Teenagers' Gaming Practices and Their Performance in STEM Courses

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Abstract - **Millions of teenagers worldwide choose digital games as their primary entertainment. Except amusement, gaming environments enhance the capacity of learning, as it has been proved by many studies. Gaming is the only activity that shows a constant positive coefficient between PISA test scores and intensity of use. This paper evaluates gaming habits in teenagers and analyzes the connection between students' performance in Science, Technology, Engineering and Math (STEM) courses and playing digital games. For the purpose of this paper, we surveyed 6th, 7th and 8th grade Croatian primary school students and evaluated their gaming culture. We analyzed their play time, genre of games they play, complexity of games and used platforms. The aim was also to gather data regarding their self-perceived gamer identity, i.e. do they feel like gamers, do they play alone or with others and their general attitude towards games. We compared the data gathered with students' grades in STEM related courses and analyzed the relationship of each variable separately to identify those who have the impact on their performance. Our results confirm that there is a partial positive relationship between increased gamer identity and success in STEM related courses.**

Keywords – gaming; gamer identity; STEM; students' grades

I. INTRODUCTION

Digital games are a source of primary entertainment for millions of children and teenagers worldwide. The amount of time spent playing is rapidly increasing, from 5.1h/week in 2011 over 6.5h/week in 2017 [1] to 12h/week in 2021 [2]. It has been shown that 89% of children (3-11 years) in Italy were video gamers, of which 19% are categorized as problematic. Although preferences differ by sex, children mostly play first-person shooters (31%), sandbox (14%) and management (11%) games [2].

Except for the obvious primary amusement factor, video gaming also has many secondary consequences. Numerous studies have proved the benefits of gaming, particularly improved spatial cognitive benefits, strategic problem solving, enhanced short-term memory, pattern recognition, focus and multitasking [4]. In 2009 Reeves, Brown, and Laurier [4] has shown that even occasional and amateur first-person-shooter players show improved reaction times, synchronizing movements and actions, sense of opponents' movements and team plays. Consequently, professional and competitive gamers have even greater skills. Because of their capabilities, they can even be included in solving problems that could not be solved by traditional or scientific methods. For example, gamers [5] discovered the correct molecular structure essential for designing drugs by playing "protein playing game", where other attempts had failed.

Numerous prejudices and stereotypes were and still are associated with gaming and gamers. For years gamers have been labeled as antisocial, childish and unsuccessful, and gaming was perceived as the notable cause of children's physical and psychical health problems. It is not so simple and straightforward, as children are influenced by many other factors at the same time. However, it is proven that excessive time in playing video games carries certain risk for the development of behavioral deviations. Internet Gaming Disorder and Gaming Disorder are recognized disorders and included in official psychological books and classifications [6][7].

Beside the previously mentioned effects, gaming can also be viewed from cultural, social and educational perspectives, which is a reason that video games have lately attracted serious academic attention. Recent advances in ICT have provided schools and educational institutions in general a possibility for applying new means of knowledge transfers, reviews and tests. Many studies analyze the effect of using games in the teaching process, particularly their influence on learners' mood, motivation, knowledge and grades or success. The whole new game category appeared - serious games are designed for an educational, rather than an entertaining purpose [8]. Gaming shows a constant positive correlation with PISA test scores, as proven by Biagi & Loi [9], Gubbels, Swart & Groen [10], Kong, Seo & Zhai [11] and many others.

Digital games expand target audience, providing a platform to reach nontraditional learners [12]. They are used to build academic skills in a positive way, because they (can) provide personalized learning material and instructions, learning alone, in groups or (competitive) teams and work collaboratively with different types of people, in different environments and learning conditions. They can develop critical thinking skills, especially when faced with different real-life concepts and situations, requiring them to play a certain role or interact with objects.

