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EDUCATIONAL POTENTIAL OF VIDEO GAMES FOR APPLICATION IN STEAM/STREAM APPROACH IN TEACHING

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Abstract: The paper analyzes the educational potentials of video games within modern teaching and learning approaches, such as STEAM and STREAM models. Video games are seen as products of the culture of the contemporary information society, which in interaction with children acquire new qualities, meanings, and potentials and can have significant educational value and application. The entire process that occurs in the child's interaction with the video game is considered, taking into account both the natural and social environment. The paper analyzes the potential of video games for developing a deeper understanding of the phenomena and processes occurring in nature and the systems of concepts, as well as for developing social relations, creativity, and emotions in children. First, the paper deals with the review and analysis of recent relevant research on the educational effects of video games, highlighting potentially positive effects for children's development, but also possible limitations and undesirable effects of the presence of video games in children's experience. The second section of the paper presents the results of the empirical research conducted with primary school teachers who use STEAM or similar approaches in their teaching on how they evaluate the pedagogical potential of video games. The preliminary results indicate that video games can be a very powerful medium in the effective implementation of the STEAM/STREAM model. The paper states that this is a very current topic that is constantly changing and that needs constant research and critical review.

Keywords: video games, STEAM/STREAM, educational potential, teaching methods, developing concepts

INTRODUCTION

The first video games appeared about sixty years ago in computer laboratories as a side effect of research and development of radar systems in the USA (Squire, 2005; Spring, 2015). During the last decades of the twentieth century, video games became commercial products, and today they are an important part of the daily life of children and adults.

Video games can be broadly defined as entertaining interactive computer programs that involve interaction between a device and a human (Ivory, 2015).

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There are many different definitions of computer games depending on which aspect of the phenomenon the authors attach more importance to. In the first studies focused on the impact of video games on children's behavior, the authors categorized video games according to the presence of violent or non-violent content (Dominick, 1984; Anderson & Ford, 1986), but later studies highlighted the division of video games according to their educational potential (Porter, 1995; Prensky, 2001), or according to the possibilities for the development of digital literacy (Gee, 2006). In recent years, authors have shown interest in video games that are purposefully constructed to have an educational character and can be used in school learning (Squire, 2005; Hayak & Avidov-Ungar, 2020; Kaimara et al. 2021).

Contemporary research in education emphasizes that the role of video games in STEAM (Science, Technology, Engineering, Arts, and Mathematics) and STREAM (Science, Technology, Reading, Engineering, Arts, and Mathematics) learning is increasingly recognized for its potential to enhance the effectiveness of education (Bayas et al., 2022). According to the recent research, video games offer an interactive and engaging platform that can foster critical thinking, problem-solving, and creativity among students (Kim & Bastani, 2017; Leavy et al., 2023). They provide immersive experiences that simulate real-world scenarios, making abstract concepts more tangible and accessible. In the context of STEAM/STREAM education, video games can serve as powerful tools for developing skills in programming, engineering design, mathematical reasoning, and artistic expression (Mayo, 2009; DeCoito & Briona, 2020). Therefore, it is right to assume that integrating video games with educational content can motivate and inspire learners, promote collaborative learning, and support the development of 21st-century skills essential for future success.

This study aims to explore the potential of video games in the implementation of modern teaching and learning approaches, such as the STEAM and STREAM models. As mentioned above, video games, as products of the contemporary information society, may help children to acquire new concepts, meanings, and ideas, offering significant educational value. The paper takes into account the entire process of children's interaction with video games, considering both natural and social environments. It analyzes the potential of video games to enhance understanding of natural phenomena and processes, conceptual systems, and the development of social relationships, creativity, and emotions in children.

The first part of the paper reviews and analyzes early and recent research on the educational effects of video games, highlighting both positive impacts on children's development and potential limitations and undesirable effects. The second part presents the findings of the empirical research designed as a survey questioning primary school teachers who use STEAM or similar ap-

proaches in their teaching. Also, the paper emphasizes that this is a dynamic and evolving topic that requires ongoing research and further critical review.

