

The Development of Esports Research and Technology in the Last 3 Decades

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Abstract – This study aims to analyze and evaluate the research and technology developments of esports in the last 30 years. 1188 Scopus articles were analyzed using VOS viewer computer software. The literature review was analyzed systematically following PRISMA guidelines. The analysis results show computer science, social sciences, and medicine are the fields of study most often associated with esports. The keywords "Esports" and "Human" are the main focus, indicating attention to the interaction between users and technology in gaming. In conclusion, esports have become more than just a game, but a complex social and technological phenomenon with broad impacts.

Keywords – Gaming technology, gaming innovation, esports, bibliometric research.

1. Introduction

Video games are starting to develop and become a new form of entertainment for people, especially children and teenagers [1].

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The development of video game began in 1995 through a device called a computer. Technological developments that occur from year to year are the basis for the emergence of video games [2]. The ongoing developments between technology and video games have had a significant impact on the modernization of video games [3]. In the beginning, video games only had low resolution graphics, but today there are many video games with high resolution graphics [4]. The graphic resolution has been updated to reflect real-life conditions more accurately [5]. Sophisticated technology and extraordinary computer systems are needed to create these graphics [6].

Video games with high and extraordinary graphics require a fast and stable Internet network [7]. The Internet network is also used as a link or means of communication when playing video games between one player and another [8]. Apart from that, it can be supported by using online streaming platforms to increase relationships and improve communication [9]. Online streaming platforms can also be used as a medium for studying a video game through games played by professional players [10]. The development of professional players who are born through online streaming platforms has also encouraged the development of video games which were initially just entertainment to become a competition event [11]. This competition continues to develop through video games, creating a new sport by adapting to the era of digitalization which is now known as esports [12]. The 21st century is a time where technology, the Internet networks, and video games are developing more rapidly [13]. Android devices or mobile phones are proof that developments have occurred, until finally a new branch of esports has emerged, namely Mobile Esports [14].

Esports continues to experience development with various competitions emerging every year [15]. Regional, national and international competitions are held regularly to develop and introduce esports to the public [16]. Competitions that continue to emerge have influenced the emergence of teams consisting of professional players [17]. Apart from that, organizations tasked with overseeing and managing the world of esports have also begun to be established [18]. In Indonesia, PBESI (Pengurus Besar Esports Seluruh Indonesia) is an organization tasked with managing and developing esports in Indonesia.

Along with the growth of esports a number of worries and issues appear, including player weariness, gaming addiction, and the requirement for uniform laws that have evolved as this business grows [19]. Experts and researchers have been working hard to address these issues, offering insightful information on how to promote player welfare, encourage responsible gaming, and create industry-wide ethical standards [20].

Scholars have investigated the psychological, physiological, and sociocultural elements of competitive gaming in depth [21]. Because esports research is multidisciplinary, it has shed light on topics including player behavior and skill development [22], and the impact of long gaming sessions on health [23]. In addition to expanding our knowledge of esports, this research has produced insights into fields like psychology, sports science, and education [24], [25].

The lines between the actual and virtual worlds are becoming more and more blurred as a result of research advancements in technology domains like augmented reality (AR) and virtual reality (VR) [26], [27]. This potential is also supported by technological advances based on artificial intelligence (AI) [28]. The development of research and technology in esports is very interesting and varied. Therefore, the author is interested in conducting bibliometric research to explore research trends on esports to evaluate its development in the last 30 years and find new things that allow it to be developed. This bibliometric research aims to:

1. To analyze esports research and technology document in the last 30 years.
2. To evaluate the most countries esports research and technology in the last 30 years.
3. To discover the subject areas related esports research and technology in the last 30 years.
4. To analyze the keyword trends of esports research and technology in the last 30 years.
5. To analyze the top 10 cited publications of esports research and technology trends in the last 30 years.

