and Education, ICFCSE 2011 2011: 384–6. DOI: 10.1109/ICFCSE.2011.98.

[9] T.W. Yu, Learning in the virtual world: the pedagogical potentials of massively multiplayer online role playing games, Int. Educ. Stud. 2 (2009) 32–38.

[10] K. Squire, From content to context: videogames as designed experience, Educ. Res. 35 (2006) 19–29, https://doi.org/10.3102/0013189X035008019.

[11] M.D. Dickey, Game design and learning: a conjectural analysis of how massively multiple online role-playing games (MMORPGs) foster intrinsic motivation, Educ. Technol. Res. Dev. 55 (2007) 253–273, https://doi.org/10.1007/S11423-006-9004-7/TABLES/2.

[12] H. Susaeta, F. Jimenez, M. Nussbaum, I. Gajardo, J.J. Andreu, M. Villalta, From mmorpg to a classroom multiplayer presential role playing game, Educat. Technol. Soc. 13 (2010) 257–269.

[13] M. Çevik, C. Şentürk, Multidimensional 21th century skills scale: validity and reliability study, Cypriot J. Educ. Sci. 14 (2019) 11–28, https://doi.org/10.18844/CJES.V14I1.3506.

[14] G. Halász, A. Michel, Key Competences in Europe: interpretation, policy formulation and implementation, Eur. J. Educ. 46 (2011) 289–306, https://doi.org/10.1111/J.1465-3435.2011.01491.X.

[15] I.S. Akçomak, L. Borghans, B. ter Weel, Measuring and interpreting trends in the division of labour in the Netherlands, Economist (leiden) 159 (2011) 435–482, https://doi.org/10.1007/S10645-011-9168-3.

[16] A.R. Saavedra, V.D. Opfer, Learning 21st-century skills requires 21st-century teaching, Phi Delta Kappan 94 (2012) 8–13, https://doi.org/10.1177/003172171209400203.

[17] E. van Laar, A.J.A.M. van Deursen, J.A.G.M. van Dijk, J. de Haan, Determinants of 21st-century digital skills: a large-scale survey among working professionals, Comput. Human Behav. 100 (2019) 93–104, https://doi.org/10.1016/J.CHB.2019.06.017.

[18] T. Valtonen, N. Hoang, E. Sointu, P. Näykki, A. Virtanen, J. Pöysä-Tarhonen, et al., How pre-service teachers perceive their 21st-century skills and dispositions: a longitudinal perspective, Comput. Human Behav. 116 (2021) 106643, https://doi.org/10.1016/J.CHB.2020.106643.

[19] I. Voulgari, V. Komis, 'Elven Elder LVL59 LFP/RB. please PM me': immersion, collaborative tasks and problem-solving in massively multiplayer online games, Learn. Media Technol. 35 (2010) 171–202, https://doi.org/10.1080/17439884.2010.494429.

[20] C.A. Steinkuehler, Why Game (Culture) Studies now? Games Cult 1 (2006) 97–102, https://doi.org/10.1177/1555412005281911.

[21] Feng J. University Students' Participation and Opinions on Esports in China: An Empirical Research. Asian Journal of Sport History & Culture 2024;3:1–21. DOI: 10.1080/27690148.2024.2395954.

[22] U. Bennerstedt, J. Ivarsson, J. Linderoth, How gamers manage aggression: situating skills in collaborative computer games, Int J Comput Support Collab Learn 7 (2012) 43–61, https://doi.org/10.1007/S11412-011-9136-6.

[23] C. Steinkuehler, Massively multiplayer online gaming as a constellation of literacy practices, E-Learn Digital Media 4 (2007) 297–318, https://doi.org/10.2304/ELEA.2007.4.3.297.

[24] D. Zheng, K. Newgarden, M.F. Young, Multimodal analysis of language learning in World of Warcraft play: languaging as Values-realizing, ReCALL 24 (2012) 339–360, https://doi.org/10.1017/S0958344012000183.

