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Virtual Reality Applications Market Analysis—On the Example of Steam Digital Platform

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Abstract: This paper presents research on the topic of virtual reality (VR) applications. It conducts a quantitative analysis of virtual reality applications available in the international market using the example of a digital platform, which was the Steam platform. The study presents and analyzes data on the number of applications in the selected categories, such as genres, types of headsets, and language. The research also includes the analysis of the top-rated VR applications, their reviews, and their features, recognized based on the tags describing them. Additionally, the article provides and systematizes new knowledge about the VR applications environment. Based on the results, it was concluded that the most numerous group of VR applications was action applications, and they account for more than half of all VR apps (51.22%). Following this, there were casual games (40.78%) and then simulation VR apps (37.35%). Referring to the results of the top-rated VR applications ('overwhelmingly positive' status on Steam), there were only two apps with a result of 98% (the highest rated) positive feedback: Half-Life: Alyx, the action and adventure app, which is a shooter described as zombie horror, and Walkabout Mini Golf VR, a casual and minimalist sport application. When it comes to the analysis of the tags of the top-rated VR applications, the most repeated tags, despite the 'VR' tag, included 'first-person' and 'singleplayer' (occurred in the descriptions of 68% of the applications).

Keywords: virtual reality (VR); digital platform; steam; VR apps; players; games; genres

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1. Introduction

The rapid growth of innovative solutions and technological achievements observed in recent years is related to the so-called Fourth Industrial Revolution (Industry 4.0). One of the characteristic features of Industry 4.0 is digitization, defined as the totality of activities aimed at increasing the availability of the Internet and its resources for people and the development of electronic services. Society wants to access the Internet from anywhere in the world. A very large percentage of society uses the Internet for entertainment purposes, e.g., playing video games, listening to music, watching movies, online shopping, performing activities in social media, chatting with people, reading news, and writing blogs [1]. Video games and applications form a huge industry in the entertainment market. Even decades ago, players used their own games by buying them physically on floppy disks and later on compact disks. Currently, players use digital platforms to distribute games in an intangible form—in digital form. Games connect consumers to each other and also to digital distribution platforms such as Steam, Xbox Live, and PlayStation network—platforms that distribute products digitally [2]. These platforms connect people to form huge communities of people with the same passion for gaming—and even more. As Limelight Networks vice president Nigel Burmeister claims [3], video gaming has evolved into a social platform. Game platform users want interactive, high performance, disruption-free experiences which let them connect with others and play longer. It puts pressure on gaming companies to deliver high-quality gaming environments to users across the globe. "State of Online Gaming 2021" [3,4], a report about the global gaming preferences and

habits, states that playing video games has risen in 2021 to a new level, with an increase of 14% over last year in consumers' play time.

The global digital media market has been growing. Gaming accounts for the biggest share of market revenue. In 2020, the global online gaming market revenue reached approximately USD 21.1 billion [5]. This translates to a record 21.9% growth compared to the previous year. The main reason for such a growth was the COVID-19 pandemic outbreak, which forced many people to stay at home. Isolated society had to find new channels to connect with other people and turn to digital avenues of entertainment. What is more, according to Howarth [4], with new platforms launched (for example, the PS5) and new gaming technology such as virtual reality (VR) and augmented reality (AR) going mainstream, there is no doubt that this market will see upward growth over the next 4–5 years. Currently, there is an estimated [5] 1 billion online gamers worldwide with China, South Korea, and Japan having the biggest online gaming reach among the population. It should be mentioned that, in 2025, online gaming audiences are projected to surpass 1.3 billion [5].

In addition to video games, digital platforms offer virtual reality applications. These applications can be of an entertainment nature, though there are many generally available applications (which does not always mean free of charge) that are training, educational, cultural-cognitive, increasing certain skills, etc. There are also more and more virtual reality technologies (headsets) available on the market in addition to hardware, applications, and gadgets. The virtual reality market is developing dynamically. According to Fortune Business Insights [6], since 2017, VR gaming has seen consistent year-over-year global revenue growth. In 2017, the industry generated USD 0.4 billion, in 2018 it was USD 0.6 billion, and in 2019 it was USD 0.8 billion. VR gaming revenue is expected to grow at a CAGR (Compound Annual Growth Rate) of 31.4% between 2021 and 2028. Hence, the revenue is estimated to reach USD 53.44 [4,6].