2. Methodology

This type of research is a bibliometric analysis and systematic review. Article searches were carried out using a comprehensive strategy on SCOPUS research journal databases. The keyword used was “esports”. 1188 articles from Scopus were mined on December 2nd, 2023, and selected for further analysis by using VOS viewer computer software. There were 10 articles selected as the most cited articles which were selected for this systematic review. For standard operationalization, this study follows the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA).

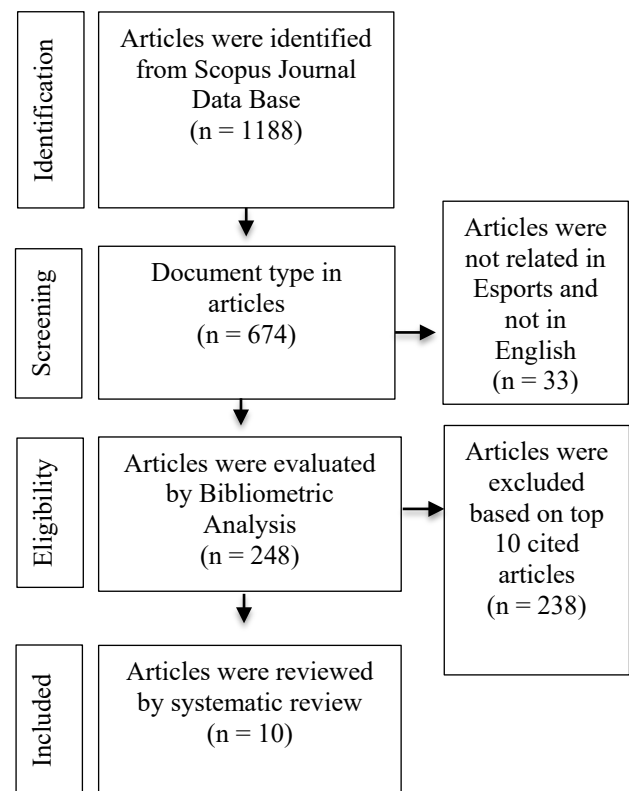


Figure 1. PRISMA flowchart of the article selection process

3. Results

The systematic review results, obtained using the PRISMA method, are presented in several subchapters based on the PRISMA flowchart. This study addresses five main topics of concern. (1) Esports Document in the Last 30 Years, (2) Country Contributed to Esports in the Last 30 Years, (3) Subject Areas Related to Esports Research in the Last 30 Years, (4) Keyword Pattern Related to Esports Research in the Last 30 Years, and (5) Top 10 Cited Publications of E-Sport Research in the Past 30 Years. The data was collected and presented in a table, and then analysed based on the subject matter.

3.1. Esports Documents in the Last 30 Years

Esports publications have undergone significant development in the last 30 years (Table 1). In 1994-2002, no research was conducted on esports. Then, in 2003 to 2005, esports research began to be conducted. This was evidenced by one study with 22 citations, with an average citation of 11.50. However, in the following years, namely 2006-2008, no research was conducted again to develop esports as a whole. In 2009-2011, research resumed and continued to grow significantly from year to year. In line with this, esports research began to grow rapidly in the 21st century, coinciding with the rapid development of technology.

Table 1. Document of esports in the last 30 years

Year	<i>f</i>	Total Cited	Average Cited
1994-1996	0	0	0.00
1996-1999	0	0	0.00
2000-2002	0	0	0.00
2003-2005	1	22	11.50
2006-2008	0	0	0.00
2009-2011	1	15	8.00
2012-2014	7	317	162.00
2015-2017	47	2117	1082.00
2018-2020	345	8463	4404.00
2021-2023	786	2940	1863.00
Total	1188	13874	7530.50

A significant increase occurred in the 2021-2023 range, with 786 studies, 2940 citations, and an average citation of 1863.00. The number of citations increased significantly between 2015-2017 and 2018-2020, from 2117 to 8463 with an average citation of 4404.00. This shows that research conducted in 2021-2023 cited many studies from 2018-2020. In addition, the impact of the pandemic in early 2020, also had an influence in encouraging digitalisation which ultimately had an impact on the development of esports. The development of esports-related research in the last three decades has produced 1187 studies. The total number of citations is 13874 and the average citation is 7530.50. The wide range of disciplines that can be related to esports influences the high number of citations of esports research.