[25] R.J. Spiro, J. Jehng, Cognitive flexibility and hypertext: Theory and technology for the nonlinear and multidimensional traversal of complex subject matter, in: D. Nix, R.J. Spiro (Eds.), Cognition, Education, and Multimedia: Exploring Ideas in High Technology, Erlbaum, Hillsdale, NJ, 1990.

[26] Karadeniz Ş. Bilişsel Esnekliğe Dayalı Hiper Metin Uygulaması: Sanal Bilgisayar Hastanesi. The Journal of Turkish Educational Sciences 2008;6:135–52.

[27] T. Ionescu, Exploring the nature of cognitive flexibility, New Ideas Psychol. 30 (2012) 190–200, https://doi.org/10.1016/J.NEWIDEAPSYCH.2011.11.001.

[28] Koçyiğit B. Yüzyılın yükselen sporu: E-spor . Digital Age 2017. https://digitalage.com.tr/yuzyilin-yukselen-sporu-e-spor/ (accessed January 8, 2022).

[29] V. Gore, 21st century skills and prospective job challenges, IUP Journal of Soft Skills 7 (2013) 7–14.

[30] J. Voogt;, N.P. Roblin, A comparative analysis of international frameworks for 21st century competences: implications for national curriculum policies, J. Curric. Stud. 44 (2012) 299–321, https://doi.org/10.1080/00220272.2012.668938.

[31] I. Pedraza-Ramirez, L. Musculus, M. Raab, S. Laborde, Setting the scientific stage for esports psychology: a systematic review, Int. Rev. Sport Exerc. Psychol. 13 (2020) 319–352, https://doi.org/10.1080/1750984X.2020.1723122.

[32] Koposov D, Semenova M, Somov A, Lange A, Stepanov A, Burnaev E. Analysis of the Reaction Time of eSports Players through the Gaze Tracking and Personality Trait. IEEE International Symposium on Industrial Electronics 2020;2020-June: 1560–5. DOI: 10.1109/ISIE45063.2020.9152422.

[33] M. Cyma-Wejchenig, J. Maciaszek, J. Ciążyńska, R. Stemplewski, The level of physical activity, E-Game-specific reaction time, and self-evaluated health and injuries' occurrence in non-professional esports players, Electronics (basel) 13 (2024) 2328, https://doi.org/10.3390/ELECTRONICS13122328/S1.

[34] A. Luu, A. Winans, R. Suniga, V.A. Motz, Reaction times for esport competitors and traditional physical athletes are faster than noncompetitive peers, Ohio J. Sci. 121 (2021) 15–20, https://doi.org/10.18061/OJS.V121I2.7677.

[35] H. Miao, H. He, X. Hou, J. Wang, L. Chi, Cognitive expertise in esport experts: a three-level model meta-analysis, PeerJ 12 (2024) e17857, https://doi.org/10.7717/PEERJ.17857/SUPP-3.

[36] B. Bediou, D.M. Adams, R.E. Mayer, E. Tipton, C.S. Green, D. Bavelier, Meta-analysis of action video game impact on perceptual, attentional, and cognitive skills, Psychol. Bull. 144 (2018) 77–110, https://doi.org/10.1037/BUL0000130.

[37] P.M. Markey, C.J. Ferguson, L.I. Hopkins, Video game play: myths and benefits, Am. J. Play 13 (2020) 87–106.

[38] D. Smirni, E. Garufo, L. Di Falco, G. Lavanco, The playing brain. the impact of video games on cognition and behavior in pediatric age at the time of lockdown, A Systematic Review. Pediatr Rep 13 (2021) 401–415, https://doi.org/10.3390/PEDIATRIC13030047.

[39] E.T. Smith, C. Basak, A game-factors approach to cognitive benefits from video-game training: a meta-analysis, PLoS One 18 (2023) e0285925, https://doi.org/10.1371/JOURNAL.PONE.0285925.

[40] eSports Games - Last 7 days n.d. https://gamesight.io/leaderboards/esports-games (accessed April 17, 2025).

[41] S. Gostilovich, A.K. Shapirov, A. Znobishchev, A.H. Phan, A. Cichocki, Biomarkers of professional cybersportsmen: event related potentials and cognitive tests study, PLoS One 18 (2023) e0289293, https://doi.org/10.1371/JOURNAL.PONE.0289293.