The data presented above shows that the market of applications has rapidly developed in recent years. It became a motivation for the author to undertake research in the field of VR applications market analysis. Moreover, the market of virtual reality applications has not yet been studied from a scientific point of view. Due to these facts, the author decided to quantitatively analyze and present data on virtual reality applications available in distributing an open innovation model market in the example of the Steam platform. The study included the data on, among others, the number of applications in the selected categories, such as genres, types of headsets, and language. The second part of analysis referred to top-rated VR applications, their reviews, and their features (recognized based on the tags describing them). The author conducted an analysis of the features of the top-rated applications.

The paper is divided into five sections. Section 2 includes a review on the literature. Section 3 describes the materials and methods. Section 4 contains the results of the research. Section 5 presents a discussion. Section 6 presents the conclusions.

2. Theoretical Background

2.1. Innovation and Digital Platforms

Contemporary digital platforms distributing games and applications more and more often operate on the principles of open market innovation. The idea of open innovation assumes an open and mutual approach aimed at creating and implementing a new or significantly improved product or service [7]. According to the idea of open innovation, entities cannot only rely on their own resources or conduct research independently, but should be increasingly open to the creative potential of their partners [8]. The open innovation organization uses its own solutions but also its external environment [9]. Thanks to the open innovation model, which is focused on cooperation with various entities and sharing ideas, the effect of creative synergy is used [8]. According to Wiprächtiger et al. [10], the market advantage is not obtained by a service or product inventor, but by the entity that properly improves them to meet customer expectations. Moreover, as Peñarroya-

Farell and Miralles [11] claim, open innovations do not pigeonhole solutions, and due to this, they do not block the flow of knowledge and skills, technology, licenses, etc. [11]. Open innovation business models make an organization more effective in creating and capturing value [12]. In an open business model, an organization collaborates with external ecosystems by building its value and innovating its business model to take advantage of emerging opportunities [13]. Organizations are actively looking for new ways to cooperate with suppliers, customers, or complementors to open and expand their business [14]. It should be noted that open innovations have a dynamic character, which means that an organization focuses on actions in the process of changing business models to achieve real results [15]. Information about what needs to be improved when it comes to a product or service is of great importance. However, in the modern world, this information is transferred by users to service providers or manufacturers [16]. Hence, not only is creation vital, but also co-creation [17].

Digital platforms distributing games and applications function in open innovation models. The gaming market is a pioneer in terms of innovation products, services distribution, as well as business models. According to the 2022 LexisNexis report [18], highlighting the top 100 innovation sectors and companies in the world, two industries are inseparably connected with games and applications; namely, Electronics (2nd place) and Information Technology (3rd place) were placed on the podium. The most innovative industry appeared to be pharmaceuticals—the pharmaceutical industry is at the very top of the list of the most innovative industries with vaccine development due to the COVID-19 pandemic. Therefore, it can be claimed that the industries most represented in the top 100 reflect the greatest global issues, such as the global pandemic and the emphasis on the continued digital transformation of the world.

Digital platforms offering games and applications are an example of an innovative approach to business and clients. Platforms provide digital products and services that are available not only to users (players). The platforms operate on an open basis, which means that the offer is basically available to everyone, and that means all stakeholders in the form of producers, creators, designers, consoles manufacturers, game developers, and many more. According to Jungherr and Schlarb [19], platform companies dominate in commercial, public, and private life. The platform companies provide spaces for producers and consumers of content, goods, and services to meet and interact [20]. Platform companies allow businesses and entire economic sectors to emerge and fulfill consumer needs by establishing and maintaining many-sided markets [21,22]. It is worth noting that economists have hailed this phenomenon as a "platform revolution" [23]. At the same time, some authors [19,24,25] highlight the growing use of game engines as platforms and the growing influence of the companies developing, providing, and maintaining game engines. The approach, represented by digital platforms, positively affects the inspiration of some solutions and ideas. This, in turn, leads to the multiplication and sharing of ideas and the creation of new solutions in the form of products and services. Today's market, especially the games and applications market, is an open market that contributes to the sharing of knowledge, ideas, and solutions as this leads to rapid progress, growth, and development. Hence, it can be claimed that the idea of digital platforms corresponds with the definition of open innovation defined as the use of purposive inflows and outflows of knowledge to accelerate internal innovation and expand the markets for external use of innovation, respectively [26]. As Chesbrough [27] notices, open innovation implies that companies should be both active sellers and buyers of intellectual property; this also takes place in the case of those platforms. What is more, according to Jeffrey et al. [28], information (mainly feedback from users) from digital platforms can be used, for example, to help developers to improve their games but also to assist players in choosing games to buy. Making an offer available in an open form allows the generation of ideas and creates innovations in a continuous and dynamic manner. Such an open model presents an innovative approach that is very different from the approach that functioned years ago, namely, a hermetically closed environment that hides its ideas, being afraid of steal-