3.2. Country Contributed to Esports in the Last 30 Years

In the last three decades, esports publications have increased significantly (Table 2). The United States leads with the highest number of publications, namely 334 articles, which have collectively been cited 3826 times. This reflects a very high average of citations per article, namely 2080.00, indicating the great influence of research carried out by

academics and researchers from that country in the field of esports. The United Kingdom comes in second with 110 studies. Although there are fewer studies than the US, the number of citations is not much different. There are 3375 citations with an average citation of 1742.50, showing that the UK also plays an important role in esports research. China has also contributed to the esports literature, with 67 publications that have been cited 423 times. Although the total number of citations is lower compared to the United States, the increasing interest from China shows the growth of esports in Asia.

Table 2. Top 10 countries that contributed to esports in the last 30 years

Country	<i>f</i>	Total Cited	Average Cited
United States	334	3826	2080.00
United Kingdom	110	3375	1742.50
Australia	96	1554	825.00
Germany	90	1060	575.00
Spain	75	485	280.00
China	67	423	245.00
Russian Federation	55	356	205.50
Finland	53	1932	992.50
Canada	48	425	236.50
South Korea	45	521	283.00
Total	973	13957	7465.00

Canada and Australia also contribute to e-sports research. Canada had 48 publications cited 425 times and Australia with 96 publications cited 1554 times. These two countries show that esports is a global phenomenon that attracts attention in various parts of the world. Meanwhile, other European countries such as Germany, Spain, Russia, and Finland as well as Asian countries such as South Korea also made important contributions, with total citations showing the existence of an active and influential research community in esports. Overall, the 973 publications produced by these ten countries have been cited 13957 times, with an average citation per article reaching 7465.00. This shows that esports are not just a cultural or economic phenomenon, but also a serious academic subject with significant and growing global influence in scientific research.

3.3. Subject Areas Related to Esports Research in the Last 30 Years

Esports research has expanded widely and crossed various disciplines over the last 30 years (Table 3). Computer science is the field of science with the largest share in esports publications, with 462 articles generating a total of 4488 citations and a high average of citations per article, namely 2475.00.

It indicates a close relationship between esports and the development of computer technology, especially in the context of game design, data processing, and network infrastructure. Social sciences also occupy an important position with 394 publications and a total of 4059 citations, resulting in an average citation per article of 2226.50. This reflects a great interest in the social and cultural aspects of esports, including player behavior, communities, and the social impact of games. The medical and health profession field, with 189 and 133 publications, shows that there is serious research regarding the impact of esports on health, such as ergonomics, mental health, wellbeing and the potential use of esports in therapy.

Table 3. Top 10 subject areas that contributed to esports in the last 30 years

Subject Area	<i>f</i>	Total Cited	Average Cited
Computer Science	462	4488	2475.00
Social Sciences	394	4059	2226.50
Medicine	189	1479	834.00
Psychology	176	3340	1758.00
Business, Management and Accounting	169	2386	1277.50
Engineering	149	585	367.00
Health Professions	133	868	500.50
Arts and Humanities	114	2317	1215.50
Mathematics	73	176	124.50
Economics, Econometrics and Finance	56	1137	596.50
Total	1915	20835	11375.00

Psychology is another significant field with 176 publications being highly cited 3340 times, giving an average citation per article of 1758.00. This indicates an in-depth exploration of the psychological aspects of esports, including motivation, competition, and team dynamics. Business, management, and accounting as well as economics, econometrics, and finance are interrelated subject areas. The number of publications 169 and 56, respectively, shows that these subject areas play an important role in the promotion of esports to the public and enthusiasts. Competitions and technology development for esports require these two subject areas as stakeholders. Meanwhile, fields such as engineering, arts and humanities as well as mathematics, also show substantial contributions with publications ranging from 73 to 149 articles and significant total citations, indicating that esports is considered relevant in various aspects of life and knowledge.