THEORETICAL BACKGROUND

Early Studies on the Effects of Video Games on Children's Behavior and Development

During the 1970s and 1980s, the first studies appeared that relied on then-dominant behaviorist learning theories, such as Alfred Bandura's learning theory (Bandura, 1977). The assumption of these studies was that video games, through the mechanisms of imitation and identification, can significantly influence the behavior of children and adults.

The conclusions of a study conducted in Georgia, USA, in which 250 high school students participated, linked aggressive behavior in adolescents with playing video games (Dominick, 1984). In a similar study, a group of authors from the New York College of Medicine conducted research on a sample of 208 male adolescents who answered questions about their experiences playing video games. The conclusions were that gaming serves to "relax" and has a "stress-relieving" and "blowing-out" effect (Kestenbaum & Weinstein 1985).

In experimental research conducted by Anderson et al., it was found that playing certain video games significantly increases the degree of short-term aggression and moderately affects anxiety, without a significant effect on the level of depressed mood in a sample of 60 university students (Anderson & Ford, 1986). In a study conducted by researchers at Utah State University on a sample of 160 students, it was found that students who played "violent video games" had less pronounced prosocial and helping behavior; the respondents engaged in cooperative and cooperative social interactions less immediately after playing these games, compared to a group of children who played video games identified as cooperative and non-violent. The same research showed that playing cooperative and non-violent video games encouraged prosocial and helping behavior in a group of children who played these types of games (Chambers & Askione, 1987).

At the end of the last century and the beginning of this century, the first studies appeared that indicated that video games can have a positive influence on the psycho-physical development of children and young people. Among the positive effects of video games on children with autism symptoms, researchers have highlighted the existence of visual schemes, fast interactive actions, and narrative elements that provide a basis for developing new and strengthening existing knowledge and skills (Porter, 1995; Edvardsen& Kulle, 2010).

Later research confirmed the therapeutic possibilities of video games in working with children who have developmental difficulties, namely in terms of the development of spatial coordination and orientation (Griffiths, 2003), then solving problems and understanding relationships (Hollingsworth & Woodward, 1993) and in the development of mathematical, especially arithmetic abilities (Okolo, 1992). Some authors have found a significant relationship between playing video games and the development of motivation to engage in school learning activities in children with various learning problems (Blechman & Rabin, 1986; Okolo, 1992).

Research conducted at the University of Nottingham has revealed that children and young people spend significant time playing video games, which hold substantial educational potential. To highlight the new qualities of video games, researchers coined the term "edutainment" media, which combines learning and entertainment (Griffiths, 2003). These researchers, who also examined the psychological mechanisms of pathological gambling, were the first to suggest that video games containing gambling-like elements can be linked to psychological addiction (Griffiths& Hunt, 1998). However, they noted that pathological discourse should consider micro and macro social contexts.

The use of video games in experimental pedagogical situations, where the focus is on learning through adventure and exploration, has been reported as a highly successful and advanced method with the potential for rapid expansion into formal and informal education systems. It has been established that educational content presented via computers can effectively supplement school curricula, and that video game-based programmed tasks can serve as an alternative to less popular homework assignments (Selwyn&Bullon, 2000).

Recent Studies on the Educational Potentials of Video Games

A characteristic of all the early research mentioned so far is that they were carried out by researchers who belonged to the generations of digital immigrants (Prensky, 2001), meaning they did not have extensive experience with video games by themselves. This is significant because recent research by younger scholars, who are more familiar with video games, has led to a significant shift in perspective on video games, information and communication technologies, and contemporary global culture (Squire, 2005; Gee, 2006). It is being increasingly recognized that video games can have substantial applications in education and that it is important to incorporate basic knowledge of educational video game design into teacher training programs (Foster & Shah, 2020). Furthermore, video games are frequently mentioned as an essential tool for developing specific talents and abilities in children identified by teachers as gifted (Budimir-Ninković & Stevanović, 2018).