ing/copying them. Modern gaming companies provide new market strategies which have changed approaches to several activities, such as product design, customer relationships reinforcement, supply chain integration, cost, and revenue structure revision [29]. It is also worth noting that development in digital distribution and rapid technological innovations have led to an increased focus on digital supply chains which significantly change the way consumers, customers, suppliers, and manufacturers interact [2]. According to Bogers et al. [30], opening up platforms creates opportunities within ecosystems for entities other than the platform leaders. Moreover, the platform can become a space for entrepreneurial pursuits as opportunities are identified and pursued to create and provide complementary products or services that become part of the platform [31].

2.2. Virtual Reality on the Market

Virtual reality is the use of computer technology to create the effect of a three-dimensional interactive world in which objects give the impression of being physically present [32,33]. VR allows the user to interact with an alternative reality and to immerse themselves in the virtual world. Virtual reality design consists of multimedia that creates an image of the real or fictional world, objects, space, or events [34]. Initially, virtual reality revolutionized the entertainment sector, mainly computer games. Currently, it is used in industry, architecture, medicine, marketing, and training and education. It has great potential in many areas of human life. The creator of the term "virtual reality" is Jaron Lanier [32], an American computer scientist, futurologist, and founder of VPL Research, which produced a prototype of VR equipment. Currently, there are many headsets available for users all over the world. The most popular headsets include the following: HTC Vive, HTC Vive Pro, HTC Vive Pro 2, HTC Vive Cosmos, Oculus Rift, Oculus Rift S, Oculus Quest, Oculus Quest 2, Valve Index HDM, Windows Mixed Reality, Sony PlayStation VR, Pico Neo, and many more [35]. These technologies differ from each other in terms of operational and technical parameters, quality, and also equipment. Some of them are wireless; others are not. In the literature, there are many comparisons of different virtual reality headsets, for example, [36–39]; however, all these modern virtual reality headsets aim at the same goal, which is to transfer users to a virtual world in which they can immerse themselves. When referring to headsets, reference should also be made to the companies that develop and provide the software and hardware for virtual reality solutions. According to Fortune Business Insights [6], the list of key players in virtual reality in the gaming market (September 2021) includes the following companies:

- Microsoft Corporation (Redmond, WA, USA);
- Facebook LLC (Oculus VR) (Menlo Park, CA, USA);
- Nvidia Corporation (Santa Clara, CA, USA);
- HTC Corporation (Taoyuan City, Taiwan);
- Unity Technologies (San Francisco, CA, USA);
- Magic Leap, Inc. (Los Angeles, CA, USA);
- Firsthand Technology Inc. (Seattle, WA, USA);
- Apple Inc. (Cupertino, CA, USA);
- Sony Corporation (Tokyo, Japan);
- Ubisoft Entertainment SA (Montreuil, France).

In the literature, various studies can be found on the analysis of the video game market. Prato et al. [40], in their study, track the evolution of the global market of games and its emerging geography with the rise of Asia. Additionally, they explore how the changes derived from mobile and online gaming enabled major transformations of the industry. Faisal and Peltoniemi [41] analyze the evolution of game genres. They concluded that until 1990, there were many genres competing for dominance, but later in history, sports racing, strategy, and action have become the most prevalent genres. According to Baltezarević et al. [42], the availability of platform and game delivery technologies is a crucial factor in the emergence of massive interest in games. In recent years, the gaming industry involving creative professionals has become a leading one. The digital game