[42] A. Idrees, U. Iftikhar, F. Latif, Role of PUBG in modifying the speaking skills of Pakistani Youth, Media Commun. Rev. 2 (2022) 01–18, https://doi.org/10.32350/MCR.21.01.

[43] D.E. Sörman, K.E. Dahl, D. Lindmark, P. Hansson, M. Vega-Mendoza, J. Körning-Ljungberg, Relationships between Dota 2 expertise and decision-making ability,

PLoS One 17 (2022) e0264350, https://doi.org/10.1371/JOURNAL.PONE.0264350.
[44] Xu Y. Applications of Psychological Principles in Game Design: Unveiling the Dynamics and Psychology of Valorant. Lecture Notes in Education Psychology and Public Media 2024;62:63–8. DOI: 10.54254/2753-7048/62/20241731.
[45] H. Taherdoost, Sampling methods in research methodology; how to choose a sampling technique for research, Int. J. Acad. Res. Manage. (IJARM) 5 (2016) 5.
[46] D. Katz, Z. Horváth, H.M. Pontes, P. Koncz, Z. Demetrovics, O. Király, How much gaming is too much? an analysis based on psychological distress, J. Behav. Addict. 13 (2024) 716–728, https://doi.org/10.1556/2006.2024.00036.
[47] H.T. Wei, M.H. Chen, P.C. Huang, Y.M. Bai, The association between online gaming, social phobia, and depression: an internet survey, BMC Psychiatry 12 (2012) 1–7, https://doi.org/10.1186/1471-244X-12-92/TABLES/4.
[48] D. Chappell, V. Eatough, M.N.O. Davies, M. Griffiths, EverQuest - It's just a computer game right? an interpretative phenomenological analysis of online gaming addiction, Int J Ment Health Addict 4 (2006) 205–216, https://doi.org/10.1007/S11469-006-9028-6/METRICS.
[49] Z. Hussain, M.D. Griffiths, T. Baguley, Online gaming addiction: classification, prediction and associated risk factors, Addict. Res. Theory 20 (2012) 359–371, https://doi.org/10.3109/16066359.2011.640442.
[50] Fernández-Arias I, Labrador M, Bernaldo-de-Quirós M, Estupiñá FJ, Vallejo-Achón M, Sanchez-Iglesias I, et al. Cognitive Patterns and Problematic Use of Video Games in Adolescents: A Cluster Analysis. International Journal of Environmental Research and Public Health 2023, Vol 20, Page 7194 2023;20:7194. DOI: 10.3390/IJERPH20247194.
[51] U. Spor, A. Bilimi, G. Menteş, Ö. Saygin, E-spor ve geleneksel spor ile uğraşan sporcuların zihinsel dayanıklılık ve bilişsel esneklik durumlarının incelenmesi, Uluslararası Spor Egzersiz Ve Antrenman Bilimi Dergisi 5 (2019) 238–250, https://doi.org/10.18826/USEEABD.639062.
[52] K. Karakuş, E-Spor ve Geleneksel Sporla Uğraşan Sporcuların Zihinsel Dayanıklılık ve Bilişsel Esneklik Durumlarının İncelenmesi, Lisansüstü Eğitim Enstitüsü (2024).
[53] M.M. Martin, R.B. Rubin, A new measure of cognitive flexibility, Psychol. Rep. 76 (1995) 623–626, https://doi.org/10.2466/PR0.1995.76.2.623.
[54] Ö. Çelikkaleli, Bilişsel Esneklik Ölçeği'nin Geçerlik ve Güvenirliği, Eğitim Ve Bilim 39 (2014) 339–346, https://doi.org/10.15390/EB.2014.3466.
[55] B.G. Tabachnick, F.LS. Using, multivariate statistics, (6th ed.)., Harper and Row, New York, 2013, 1024.
[56] J. Cohen, Statistical Power Analysis for the Behavioral Sciences, 2nd ed., Lawrance Erlbaum Associates Publishers, Hillsdale, NJ, 1988.
[57] A. Field, Discovering Statistics using IBM SPSS Statistics, 4th ed., Sage Publications, California, 2013.
[58] J. Durbin, G.S. Watson, Testing for serial correlation in least squares regression. III, Biometrika 58 (1971) 1–19, https://doi.org/10.1093/BIOMET/58.1.1.
[59] L.S. Colzato, P.J.A. van Leeuwen, W.P.M. van den Wildenberg, B. Hommel, DOOM'd to switch: superior cognitive fl exibility in players of first person shooter games, Front. Psychol. 1 (2010) 1515, https://doi.org/10.3389/FPSYG.2010.00008/BIBTEX.
[60] A. Miyake, N.P. Friedman, M.J. Emerson, A.H. Witzki, A. Howerter, T.D. Wager, The unity and diversity of executive functions and their contributions to complex "frontal lobe" tasks: a latent variable analysis, Cogn. Psychol. 41 (2000) 49–100, https://doi.org/10.1006/COGP.1999.0734.