Some research emphasizes that success in implementing video games in pedagogy requires an understanding of children's digital culture and their willingness to adapt the adult culture accordingly (Creeber & Martin, 2008). Studies analyzing the use of video games in educational practice have found that children, much like scientists, formulate hypotheses, discover laws, and encounter unanswered questions through gaming. Research has shown that children often learn facts, laws, and basic concepts earlier than what is outlined in the curriculum (Adachi & Willoughby, 2012).

These insights into the interaction between children and culture have led to a new approach in designing video games as educational tools. Several comprehensive studies have been published on the design and implementation of pedagogically effective video games (Edvardsen & Kulle, 2010). These studies highlight the importance of considering children's needs and their right to freely engage with the world around them. The authors stress that adults' perceptions of children's needs can significantly differ from the actual needs, emphasizing that video games are an intervention of adult culture into child culture, which must be considered in their design.

Recent findings on the potential effects of video games on the well-being of children and young people indicate that many games use manipulative techniques similar to gambling and are often targeted at young audiences (Molde et al., 2019). Although initial research on the link between gambling and video games appeared in the late twentieth century (Gupta & Derevensky, 1996), more contemporary meta-analyses on the use of gambling-based manipulative mechanisms in popular video games have been conducted only recently. These studies revealed that many game developers intentionally implement such mechanisms to ensure long-term player engagement and profit (Zendl, 2020). The public reaction to these findings led to changes in legislation in many countries regarding the creation and release of video games (Griffiths, 2018). These studies have also raised ethical concerns about the use of video games for various forms of manipulation of children (Shao & Henderson, 2021).

Multiple findings suggest that video games in STEAM education offer numerous benefits. They enhance student engagement by making learning enjoyable and motivating (Kim & Bastani, 2017; Bayas et. al., 2022; Leavy et. al., 2023. Video games provide interactive environments for experimentation and decision-making, deepening students' understanding of concepts. They foster essential skills such as problem-solving, critical thinking, and strategic planning, and simulate real-world scenarios, bridging abstract concepts with practical applications (Mayo, 2009; DeCoito& Briona, 2020). Some authors suggest that video games also encourage teamwork and communication through multiplayer settings and stimulate creativity and innovation in a risk-free environment.

They adapt to individual learning paces and styles, offering personalized feedback and challenges. The immediate feedback from games helps students learn from their mistakes quickly.

Additionally, video games involve coding and programming tasks, developing technical skills crucial for STEAM disciplines. They integrate multiple STEAM subjects, promoting cross-disciplinary learning and demonstrating the interconnectedness of different fields (Leavy, et. al., 2023). It may be assumed that video games provide a safe space for exploration and experimentation without real-world consequences, making them a powerful tool for dynamic and effective STEAM education.

Finally, it can be said that video games can be a valuable tool within the STEAM/STREAM approach, but they are also a complex social, cultural, economic, and psychological phenomenon that cannot be viewed monolithically, similar to music, film, or sports. Therefore, when determining the suitability of video games for educational practice, especially in the STEAM/STREAM approach, it is essential to consider the characteristics of the game itself, its content, themes, objectives, and various cultural, social, and individual factors.

RESEARCH METHODOLOGY

The basic problem that this research tries to engage in is to understand the perceptions of teachers who use STEAM/STREAM in their teaching practice, regarding the importance, roles, and effectiveness of video games. The study focuses on all video games that are available to children and that they independently choose, regardless of genre, features, and the type or nature of tasks. The idea is to approach video games as a general phenomenon that children and adults encounter daily.

The research specifically took into consideration the fact that teachers are not a homogeneous group when it comes to experience with video games, as well as that this topic gains importance in moments of the increasingly frequent application of distance learning and the rise of information technologies in education.

Bearing in mind the characteristics and complexity of the problem, it can be said that the aim of this research is to determine the opinions of STEAM/STREAM teachers about the possibilities of using video games in educational practice and their opinion on potential hazards for children's well-being.

Therefore, specific research tasks can be derived from the general aim:

- to determine to what extent teachers had direct experience with playing video games,

- to determine the level of positive or negative attitudes toward video games in the STEAM/STREAM approach,
- to determine the percentage of teachers who believe that video games can be used in the STEAM/STREAM approach, and
- to determine the opinions on the games' educational content application with the most educational potential.