sector remains very strong, and with other media industries' decline, it represents a rapidly growing business branch and opens a broad platform for new businesses. Clarke et al. [43] explore the current affordances and limitations of the genre of video games from a library and information science perspective with an emphasis on classification theory. The paper of Planells [44] analyzes the gaming market in terms of funding. The author analyzes the 10 most funded games on Kickstarter. This qualitative analysis concludes that positive arguments for the video games collective financing model develop an emancipatory–utopian framework that is critical with publishers, libertarian with users, and melancholic–postmodern with the content developed in the past. The author notices that the top-down culture of game business becomes a bottom-up participatory culture intervening mainly in game genres, topics, and mechanics. The paper of Frutos-Pascual and Zapirain [45] reviews the use of AI techniques in serious games. The authors consider that over recent years enough knowledge has been obtained to create new intelligent serious games that take into account not only the final aim but also the technologies and techniques used to provide players with a real experience. Orme [46], on the other hand, performs the analysis of non-player motivations for video game spectatorships. There is also a group of research on female characters in games. The paper of Lynch et al. [47] analyzes female characters in video games and discusses the results in light of theories of social identity and objectification. Kondrat [48] also analyzes games in terms of female characters, focusing on how they are represented and stereotyped. Furthermore, in the literature, there are more studies on such issues, for example, [49–51].

Referring to research publications analyzing and discussing the topic of virtual reality applications on the market, it can be claimed that this field is not scientifically explored yet. First of all, there is a group of papers referring to the analysis of VR applications in the field of education. Radianti et al. [52] analyze VR applications that were acquired from online stores to capture the state of the market. They analyze the picture of available apps by categorizing them according to design elements and learning content. According to the authors, despite the fact that several immersive VR applications for higher education have been described, there is no structured analysis of them on the market. According to Smutny [53], there is no structured analysis of educational VR applications on the market, and therefore they conducted research in this field. This study analyzes the market for educational VR applications in VR in 2019–2021, but also development trends in their offerings, content, and parameters. On the basis of the results, it was concluded that more than half of the sample applications are available free of charge, and they mostly use English as the communication language. There is also some other research on the topic of the analysis of educational VR applications, including, for example, [54,55]. It should be noted that the use of VR educational applications is a promising solution to combine entertainment and education [56,57]. Referring to other fields, according to Bonetti et al. [58], academic research on and practical VR applications in retail are still fragmented. Due to this, the authors undertake a comparative chronological analysis of AR and VR research and applications in a retail context.

While studying the subject of analyses of VR applications on the market, I was also reviewing articles relating not only to individual subject areas but also to the entire market. After analyzing the literature, I can claim that there are practically very few such articles. The first was the article of Foxman et al. [59]. The authors confirmed that there is currently no cohesive classification for commercial VR offerings. They conducted some research on the popularity of VR apps and concluded that action, shooter, and simulation were the most frequently downloaded genres. I also reviewed one work on VR application market analysis in the example of one country—Tapanainen [60] wrote a thesis on VR market analysis in Finland. Kerdvibulvech [61] presents a novel study of pioneering geo-based mixed reality games, including the author's own research, to explore the evolution of mixed reality games using location-based features. However, the author selected five major geo-based mixed reality games for analysis. They included Human Pacman, AR Car Game, Ingress, Pokémon Go, and AR Mario Kart Live. The author compares games based on the year built,

devices, the purpose of the game, the number of academic paper downloads, revenue, the number of downloads, and types of virtual items. On the other hand, Järvinen [62] places the development of virtual reality in the context of trend diagnosis methods to sketch out a comprehensive, research-based trend description of VR that outlines the various contexts that impact it.

Summarizing, based on the literature analysis presented above, it can be claimed that there are some papers on games and gaming market analyses; however, there is a lack of scientific articles dealing with virtual reality applications available on the market from a quantitative point of view. The author found a research gap in the field of the quantitative analysis of data on virtual reality applications available on the market. Furthermore, this observation is confirmed by other authors in their articles [52,53,59]. The results of the literature analysis confirmed to the author that there is a need and premise to undertake research in the field of the analysis of virtual reality applications available on the global market.