As gaming has become an important part of children's and teenagers' lives, many of them become members of cliques or gaming communities. The term gamer describes

a person who plays video games, but this is a different concept from a gamer identity, i.e., from a person who feels or thinks that he is a gamer. “How people identify as gamers, is a different question from who counts as a gamer” [13]. Griffiths, Moore, and Richardson 2007 [14] explored and quantified gamer identity through a series of interviews. Authors examine the relationship to gamer identity of the tested players, how players interact with game texts (identification and interaction), and their thoughts about media representation. Their research shows that objective metrics such as overall time spent playing, frequency of play etc. are not always correlated with one’s perception as a gamer.

One of the tools used for quantification of gamer motivations is Video game uses and gratifications instrument (VGUGI) [15]. VGUGI is a self-report assessment of different motivations underlying video game play. Gamer Identity Strength (GIS) has been introduced by Neys, Jansz, and Tan 2014 [16], which is based on social identity theory three groups of gamers were defined: hardcore, heavy and casual. Authors confirmed the self-reported labels by gamers through investigation of time and frequency played, but also other reasons given for a particular GIS label through classification using systematic content analysis. The central aim of research by De Grove, Courtois, and Van Looy 2015 [17] was to identify relevant indicators of why players attribute the category of gamer to themselves or to others. They presented a model for measuring gamer identity comprising factors such as frequency of play, degree to which gamer identity is attributed to friends, genre impact, frequency of game-talk etc.

A recent study by Howe, Livingston, and Lee 2019 [18] examined the hours spent in the game, the genre of games and the medium on which the players played, and it was concluded that there is a statistically significant difference between men and women, where men feel like gamers more often and spend more time playing games. Also, gamers who spent more time in the week playing games are also more likely to feel like gamers. As for the game genres themselves, the most gamers were found to be among people who play first-person shooters, role-playing games and sports games, which is a shift from previous research in which people who felt like gamers most often played MMORPGs.

Study by Dindar [19] examined the gender-based disparities in the video gaming habits of 479 high school students as well as the connections between video gaming, academic success, and complex problem-solving abilities (CPS). The characteristics of playing video games alone versus with a team, game experience, game time, game frequency, perceived gaming skills, and game type were all measured. CPS was assessed using data from the 2012 Creative Problem Solving section of the Programme for International Student Assessment (PISA). The results indicated that the sampled males spent more time playing video games than their female counterparts and had better expertise and skill in the field. Any correlation between the video game factors examined in the study and CPS or academic success was not found to be of practical importance. The resulting findings show that the transfer of gaming skills to real-world problem solving may not be as straightforward as is claimed in the literature and add to the sparse empirical evidence on the association between video gaming and CPS.

Smith & Mcgregor [20] define collaborative learning as „an umbrella term for a variety of educational approaches involving joint intellectual effort by students, or students and teachers together”. It usually involves students working in groups of two or more, allowing them to pool their skills and knowledge. Cooperative learning represents the most carefully structured end of the collaborative learning continuum. Collaborative learning techniques represent a significant shift from the traditional teacher or lecture centered contexts in the classroom.

Baek and Achraf [21] described an empirical study that examined gender differences in cooperative and collaborative social gaming in connection to accomplishments and attitudes. Additionally, it compared the learning outcomes achieved by students in cooperative versus collaborative digital game-based learning environments. In this study, 164 sixth graders from five separate classrooms at an elementary school in South Korea actively participated. Findings shows that male students exhibit more positive game attitudes in collaborative settings, whereas female students exhibit more positive game attitudes in cooperative settings, based on interaction effects. Furthermore, data indicated that regardless of the circumstances surrounding grouping, male students express higher favorable attitudes toward group work than female students. In terms of academic and gaming success, female students shown greater academic success under cooperative conditions, whilst male students demonstrated greater academic success under collaborative situations. According to the study's findings, gender-balanced groups do much better in collaborative gaming than cooperative gaming. According to research by Gupta, Manju, and Pooja [22], students who were taught using the cooperative learning strategies TAI and STAD outperformed the control group on the post-test, clearly demonstrating the superiority of cooperative learning over traditional methods of instruction. As a result, when compared to traditional teaching methods, cooperative learning was proven to be a more successful instructional paradigm for mathematics.