The study uses a descriptive method and the data is collected via a survey. The Likert-type assessment scale with 16 items was specially constructed with Google Forms. The reliability of the scale is measured through internal consistency based on the average inter-item correlation and the value Cronbach's coefficient of 0.7942 shows that the scale can be considered reliable. The structure of the instrument was designed to contain three questions that collect basic data like age, gender, and years of service. 12 items were constructed in the form of statements about video games in the range of agreement from 1 to 5, where option 1 represents strong disagreement and option 5 strong agreement. The data collection was carried out in March–April 2024 and the survey was distributed via e-mail and through social networks and groups that bring together teachers and educators.

The sample consisted of a total of 116 teachers, who declared themselves as teachers who use the STEAM/STREAM approach, from 8 schools in 6 cities in Serbia (Belgrade, Kragujevac, Niš, Smederevo, Jagodina, and Paraćin), among whom there were elementary school teachers (1^{st} to 4^{th} grade) of N = 39, and middle school teachers (5^{th} to 8^{th} grade) of N =77.

It should be noted that one of the limitations of this study is that the survey was conducted via the Internet, which is more used by, conditionally speaking, younger teachers. It also can be stated that, having in mind structure of the participants, the findings reflect the opinions of the middle school teachers more than those who teach younger children.

DATA ANALYSIS AND DISCUSSION

One of the key data that can influence the opinion of teachers about the application of video games in STEAM/STREAM education is whether they play video games and how often they do so.

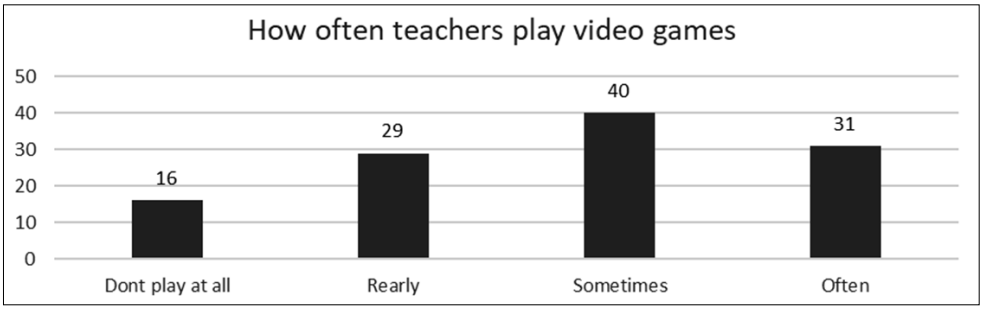

Chart 1: Structure of respondents according to how often they play video games

The obtained data indicate that the majority of teachers have had experience with video games, that is, that they have played video games. About two-thirds of teachers (N=71) belong to the category that plays video games often or sometimes. It should be noted that almost all respondents who play video games to some extent belong to the category of students or teachers with less than 5 years of work experience. 14 respondents, out of 16 who never play video games, are teachers who already work in schools and whose work experience exceeds 15 years. Considering these data, we can say that the majority of teachers have had direct experience with playing video games.

After examining to what extent teachers play video games in their free time, they were asked to express their degree of agreement to the claims that express the possible positive effects of video games on children's well-being.

Table 1. Degree of teachers' agreement with statements about the positive effects of video games.

No.	Statement	Do not play at all (n=16)	Rarely (n=29)	Sometimes (n=40)	Often (n=31)
1.	Video games are useful for acquiring knowledge	1.6	2.4	2.7	3.1
2.	Video games are useful for the development of thinking	1.5	1.6	2.0	2.9
3.	Video games are useful for developing social skills	1.4	1.5	1.8	2.5
4.	Video games are useful for language learning	2.9	3.0	3.4	3.6
5.	Video games are useful for spatial orientation	1.4	1.7	2.3	2.7
6.	Video games help children with developmental disabilities	1.9	1.7	3.2	3.1
/	**Average for all positive claims**	**1.8**	**2.0**	**2.6**	**3.0**

The data from *Table 1* indicate that all groups of teachers are very reserved in their attitudes on the positive effects of video games. The most affirmative attitude is held by teachers who play video games often, but it can also be characterized as mostly neutral. The positive effect of video games with which teachers agree the most is that "Video games are useful for language learning" and then that "Video games help children with developmental disabilities." The teachers generally agree that they do not see many positive effects of video games.