3. Materials and Methods

Research on the analysis of the market of virtual reality applications available on the Steam platform was carried out in July 2022. Steam is a platform that is constantly updated, which means, for example, uploading, removing, and updating games and applications by the website operators. It also involves adding, deleting, and editing reviews by users, i.e., players of video games and applications (including virtual reality applications). This means that available resources (in the form of games and apps), data, and information (e.g., number of games and apps in the given categories, reviews, feedbacks, ratings, and many more) are changeable in time. Therefore, the collection of research data on VR applications—in the form of the number of applications in specific categories and reviews issued by the Steam users—from the Steam platform had to take place at the same time; it could not be stretched over time. Considering the above, the author had to plan which data would be needed for the research beforehand, in order to efficiently find and collect all the data within a few hours in the same day. In summary, the first stage of the research was to recognize the platform, search engines, and search possibilities, and what potential research data Steam offers. Then, the author collected data from the Steam platform (https://steampowered.com, accessed on 6 July 2022 [35]). The data was collected in an Excel file. This stage was carried out on 6 of July 2022. The data included:

- Number of games and applications based on genre;
- Number of VR applications based on the number of players;
- Number of VR applications based on the headset;
- Number of VR applications for a given headset based on the genre;
- Number of VR applications based on the play area;
- Number of VR applications based on language;
- Number of VR apps with tags unsuitable for some groups of people;
- Data on top-rated VR applications (names, genres, number of positive reviews, number of tags, and names of tags).

Based on those data, the author conducted an analysis of the market of virtual reality applications available on Steam. The analysis included statistical analysis of the data and interpretation of the market and its trends based on the features of top-rated virtual reality applications. The features of the top-rated applications were identified based on the tags describing the applications. The author examined which tags were most often repeated in the top-rated applications and what was their share. The analysis was conducted in MS Excel program. Thanks to the analysis of the tags, it was possible to recognize the features of the top-rated applications and systematize new knowledge about them. Some terms (tags) are very characteristic for games and gamers; hence, this article helps to recognize a part of the environment of the players. Therefore, the added value of this article, apart from the analysis of the modern innovative market that operates in the model of open innovation and shares and exchanges informatics solutions and knowledge, is that the

article introduces and explains concepts from the gaming environment; thus, it organizes knowledge as well as provides new knowledge about the virtual reality applications market in the example of Steam.

It should be emphasized that Steam is one of the largest platforms that distribute games and applications worldwide. It generates tons of data including data on users' reviews, which are regularly updated. Thus, using data from Steam in the analysis is justified. The number of users is huge. Figure 1 shows the statistics from the Steam website of the number of users from 4:00 p.m. of 5 July to 2:00 p.m. of 6 July 2022. Based on the chart, it can be concluded that the concurrent Steam users during the generation of the chart was 26,187,878 users, while the peak was 26,681,938. The ratings given by users were the basis of analyzing the top-rated applications.