3.4. Keyword Pattern Related to Esports Research in the Last 30 Years

In the last three decades, keywords related to esports have shown various aspects of research developing in this sector (Table 4). The keyword "Esports" itself is naturally the most dominant, with 422 articles using this term, showing a very high total citations, namely 3717. This reflects a paradigm shift where esports are recognized as a significant field both in the context of competitively and as a research subject, with an average citation per article reaching 2069.50. "Video Games" as the foundation of esports, became a keyword in 164 articles with a total of 4157 citations and an average of 2160.50, reflecting the importance of games as the main medium of esports. "Sport" as a keyword in 116 articles shows that esports are often studied in relation to traditional sports, with total citations reaching 1099 and average citations of 607.50, indicating the recognition of esports as a form of competition.

Table 4. Top 10 keyword patterns in esports in the last 30 years

Keyword Patterns	<i>f</i>	Total Cited	Average Cited
Esports	422	3717	2069.50
Video Games	164	4157	2160.50
Sports	116	1099	607.50
Human Computer Interaction	103	1523	813.00
Humans	86	3087	1586.50
Gaming	52	461	256.50
Electronic Sports	52	722	387.00
Human Experiment	50	3020	1535.00
Performance	48	446	247.00
Controlled Study	47	430	238.50
Total	1140	18662	9901.00

The keyword "Human Computer Interaction" (HCI) was found in 103 articles with a total of 1523 citations, indicating that human computer interaction is a key aspect of the esports experience, with implications in game design and ergonomics. "Human" was used in 86 articles, indicating that humans as players and as research subjects are very central in esports studies, with a total of 3087 citations and a high average citation of 1586.50. This emphasizes that esports is not only about the game, but also about the players, including psychological, physiological and social aspects. "Gaming" and "Electronic Sports" have the same number of publications at 52 studies with 461 and 722 citations respectively. This indicates that the habit of playing online games (gaming) or electronic sports, has an influence on esports research.

On the other hand, "Human Experiment", "Performance", and "Controlled Study" are evidence of the influence of gaming behaviour and electronic sports. Based on the number of research 47-50 publications, it shows that esports can be viewed from the gaming habits researched through experimental studies. The high number of citations from "Human Experiment", which is 3020 times, is evidence of this statement.

Theme and keyword interactions in esports research show the relationship between various concepts related to esports (Figure 2). The themes of "performance" and "participant" were grouped into one cluster, indicating an inherent connection. The keywords shown in the "performance" theme, namely "ability", "esports athlete", and "health" define these three things as important and influential in the performance of esports athletes. The keywords "attitude", "behavioural intention", and "consumer" in the "participant" theme show how esports enthusiasts behave in their participation in esports. The performance shown by esports athletes will affect the participation of esports enthusiasts.

On the other hand, both themes are related to the keywords "cognitive function", "burnout", and "gaming disorder". This is because the performance and participation of esports will affect the psychology of athletes and enthusiasts through the victories and defeats experienced. The theme "industry" with the keywords "entertainment", "esports research", and "esports industry" shows how the world of esports has grown significantly. Social media plays a role in the entertainment world in providing information to various groups. The research conducted serves as an evaluation for esports activists. The esports industry will also be involved in the development of esports, because of the role of the two stakeholders in advancing the world of esports.

The keywords "athlete", "career", "adolescent", and "male" mean that esports athletes are dominated by adolescent boys. There are many male athletes pursuing their careers in esports. This also shows that the participants in the study are dominated by adolescent boys. The interaction between these themes underscores the multidisciplinary nature of esports research, encompassing social, technical, physical, health and professional elements.