II. METHODOLOGY

The aim of this paper was to evaluate gaming habits in teenagers; their play time, genre of games they play, complexity of games [23] and used platforms. In addition, information about the participants' self-perceived gamer identities, including whether they play alone or with others and how they feel about games in general, was sought. To determine the factors that affect students' performance, we compared the data collected with their grades in STEM-related courses and examined the relationships between each variable separately. Three hypotheses were derived:

1. There is no statistically significant difference between students who feel like gamers and those who do not feel like gamers and their grades in STEM related subjects.

2. There is no statistically significant difference in students' preference for more complex games (role-playing games, strategy games, action games and first-person shooter games) and their grades in STEM related subjects.
3. There is no statistically significant difference between female and male respondents and their self-perceived gamer identity.

The questionnaire was a paper-and-pencil instrument administrated to participants at schools after obtaining the written consent of participants' parents. The participants were given all the instructions necessary for filling in the questionnaires. Participation in the survey was voluntary and anonymous.

The questionnaire was distributed between 286 13-15 years old students in 6st, 7th and 8th grade of primary education schools in Croatia in Zagreb, Čakovec and Petrinja. The first part of the questionnaire collected their demographic data as well as their grades in STEM related subjects; mathematics, chemistry, biology, physics and informatics. The participants also stated how many hours per week they play, which platforms they use as well as and which game genres they prefer.

The second part of the questionnaire consisted of 22 statements regarding the participant's self-perceived gamer identity. Participants specified their level of agreement with each statement on a five-level Likert scale: 1 – Strongly disagree; 2 – Disagree; 3 – Neither agree nor disagree, 4 – Agree, and 5 – Strongly agree.

III. RESULTS

Participants' demographic characteristics with regard to gender and age was following: Female participants: 50,/%, male participants: 49,3%; 6th grade: 40,9%, 7th grade: 33,6% and 8th grade: 25,5%.

Table 1. shows the average participants' marks in STEM subjects. It can be seen that there is a high average mark in individual subjects as well as the average success of students in all STEM related subjects. Because of that, it would be hard or unsuccessful to perform the analysis and correlations between students' success and other observed variables. So, the participants' success was recoded; they were given a lower success rate for each subject if they have a grade below the sample average, and a higher success rate if they have a grade above the sample average. Therefore, regarding success in STEM subjects, the respondents were divided into two groups, with lower and higher success.

TABLE 1. – MEAN VALUES OF STEM SUBJECTS

Independent variable	Mean
Informatics	4,86
Science (6th grade only)	4,28
Biology	4,17
Mathematics	3,95
Chemistry	3,82
Physics	3,79
Overall achievement in STEM subjects	4,2544

Self-perceived gamer identity was measured with a series of statements such as *I feel like a gamer*, *My friends see me as a gamer*, *Playing games is cool*, *I could not do without playing games*, *I believe that the knowledge I learned in games was useful in class*, *When I play with friends in a group, it is important for me to cooperate in order to win*, *I post my gaming endeavors on social networks (Facebook, YouTube, etc.)*, *I follow famous gamers on Youtube and other platforms* and similar where the participants can show how important gaming is in their lives.

The results show that more than 30% of participants play between 5 and 10 hours a week (Chart 1.), but also that about 25% of them play less than 1 hour a week and possible do not play at all, which is quite unexpected..

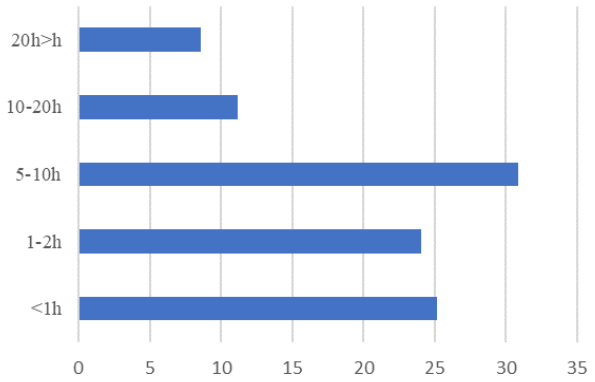

Chart 1. Hours spent playing games per week

Regarding devices they use for playing games the participants could choose one or more devices and the results showed that the majority of students use Smartphones followed by PC, while Wii and Xbox did not prove to be popular devices for playing videogames (Chart 2.)