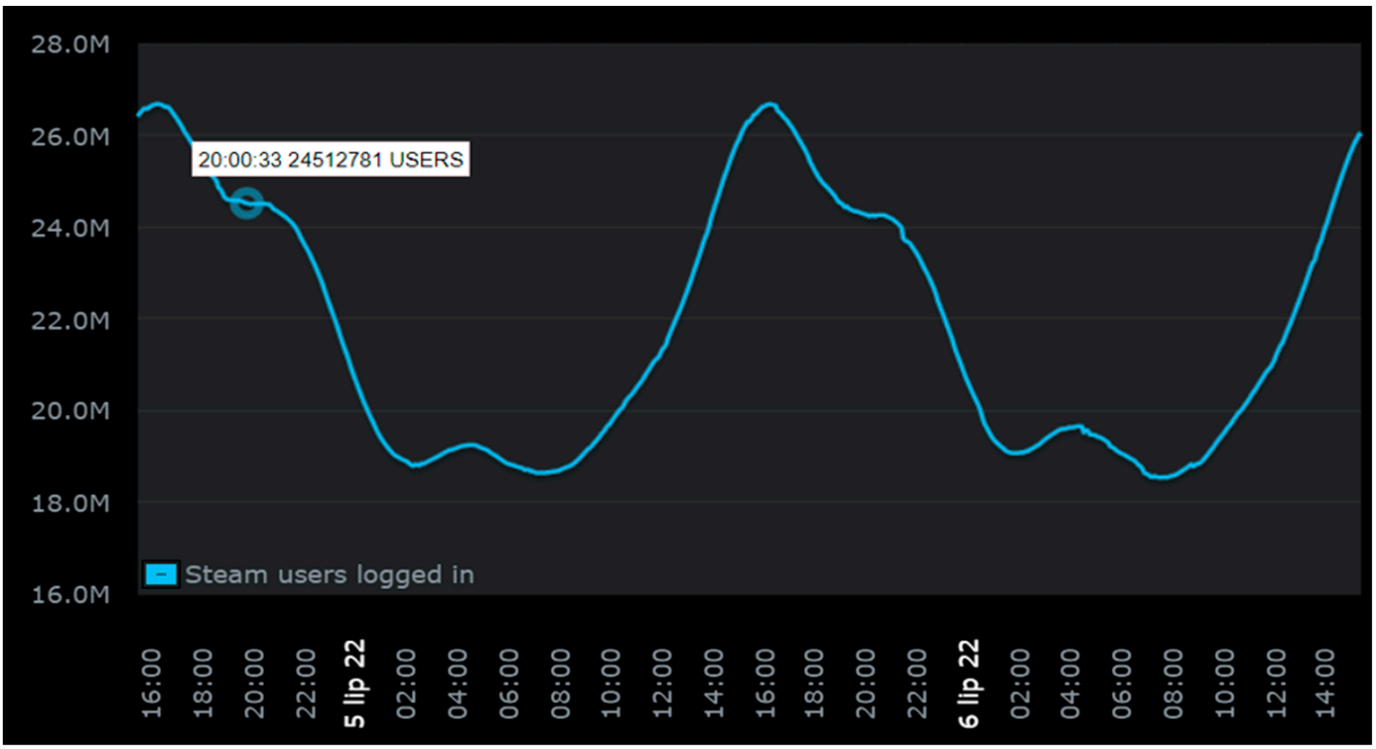

Figure 1. The number of Steam users—data on 5–6 July 2022 [accessed: 6 July 2022, 3:44 p.m. (GMT+2:00) Warsaw], source of Figure: [35].

The goals of the research described in the paper included:

- The main goal, which was:
  - To quantitatively analyze and present data on virtual reality applications available on the digital platform distributing in an open innovation model in the example of the Steam platform;
- The detailed goals, which consisted of:
  - Identification of input data for analysis;
  - Providing and systematizing new knowledge/concepts about the VR applications environment;
  - Identifying the top-rated VR applications;
  - Identifying the features of the top-rated applications.

The study includes the following research methods:

- Searching and browsing the Steam website and using the search engine;
- Data collection, processing, and presenting (MS Excel);
- Statistical analysis (MS Excel).

Data were collected from the Steam website [35] by searching and browsing the website and using the search engine. The search engine on the Steam platform allows searching for games depending on the keyword but also according to the given parameters/features. Applications and games can be searched, for example, in certain categories. Search features may be cumulative. In the case of this analysis, I chose a category of VR games in the first place, and then I chose more features, searching, for example, applications in given genres, languages, with given tags, etc.

4. Results

4.1. Total Number of Applications and Games

This stage of the research included gathering, analyzing, and presenting data on applications and games available on the Steam platform. Data were collected from the Steam website [35] by searching and browsing the website and using the search engine. Table 1 summarizes the results of the search in numbers and of the analysis of those data in percentage terms. It includes genres in which there were more than 10,000 total games and applications (state on 6 July 2022). It also shows the number of VR applications in the given genre—they were searched with the "VR" tag. It is worth noting that there are many games available that are at the same time VR and non-VR. This means that they were usually non-VR games first, but the VR version became available too. The example of such a game is "Keep Talking and Nobody Explodes". It is possible to play it via PC but also using some of the popular headsets, such as HTC Vive, Oculus Rift, etc. However, there are many games that were created exclusively for Virtual Reality. They have been tagged as "VR-only".

Table 1. The number and percentage of applications and games on Steam based on the genre [state on 6 July 2022].

Genre	All Apps and Games [Number]	VR Apps [Number]	VR-Only Apps [Number]	VR Apps of All Apps and Games [%]	VR-Only Apps of All Apps and Games [%]	VR-Only of VR [%]
All types	126,573	6683	5168	5.3%	4.1%	77.3%
Action	53,573	3423	2711	6.4%	5.1%	79.2%
Adventure	46,570	2344	1835	5.0%	3.9%	78.3%
Casual	47,242	2725	2216	5.8%	4.7%	81.3%
Simulation	29,402	2496	1820	8.5%	6.2%	72.9%
Strategy	27,492	771	565	2.8%	2.1%	73.3%
RPG	28,850	548	407	1.9%	1.4%	74.3%
Atmospheric	17,786	974	657	5.5%	3.7%	67.5%
Puzzle	16,228	710	512	4.4%	3.2%	72.1%
Story Rich	15,256	432	298	2.8%	2.0%	69.0%
Fantasy	14,142	425	332	3.0%	2.3%	78.1%
Exploration	12,496	805	545	6.4%	4.4%	67.7%
Arcade	10,460	697	518	6.7%	5.0%	74.3%
Anime	10,202	237	156	2.3%	1.5%	65.8%

Source: Author's own work based on data from [35].