[61] C.S. Green, D. Bavelier, Enumeration versus multiple object tracking: the case of action video game players, Cognition 101 (2006) 217–245, https://doi.org/10.1016/J.COGNITION.2005.10.004.
[62] B.D. Glass, W.T. Maddox, B.C. Love, Real-time strategy game training: emergence of a cognitive flexibility trait, PLoS One 8 (2013) e70350, https://doi.org/10.1371/JOURNAL.PONE.0070350.
[63] K.L. Powers, P.J. Brooks, N.J. Aldrich, M.A. Palladino, L. Alfieri, Effects of video-game play on information processing: a meta-analytic investigation, Psychon. Bull. Rev. 20 (2013) 1055–1079, https://doi.org/10.3758/S13423-013-0418-Z/TABLES/11.
[64] R. Spiro, H. Klautke, C. Cheng, A. Gaunt, Cognitive Flexibility Theory and the Assessment of 21st-Century skills. Handbook on Measurement, Assessment, and Evaluation in Higher Education, 2nd ed.,, 2018, pp. 844–852.
[65] S.P. Idawati, D. Kuswandi, S. Ulfa, Investigating the effects of problem-solving method and cognitive flexibility in improving university students' metacognitive, J. Educat. Gifted Young Scient. 8 (2020) 651–665, https://doi.org/10.17478/jegys.652212.
[66] F. Aydın, Y. Silik, Teknoloji okuryazarliği: tarihsel bir betimleme, Ihlara Eğitim Araştırmaları Dergisi 3 (2019) 107–126.
[67] G. Salomon, Cognitive effects with and of computer technology, Communic Res 17 (1990) 26–44, https://doi.org/10.1177/009365090017001002.
[68] R.D. Pea, Integrating human and computer intelligence, Ew Direct. Child Develop. 28 (1985) 75–96.
[69] P.M. Greenfield, Mind and Media: the Effects of Television, Video Games and Computers, Harvard University Press, Massachusetts, 1984.
[70] Tiatri S, Beng JT, Fiscarina C, Dinata H. Challenges in Developing Literacy Learning Models for Teachers to Develop Cognitive Strategies for Elementary School Students. The 2nd Tarumanagara International Conference on the Applications of Social Sciences and Humanities (TICASH 2020), Atlantis Press; 2020, p. 754–8. DOI: 10.2991/ASSEHR.K.201209.119.
[71] I. Granic, A. Lobel, R.C.M.E. Engels, The benefits of playing video games, Am. Psychol. 69 (2014) 66–78, https://doi.org/10.1037/A0034857.
[72] C.S. Green, T. Gorman, D. Bavelier, Action Video-Game Training and its Effects on perception and Attentional Control, in: T. Strobach, J. Karbach (Eds.), Cognitive Training, 1st ed., Springer International Publishing, Switzerland, 2016, pp. 107–116.
[73] S. Kühn, J. Gallinat, A. Mascherek, Effects of computer gaming on cognition, brain structure, and function: a critical reflection on existing literature, Dialogues Clin. Neurosci. 21 (2019) 319, https://doi.org/10.31887/DCNS.2019.21.3/SKUEHN.
[74] F. Pallavicini, A. Ferrari, F. Mantovani, Video games for well-being: a systematic review on the application of computer games for cognitive and emotional training in the adult population, Front. Psychol. 9 (2018) 2127, https://doi.org/10.3389/FPSYG.2018.02127/BIBTEX.
[75] C. Reynaldo, R. Christian, H. Hosea, A.A.S. Gunawan, Using video games to improve capabilities in decision making and cognitive skill: a literature review, Procedia Comput. Sci. 179 (2021) 211–221, https://doi.org/10.1016/J.PROCS.2020.12.027.
[76] P. Wang, H.H. Liu, X.T. Zhu, T. Meng, H.J. Li, X.N. Zuo, Action video game training for healthy adults: a meta-analytic study, Front. Psychol. 7 (2016) 907, https://doi.org/10.3389/FPSYG.2016.00907/BIBTEX.
[77] A. Buğa, E. Özkamalı, F. Altunkol, A. Çekiç, Üniversite öğrencilerinin bilişsel esneklik düzeylerine göre sosyal problem çözme tarzlarının incelenmesi, Gaziantep Üniversitesi Eğitim Bilimleri Dergisi 2 (2018) 48–58.
[78] A. Bedel, E. Ulubey, Ergenlerde Başa çıkma Stratejilerini Açıklamada Bilişsel Esnekliğin Rolü, Elektronik Sosyal Bilimler Dergisi 14 (2015) 291–300.
[79] Taş S, Deniz S. Sekizinci Sınıf Öğrencilerinin Matematiğe Yönelik Öğrenilmiş Çaresizliklerinin Yordanması: Problem Çözme Becerisi ve Bilişsel Esneklik. Turkish Journal of Computer and Mathematics Education (TURCOMAT) 2018;9:581–617. DOI: 10.16949/TURKBILMAT.415087.