The following group of claims expresses the negative effects of video games on children's well-being.

Table 2. Degree of teachers' agreement with statements about the negative effects of video games.

No.	Statement	Do not play at all (n=16)	Rearly (n=29)	Sometimes (n=40)	Often (n=31)
1.	Video games are psychologically addictive	4.0	**4.3**	3.6	3.2
2.	Videogames encourage violence	**3.8**	3.7	3.3	2.8
3.	Video games evoke negative emotions	**3.1**	**3.3**	2.7	2.8
4.	Video games lead to antisocial behavior	**3.8**	3.6	3.3	3.4
5.	Video games can be a tool of manipulation	**4.2**	4.1	3.7	35
6.	Video games harm physical health	**4.5**	4.4	4.3	3.8
/	**Average for all negative claims**	**3.9**	**3.9**	**3.5**	**3.3**

The data show that teachers generally agree on the negative effects of video games, regardless of their group. Most believe video games harm physical health (e.g., eyesight, obesity, spine issues), can manipulate children, and lead to psychological addiction. There is slightly less agreement on video games inciting violence, causing negative emotions, and promoting antisocial behavior. Teachers who play video games sometimes or often are less likely to agree with the negative effects but still tend to have a neutral or moderate agreement.

The data presented in *Tables 1* and *2* indicate that there is a statistically significant difference (according to the t-test) between the groups of respondents who have had direct experience with playing video games and those who have not.

The research indicates a significant statistical difference in attitudes towards the positive effects of video games on children's well-being between frequent

players (N=31, score 3.0) and non-players (N=16, score 1.8) according to the t-test (t = 5.8928, df = 47, p<0.0001, sed = 0.203). When combining frequent players with occasional (N=44) and rare players (N=31), the difference compared to non-players remains significant (t = 4.3215, df = 118, p<0.0001, sed= 0.174), though the average score drops to 2.6. This suggests a proportionality between personal experience with video games and a positive attitude toward their educational potential. Future and current teachers with direct video game experience generally view their effects positively, but the overall average score remains below 3.0.

Teachers who play video games are somewhat less critical of their negative effects, though, in certain statements (5 and 6), their opinions align closely with non-players, who hold very negative views. The statistical analysis shows a significant difference in opinions between frequent players (N=31) and non-players (N=16) (t = 3.9313, df = 47, p=0.0003, sed = 0.203). When combining frequent, occasional, and rare players, the statistical significance remains at the p=0.05 level but is lost at the p=0.01 level (t = 2.1667, df = 119, p=0322, sed = 0.184). For statement 5 alone, the significance is marginal (p=0.0559). This suggests differences in opinions about negative effects exist but are not as pronounced as those for positive effects. Most respondents agree that negative effects are significant and more pronounced than positive ones.

In accordance with the set goal and tasks of the research, it was crucial to examine what teachers think about the possibilities of applying video games in the STEAM/STREAM teaching approach. Teachers were asked several questions referring to the teaching contents that video games are pedagogically useful for. The following chart summarizes the teachers' opinions.