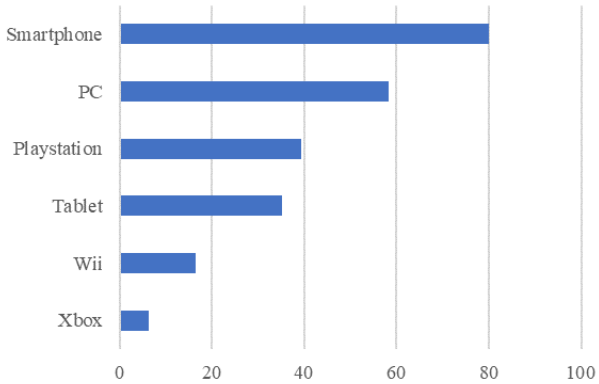

Chart 2. Devices used for playing games

Chart 3. shows the popularity of game genres among participants. The most popular genres seem to be Educational games (like Učilica, Sebran, Glaskalica and other ICT-AAC games) and Role playing games (like Witcher and World of Warcraft). Logical games (like Putt Putt and World of Goo), Simple online games (like Farmville) and Adventure games (like Life is Strange, Sherlock Holmes and Broken Sword) are approximately equally represented. Strategy games (like League of

Legends, Minecraft and Starcraft) and First-person shooter games (like Counter strike and Call of Duty) are played rarely.

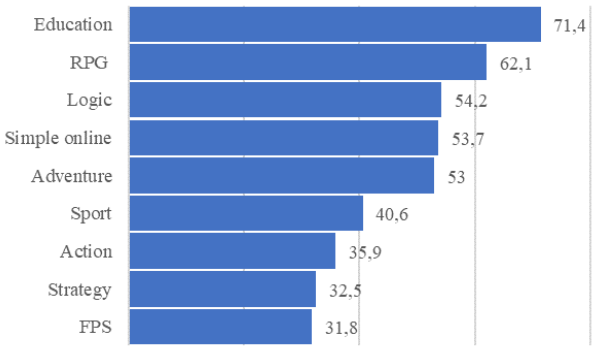

Chart 3. Percentage of game genres played by participants.

Regarding the **first hypothesis:** "There is no statistically significant difference between students who feel like gamers and those who do not feel like gamers and their grades in STEM related subjects" the results of the Mann-Whitney U (MWU) test of differences in the perception of oneself as a gamer showed that respondents with a lower level of success in STEM subjects attach more importance to cooperation with friends in order to win and that they more often put their gamer endeavors on social networks (Table 2.)

TABLE 2. DIFFERENCES IN SELF-PERCETION AS A GAMER WITH REGARD TO SUCCESS IN STEM SUBJECTS

When I play with friends in a group, it is important for me to cooperate in order to win.	Lower level	155,36	MWU	8451,5
			Wilcoxon W	23329,5
	Higher level	135,64	Z	-2,184
			Asymp. Sig. (2-tailed)	0,029
I post my gaming endeavors on social networks (Facebook, YouTube, etc.).	Lower level	151,18	MWU	8435,5
			Wilcoxon W	22970,5
	Higher level	135,12	Z	-2,015
			Asymp. Sig. (2-tailed)	0,044

The results also show that students with a higher level of success in the subject of physics statistically significantly more believe that the knowledge they learned in games was useful in class (Table 3.).