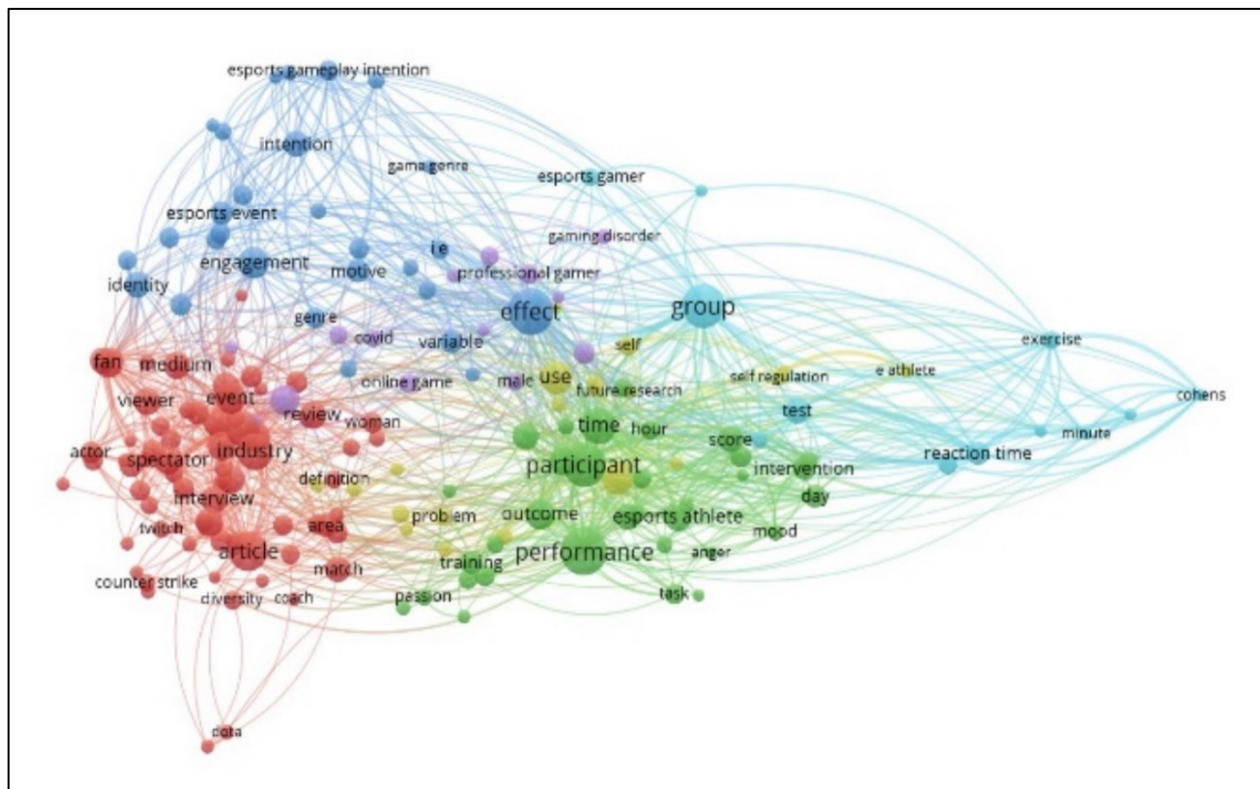


Figure 2. The Visualization of esports keywords and theme interaction

3.5. Top 10 Cited Publications of Esports Research in the Past 30 Years

Table 5. Top 10 cited publications of esports in the last 30 years

Author	Total Cited	Research Purpose	Method	Results
[29]	482	Investigating the reasons why people spectate esports online.	Survey	It was discovered that factors such as escape, learning about the games being played, novelty, and the aggressiveness of esports athletes significantly predicted the frequency of esports viewing.
[30]	251	Encourage discussion on the accepted academic definitions of sport and whether esports should be classified as a sport.	Descriptive	Determining whether esports can be classified as a sport is a matter of interpreting the nature and historical definition of sport. Esports involves games, rules, and skills, and has a large following, despite the absence of physicality and institutionalisation.
[31]	150	This text reviews the main psychological topics related to esports and examines the similarities between esports and professional and problem gambling.	Literature Review	Professional video game play and provides initial insights into the psychology of esports players. The future research should focus on the psychological vulnerabilities of esports players.
[32]	145	Review different fields to understand the current state of esports academic research and identify converging research trends across different fields.	Literature Review	The study of esports is distinct in that it spans several disciplines. There are chances to include several fields into its theoretical and methodological foundation.
[33]	131	To investigate the new phenomena of organized, competitive computer game play known as electronic sports or esports, by providing a fresh understanding of esports as a collection of consumer behaviors.	A three-stage iterative	Our findings demonstrate that, in spite of the increasing interest in computer game consumption, the entertainment software industry's primary marketing and consumer behavior challenges remain largely unaddressed.
[34]	130	Examining the functions of different stakeholders within the actors' value network in esports.	Descriptive	The cooperative endeavors of gaming businesses, players, online communities, regulatory authorities, and numerous other stakeholders are crucial in enhancing and maintaining the experiential worth of engaging with esports.
[35]	129	Evaluates the impact of popular sport consumption reasons on esports viewership and game attendance frequency.	Survey	Traditional sports and esports are consumed in a similar way, suggesting that sports industry professionals can manage and market esports events in a similar way to traditional sports events.

Author	Total Cited	Research Purpose	Method	Results
[36]	118	Examines the relationships between a range of gambling activities and the consumption of video games in general, and the emerging phenomenon of esports in particular.	Survey	Modern video games do not, by themselves, raise the risk of problematic gambling; in fact, it is debatable whether issue gaming and problem gambling are inherently related.