[80] W.L. Lin, P.H. Tsai, H.Y. Lin, H.C. Chen, How does emotion influence different creative performances? the mediating role of cognitive flexibility, Cogn. Emot. 28 (2014) 834–844, https://doi.org/10.1080/02699931.2013.854195.
[81] J.R. Star, B. Rittle-Johnson, Flexibility in problem solving: the case of equation solving, Learn. Instr. 18 (2008) 565–579, https://doi.org/10.1016/J.LEARNINSTRUC.2007.09.018.
[82] Stevens AD. Social Problem-Solving and Cognitive Flexibility: Relations to Social Skills and Problem Behavior of At-Risk Young Children Associate Professor of Clinical Psychology Committee Member. 2009.
[83] D. Bavelier, C.S. Green, D.H. Han, P.F. Renshaw, M.M. Merzenich, D.A. Gentile, Brains on video games, Nat. Rev. Neurosci. 12 (2011) 368, https://doi.org/10.1038/NRN3135.
[84] D.R. Dajani, L.Q. Uddin, Demystifying cognitive flexibility: implications for clinical and developmental neuroscience, Trends Neurosci. 38 (2015) 571–578, https://doi.org/10.1016/J.TINS.2015.07.003.
[85] E.R. Hirt, E.E. Devers, S.M. McCrea, I want to be creative: exploring the role of hedonic contingency theory in the positive mood-cognitive flexibility link, J. Pers. Soc. Psychol. 94 (2008) 214–230, https://doi.org/10.1037/0022-3514.94.2.94.2.214.
[86] A.K. Barbey, R. Colom, J. Grafman, Architecture of cognitive flexibility revealed by lesion mapping, Neuroimage 82 (2013) 547–554, https://doi.org/10.1016/J.NEUROIMAGE.2013.05.087.
[87] Q. Chen, W. Yang, W. Li, D. Wei, H. Li, Q. Lei, et al., Association of creative achievement with cognitive flexibility by a combined voxel-based morphometry and resting-state functional connectivity study, Neuroimage 102 (2014) 474–483, https://doi.org/10.1016/J.NEUROIMAGE.2014.08.008.
[88] C.K.W. De Dreu, M. Baas, B.A. Nijstad, Hedonic tone and activation level in the mood-creativity link: toward a dual pathway to creativity model, J. Pers. Soc. Psychol. 94 (2008) 739–756, https://doi.org/10.1037/0022-3514.94.5.739.
[89] F.M. Der, M.A. Uy, C. Murnieks, Beyond affective valence: untangling valence and activation influences on opportunity identification, Enterp. Theory Pract. 39 (2015) 407–431, https://doi.org/10.1111/ETAP.12045.
[90] B.A. Nijstad, D.C. De, E.F. Rietzschel, M. Baas, The dual pathway to creativity model: creative ideation as a function of flexibility and persistence, Eur. Rev. Soc. Psychol. 21 (2010) 34–77, https://doi.org/10.1080/10463281003765323.
[91] J. Ratan, S. Dheer, T. Lenartowicz, Cognitive flexibility: impact on entrepreneurial intentions, J. Vocat. Behav. 115 (2019), https://doi.org/10.1016/J.JVB.2019.103339.
[92] D.A. Shepherd, Party on! a call for entrepreneurship research that is more interactive, activity based, cognitively hot, compassionate, and prosocial, J. Bus. Ventur. 30 (2015) 489–507, https://doi.org/10.1016/J.JBUSVENT.2015.02.001.
[93] T. Treffers, I.M. Welpe, M. Spörrle, A.O. Picot, The Role of emotions and cognitions in the pre-entrepreneurial process: what's new? Int. Stud. Entrepreneurship (2017) 243–259, https://doi.org/10.1007/978-3-319-45544-0_16.
[94] M. Daly, M. Egan, F. O'Reilly, Childhood general cognitive ability predicts leadership role occupancy across life: evidence from 17,000 cohort study participants, Leadersh. Q. 26 (2015) 323–341, https://doi.org/10.1016/J.LEAQUA.2015.03.006.
[95] M.D. Mumford, S. Connelly, B. Gaddis, How creative leaders think: experimental findings and cases, Leadersh. Q. 14 (2003) 411–432, https://doi.org/10.1016/S1048-9843(03)00045-6.
[96] R.G. Lord, C.L. De Vader, G.M. Alliger, A Meta-Analysis of the Relation between Personality Traits and Leadership Perceptions. An Application of Validity Generalization Procedures, J. Appl. Psychol. 71 (1986) 402–410, https://doi.org/10.1037/0021-9010.71.3.402.
[97] P.R. Merrifield, J.P. Guilford, P.R. Christensen, J.W. Frick, The role of intellectual factors in problem solving, Psychol. Monogr. Gen. Appl. 76 (1962) 1–21, https://doi.org/10.1037/H0093850.