The total number of apps and games available on Steam is 126,573, of which VR apps account for 5.3% of them and VR-only apps stand for 4.1%. However, VR-only apps account for more than $\frac{3}{4}$ of VR apps—77.3%. The most numerous group of all apps and games is in the action games category (42.33%), then casual games (37.32%), and the third place is occupied by adventure games (36.79%). In the case of VR apps, the most numerous group is also action apps. They account for more than half of all VR apps (51.22%) and for 6.4% of all action apps and games. Then, there are also casual games (40.78%); however, the third most numerous games consist of simulation VR apps (37.35%). Simulation VR apps account for 8.5% of all simulation apps and games on Steam. When it comes to VR-only apps, the biggest group is also action apps (2711, which is 52.46% of VR-only apps). Action VR-only apps stand for 79.2% of VR apps and 5.1% of all action apps and games. The casual VR-only apps (2216, which is 42.88%) are in second place, and they account for 81.3% of VR apps and 4.7% of all action apps and games. Then, there are adventure games (2216; 35.51%). The next group consists of simulation apps at almost 2000 (35.22%). Games below

1000 are included in the following genres: atmospheric (5th place), strategy (6th place), exploration (7th place), arcade (8th place), and puzzle (9th place). The rest of the categories include fewer than 500 apps. However, it is important to emphasize that some games are placed in more than one category. Some games are very different and can therefore be found under different categories and tags. Figure 2 shows the percent of applications and games in each given genre.

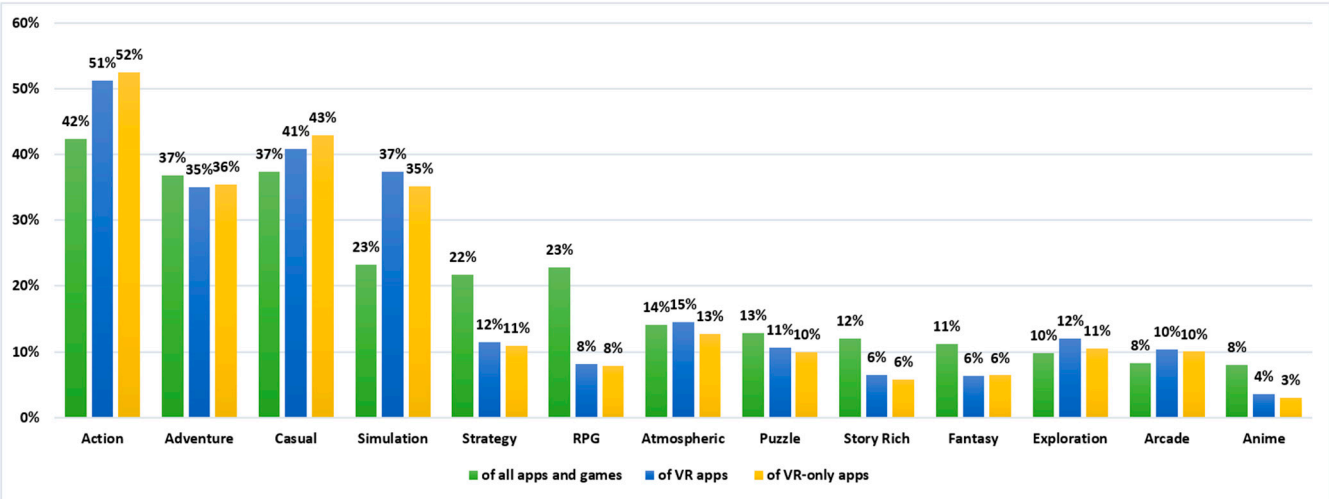

Figure 2. Percent of applications and games based in the given genre on Steam (author's own study based on data from [35]).