TABLE 3. DIFFERENCES IN SELF-PERCETION AS A GAMER WITH REGARD TO SUCCESS IN PHYSICS

The knowledge learned in games was useful to me in class.	Lower level	52,16	MWU	1323,500
			Wilcoxon W	2451,500
	Higher level	67,35	Z	-2,362
			Asymp. Sig. (2-tailed)	,018

Additionally, differences in gamer identity with respect to success in STEM subjects were examined separately for male and female respondents. The results showed that male respondents with lower success in STEM subjects give statistically significantly more importance to cooperation with friends in the group in order to win compared to male respondents with higher success. The results also showed that male respondents with higher success in STEM subjects statistically significantly more believe that playing games stimulates their imagination and that the knowledge learned in games was useful to them in class. Also, male respondents with higher success in STEM subjects feel statistically significantly more like gamers compared to male respondents with a lower level of success (Table 4.).

TABLE 4. DIFFERENCES IN SELF-PERCETION AS A GAMER WITH REGARD TO SUCCESS IN STEM SUBJECTS - MALE

When I play with friends in a group, it is important for me to cooperate in order to win.	Lower level	78,58	MWU	1979,500
			Wilcoxon W	5060,500
	Higher level	64,88	Z	-2,303
			Asymp. Sig. (2-tailed)	,021
I find that playing games stimulates my imagination.	Lower level	63,14	MWU	1962,000
			Wilcoxon W	3978,000
	Higher level	77,35	Z	-2,181
			Asymp. Sig. (2-tailed)	,029
The knowledge learned in games was useful to me in class.	Lower level	60,73	MWU	1812,500
			Wilcoxon W	3765,500
	Higher level	78,26	Z	-2,603
			Asymp. Sig. (2-tailed)	,009
I feel like a gamer.	Lower level	62,06	MWU	1895,000
			Wilcoxon W	3848,000
	Higher level	76,39	Z	-2,142
			Asymp. Sig. (2-tailed)	,032

Results also showed that when compared to female respondents with higher success in STEM subjects, female respondents with lesser success in STEM subjects were statistically significantly ($p<0,021$) more likely to think that playing games is just for boys.

From this we can conclude that the first hypothesis is partially refuted because for some STEM subjects there are statistically significant differences in the statements used to determine the gamer identity and male respondents with higher success in STEM subjects feel statistically significantly more like gamers compared to male respondents with a lower level of success.

Second hypothesis: "There is no statistically significant difference in students' preference for more complex games (role-playing games, strategy games, action games and first-person shooter games) and their grades in STEM related subjects." was partially refuted. In the entire sample, no statistically significant differences

were found in students' preference for more complex games (role-playing games, strategy games, action games and FPS games) and their grades in STEM related subjects. However, for male respondents with higher success in STEM subjects, there was a statistically significantly difference in the following (complex) genres they play: role playing games (p<0,004), strategy games (p<0,023) and adventure games (p<0,007) than male respondents with lower success in STEM subjects. For male respondents with higher success in mathematics, it was determined that they play role-playing games statistically significant (p<0,028) more often compared to male respondents with lower success in mathematics. By measuring the correlations between the perception of oneself as a gamer and certain types of games, positive correlations were found between the statement *I feel like a gamer* and the shaded statements about the game genres, which indicates that respondents who feel more like gamers choose the shaded (complex) games more (Table 5.).

TABLE 5. CORRELATIONS BETWEEN THE PERCEPTION OF ONESELF AS A GAMER AND GAME GENRES

Spearman's rho		I feel like a gamer.
Role playing games	Correlation Coefficient	,341**
	Sig. (2-tailed)	,000
	N	278
Strategy	Correlation Coefficient	,478**
	Sig. (2-tailed)	,000
	N	279
Action	Correlation Coefficient	,506**
	Sig. (2-tailed)	,000
	N	283
FPS	Correlation Coefficient	,513**
	Sig. (2-tailed)	,000
	N	282
Sport	Correlation Coefficient	,296**
	Sig. (2-tailed)	,000
	N	282
Logic	Correlation Coefficient	,116
	Sig. (2-tailed)	,053
	N	282
Adventure	Correlation Coefficient	,205**
	Sig. (2-tailed)	,001
	N	281
Education	Correlation Coefficient	-,080
	Sig. (2-tailed)	,180
	N	283
Simple online	Correlation Coefficient	-,042
	Sig. (2-tailed)	,487
	N	281
I like more complex games that require a lot of thinking and strategy.	Correlation Coefficient	,228**
	Sig. (2-tailed)	,000
	N	283
I like simpler games for relaxation and distraction.	Correlation Coefficient	,026
	Sig. (2-tailed)	,662
	N	281