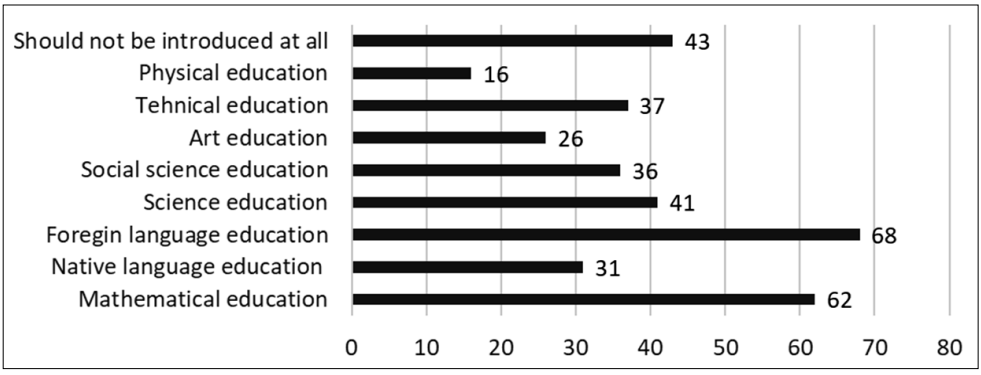

Chart 2: Educational STEAM/STREAM contents in which video games should be introduced (multiple answers possible)

Regarding the introduction of video games in teaching STEAM/STREAM content, especially during frequent remote teaching, over a third of respondents

(N=43) do not agree. Most negative responses came from teachers who do not play video games (N=16), but also from those who rarely (N=15) or occasionally (N=11) play them. However, about two-thirds (N=72) believe video games can be used in some teaching content. Most teachers (N=68) support using video games in foreign language teaching, followed by mathematics (N=62). Fewest teachers think video games are suitable for physical and health education, aligning with their concerns about video games' negative impact on health.

The results of this study are limited in terms of generalization due to the nature of the phenomenon, sample, and research circumstances. However, they align with the recent findings (Mayo, 2009; Squire, 2015; Kim & Bastani, 2017; DeCoito & Briona, 2020; Bayas et al., 2022; Leavy et al., 2023;), which increasingly view video games as a STEAM/STREAM pedagogical tool. Studies have shown that the inclusion of video games in the school curriculum enhances student participation, peer cooperation, problem-solving, and self-evaluation (Squire, 2015). Teachers with video game experience and more advanced professional careers have a more positive attitude towards using video games in education (Hayak & Avidov-Ungar, 2020), consistent with the findings that video games are used in the education of children with special abilities, supported by specially trained teachers (Budimir-Ninković & Stevanović, 2018). Recent research indicates that the main obstacles to using video games for educational purposes are insufficient information, lack of personal experience, and lack of ICT knowledge and skills among students (Kaimara et al., 2021). The findings support the idea that basic knowledge and principles of STEAM/STREAM learning through video games should be integrated into initial teacher education (Foster & Shah, 2020). Further research should explore how educational video games contribute to better school learning and overall children's well-being.

CONCLUSION

In addition to extensive scientific literature from the seventies and eighties on mostly harmful connections between video games, behavior, and educational effects, the topic remains very relevant for many researchers in education and social sciences today. The recent social and economic changes, along with the increased use of information technologies in education and the shift to distance learning, have led to a change in perspective favoring more positive aspects regarding video games.

The empirical research presented in this paper shows that most STEAM/STREAM-oriented teachers recognize the pedagogical potential of video games to some extent. They see benefits such as aiding the adoption of conceptual and functional knowledge, enhancing thinking, cooperation, social skills, language

learning, and spatial orientation, and helping children needing additional support. However, teachers generally have a skeptical or neutral attitude towards the positive effects of video games on children's well-being and agree more on the possible negative impacts.

The positive effects highlighted here include foreign language learning, mathematical skills, and support for children with developmental disabilities. The negative effects noted are risks to physical health, manipulation of children, and psychological addiction. Teachers who play video games themselves have a slightly more positive attitude but still express significant concerns about the impact on children's well-being.

Due to the nature of the phenomenon and the influence of many factors, this paper cannot cover all important issues regarding the relations between video games and STEAM/STREAM education. One limitation of this research is that the survey was conducted online, primarily reaching younger teachers. Additionally, the findings mainly reflect the views of teachers of 5th to 8th graders, rather than those working with younger students. Finally, it should be noted that the participants' structure and limitations of the research method make it difficult to generalize the results. Therefore, this research should be seen as a starting point for further studies examining specific aspects of the educational potential of video games in STEAM/STREAM education.

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