[98] T.L. Friedrich, M.D. Mumford, The effects of conflicting information on creative thought: a source of performance improvements or decrements? Creat. Res. J. 21 (2009) 265–281, https://doi.org/10.1080/10400410902861430.
[99] G.M. Scott, D.C. Lonergan, M.D. Mumford, Conceptual combination: alternative knowledge structures alternative Heuristics, Creat. Res. J. 17 (2005) 79–98, https://doi.org/10.1207/S15326934CRJ1701_7.
[100] N. Muja, S.H. Appelbaum, Cognitive and affective processes underlying career change, Career Dev. Int. 17 (2012) 683–701, https://doi.org/10.1108/13620431211283814/FULL/XML.
[101] M.C. Pérez-López, M.J. González-López, L. Rodríguez-Ariza, Applying the social cognitive model of career self-management to the entrepreneurial career decision: the role of exploratory and coping adaptive behaviours, J. Vocat. Behav. 112 (2019) 255–269, https://doi.org/10.1016/J.JVB.2019.03.005.
[102] S. Yükçü, E. Kaplanoğlu, ÜİK e-Spor Endüstrisi, Uluslararası İktisadi Ve İdari İncelemeler Dergisi (2018) 533–550, https://doi.org/10.18092/ULIKIDINCE.435207.