Third hypothesis: "There is no statistically significant difference between female and male respondents and their self-perceived gamer identity" was refuted. The results of MWU test showed statistically significant difference (p<0,01) in the perception of oneself as a gamer regarding gender where male subjects perceive themselves as gamers statistically significantly more than female subjects in the following statements: *I think gaming is cool. I couldn't do without playing games. When I play with friends in a group, it is important for me to cooperate in order to win. When I play with friends in a group, it's important to me to be the best in the group. I feel like a gamer. My friends consider me a gamer. I post my gaming endeavors on social networks (Facebook, YouTube, etc.). Famous gamers are my idols. I follow YouTube channels of famous gamers.*

IV. DISCUSSION

Our results are mainly in accordance with the ones mentioned in the Introduction. While Donati, Alessia Guide et all. [2] report the average of 12h of playing per week, our results show 31% of teenagers play between 5 and 10h per week. The same authors report that more than 50% of teenagers play first-person shooters, sandbox and management games, we found out that teenagers mostly play education, role-playing and logic games. However, our results are in accordance with Howe, Livingston and Lee [16] who determined that people who felt like gamers nowadays most frequently play role-playing games. The same research showed that male participants more often feel like gamers and play more often, which was also indicated by our data. Reeves, Brown, and Laurier [4] showed many studies that proved the benefits of gaming, particularly improved spatial cognitive benefits, strategic problem solving, enhanced short-term memory, pattern recognition, focus and multitasking and Biagi & Loi [9] proved that gaming is the only activity that shows a constant positive coefficient between PISA test scores and intensity of use. We also partially confirmed those results by showing that male respondents with higher success in STEM subjects statistically significantly more believe that playing games stimulates their imagination and that the knowledge learned in games was useful to them in class and also, male respondents with higher success in STEM subjects prefer to play more complex games such as role playing games and strategy games. This conclusion is in contrast with Dindar [19] where no positive relationship between playing games and academic success was found.

When it comes to cooperation with friends respondents with a lower level of success in STEM subjects attach more importance to cooperation with friends and especially male respondents with lower success in STEM subjects give statistically significantly more importance to cooperation with friends. This is an interesting conclusion because according to Baek & Archraf [21] male students express higher favorable attitudes toward group work than female students and Gupta, Manju, and Pooja [22] demonstrated the superiority of cooperative learning over traditional methods of instruction. We draw the conclusion that students with lower success in STEM subjects prefer cooperation because it may help them learn more effectively. A paradigm shift in education is necessary because the advantages of collaborative learning have been established.

Regarding gamer identity Howe, Livingston, and Lee [18] proved that men feel like gamers more often and spend more time playing games which was also confirmed by our study. In light of this, we also came to the conclusion that male respondents who reported greater success in STEM subjects feel statistically much more like gamers than male respondents who reported lower success in STEM subjects.

CONCLUSION

The aim of this paper was to analyze teenagers' habits of playing video games and the connection between their performance in Science, Technology, Engineering and Math related courses. Our research showed that about one third of teenagers play between 5 and 10 hours per week, and mostly play educational, role-playing and logic games.

The three hypotheses we set were partially refuted. We determined that there partially exists a difference between students that feel and do not feel like gamers, and their grades in the STEM courses. Also, there partially exists a difference between preference for more complex games and their grades in STEM courses. The third hypothesis, that there exists no statistically significant difference between female and male respondents and their self-perceived gamer identity, was also refuted. More research is needed to further the link between gaming and success in STEM field, and to relate it with other levels of education.

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