[37]	82	Esports require the learning and performance of motor skills, and this embodiment within a virtual environment can be considered playful or even athletic.	Descriptive	There are good conceptual reasons to consider the skills learned in esports as FMS. However, we do not conclude that these skills should be learned in physical education.
[38]	82	This study focuses on the experiences of female gamers in the male-dominated esports industry with regards to both positive and negative feedback as well as sexual harassment.	Observation and Survey	Study 1 suggests a diverse experience for women in competitive online gaming, with minimal gender differences in criticism and a higher incidence of praise from same-sex players. Meanwhile, Study 2 reveals an escalation of sexual harassment directed at women streaming on Twitch. Despite a higher frequency of positive comments, many are centred on physical appearance.

The discussion of the 10 publications in esports with the most citations in the last 30 years can be categorized into three discussion themes, namely: (1) Social Behaviour and Community, (2) Esports and Physicality, and (3) The Relationship Between Gambling and Esports. Each of these themes describes a different aspect of esports and reflects the complexity and depth of this field.

3.5.1. *Social Behaviour and Community*

The behaviour exhibited by esports supporters is based on the games they are interested in and the appeal of the games themselves [29]. This has led to the emergence of social behaviour with the result that a community of various esports genres has emerged. The surge in market demand for the entertainment software industry is a problem that arises from this social behaviour [33]. This phenomenon illustrates that the world of esports is starting to grow rapidly. The role of various stakeholders such as the government or business people is needed to support this development [34]. The overall marketing of esports is done using the same methods as sports marketing in general [35]. This is because people have the same way of attracting sports that suit their tastes.

On the other hand, the significant development of esports has brought about a significant development of the digital era. Therefore, negative impacts such as inter-gender sexual violence occur in social practices in esports [38].

3.5.2. *Esports and Physicality*

Research by Jenny et al. [30], explains how esports has become a social debate within academia. The debate arises because esports is defined as a sport that does not have a physical aspect to it. Despite these shortcomings, esports is categorised within the scope of sports because it is considered to have rules, special skills in playing it, and many enthusiasts. As with the research conducted by Hilvoorde and Pot [37], physical learning needs to be an important consideration for esports activists. Fundamental movement skills are an alternative for esports development in the realm of physicality.

3.5.3. *The Relationship Between Gambling and Esports*

Gambling has become so common these days, it's no wonder that in esports there are indications of gambling practices being carried out. Banyai et al. [31] said, playing esports does not rule out the possibility of gambling practices occurring.

Esports does not independently increase gambling practices, but the concern is whether esports and gambling are inherently related [36]. Banyai et al. [31], suggested that future research should focus more on the psychology of esports players rather than gambling practices. Supporting this, research Reitman et al. [32], prove that esports has a wide range of interrelationships with various disciplines. Starting from the fields of business, sports science, law, informatics, sociology, and so on. Thus, the research trend of esports will be more widespread and developed.

4. Discussion

Technology research and development in esports helps players learn more effective game strategies, data analysis, and use of appropriate equipment [39], [40]. Research and technology also helps in the development of better gaming equipment, such as mice, keyboards, and specialized headsets, which can improve player comfort and performance [41], [42].

Technology in esports has a key role in creating an interesting and memorable viewing experience [43]. The use of advanced cameras, realistic graphics and expert commentary makes the esports viewing experience even more interesting [44]. Developments in research and technology have also brought advancements in live streaming allowing viewers around the world to enjoy esports matches live via online platforms [45], [46].

Esports must strengthen its security and integrity in order to handle issues like match manipulation and fraud [47]. To identify and stop game cheating, computer security systems and artificial intelligence algorithms were used to create security protection measures [48]. In the field of esports, technological advancements and research have the ability to uphold professionalism and foster audience trust [49].

A technique for measuring and evaluating scientific publications in a certain topic is called bibliographic research. Esports is just one example of the technological advancements for which bibliometric research has recently grown in importance as a tool for analysis. Since the early 2000s, electronic sports, or esports, have grown quickly. We can comprehend study patterns and technological advancements in esports during the last thirty years thanks to bibliometric research.

Esports first appeared and gained popularity in the gaming community throughout the first ten years, from 1994 to the beginning of 2003 [50]. Initial studies were carried out at this time to comprehend the effects of esports on young people, the possibilities for competition, and technological advancements [51].

These studies offer preliminary recommendations regarding the integration of technology into the expanding esports community.

The academic community started to pay more attention to esports in the second decade, which ran from 2004 to early 2013. The development of esports contests and infrastructure has been made possible by the advent of the internet and new technologies [52]. This era of research centers on the characteristics of esports athletes [53], the role of the technology in the gameplay [54], and the effect of esports on human wellness and behaviors [55]. This study demonstrates a strong correlation between the psychological and social effects on people and the usage of technology in esports.

From the third decade of 2014 until the present, there has been a notable surge in research on esports, which has peaked. During this time, esports became acknowledged on a global scale as a respectable and legitimate sport. Numerous investigations were carried out to determine the variables that impact player performance, gaming algorithms, and comprehensive data analysis [56]. Research subject areas were psychological [57], technology [58], and the esports economy industry [59]. In an increasingly digitally connected world, esports continues to develop and attracts the interest of researchers from various scientific disciplines [60]. This research provides a deeper understanding of the technical and strategic aspects of esports, thereby helping to develop better technology and effective gaming strategies.

5. Conclusion

Technology advancements and research in the field of esports play a critical part in fostering the growth of esports. Enhancements in player performance, enhanced visual experiences, and heightened security and integrity are all possible thanks to research and technological advancements in esports. Therefore, research in esports and technological advancements must continue to develop research in this field of esports. The symbiotic relationship between research and technology has pushed esports towards greater popularity. This gives an idea of the endless possibilities that will occur in esports. The esports phenomenon has now also been categorized as a cultural phenomenon with widespread impacts. This is both an opportunity and a challenge for the direction of research and technology development in esports in the future. Research that looks at cultural aspects as a variable in esports research can have the potential to overcome problems and concerns in society.

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