4.2. Features of VR Applications

In the next stage of research, the applications were divided based on the number of players. VR headsets are designed for a single user; when we buy a headset it has one piece of VR goggles and two controllers for two hands. However, the players also have the possibility to share a given game with other players. This is naturally done by using a different VR set, and players are usually separated by distance—they play with players from a different place. On the other hand, it is possible that players are in the same area; however, they are usually from different places. For this reason, I (the author) decided to review the app types depending on the number of players. It appears that there are more types of VR apps than singleplayer and multiplayer apps, and they are signed with special tags. Steam differentiates multiplayer apps in a more advanced way. First of all, there are "PvP" apps, which stands for Player versus Player apps. They can be "online PvP", "LAN PvP", and "Shared/Split Screen PvP". LAN is an abbreviation for local area network—in this case, gamers use local area network—as the name suggests. On the other hand, there are "Co-op" apps which are cooperation apps. Again, among co-op, there are three detailed tags: "online Co-op", "LAN Co-op", and "Shared/Split Screen Co-op". Another popular tag is just "Shared/Split Screen". There is also a "Cross-Platform Multiplayer" type of app, which means that, in a given app, players from different platforms have the possibility to play together, sharing the same online service. The last type of apps shows how much the world of online apps and game is open, and from the open innovations' point of view. They are based on sharing, combining, and connecting rather than hiding some ideas and knowledge. Table 2 presents the number of VR apps in the mentioned categories. It is worth noting again that some apps can be in more than one category. Some apps can even be in both singleplayer and multiplayer categories because one of those ways can be chosen by the player based on their preferences.

On the market, there are a few VR sets that users can use to play VR apps. Steam gives a possibility to play games that target different VR sets. Steam provides apps for four main VR sets categories: Valve Index, HTC Vive, Oculus Rift, and Windows Mixed Reality. The largest number of apps is targeted at HTC Vive. This headset was developed by HTC

company which discovered virtual reality beyond imagination—HTC Vive in 2016, as their website says [63]. The second place is taken by Valve Index which was released in 2019 [64]. Valve Index is a headset produced by Valve Corporation. Then, there is Oculus Rift which was released to the market in 2016 [65]. The last headset is Windows Mixed Reality, which is Microsoft's hardware and software for augmented and virtual reality. Current generation Mixed Reality goggles are offered by Acer, Dell, HP, Lenovo, and Samsung [64]. Table 3 presents the number of VR apps based on the mentioned headsets available on Steam. However, some apps are dedicated to more than one headset. One example is the Superhot VR app, which can be supported by all of the mentioned headsets, and City Car Driving, which can be played on two of them—HTC Vive and Oculus Rift.

Table 2. The number of VR applications based on the number of players [state on 6 July 2022].

Number of Players	VR Apps [Number]
Singleplayer	6058
Multiplayer	1320
PvP	946
Online PvP	853
LAN PvP	52
Shared/Split Screen PvP	241
Co-op	691
Online Co-op	552
LAN Co-op	51
Shared/Split Screen Co-op	144
Shared/Split Screen	192
Cross-Platform Multiplayer	356

Source: Author's own work based on data from [35].

Table 3. The number of VR applications based on the headset [stated on 6 July 2022].

Headset	VR Apps [Number]
Valve Index	5416
HTC Vive	5784
Oculus Rift	4744
Windows Mixed Reality	1906

Source: Author's own work based on data from [35].

In the next stage of the research, it was decided to study the genres of applications for a given headset. Figure 3 shows the number of VR applications for a given headset based on the genre. Data was obtained from the Steam library. Figure presents genres in which there were more than 100 applications for at least three out of four headsets. It has to be mentioned that some applications can be found in more than one genre, as well as used by more than one headset. The biggest number of VR applications are action apps available for HTC Vive; there are 30,004 of them. More than 2000 apps are dedicated to play also on HTC Vive in the following genres: casual, simulation, and adventure. In the reference to Valve Index, the most numerous are action and casual apps. More than 2000 apps for Oculus Rift are only in one genre—action. Action apps are the biggest group also for Windows Mixed Reality; however, there are almost three times less than in the case of HTC Vive apps. There are many car-related apps—they are tagged as "driving" and "racing". Education-related apps can also be found on Steam—they are tagged as "education". There are quite a lot of "anime" apps. For players that like to exercise their brains, strategy and puzzle apps will be matched and will meet users' expectations. By analyzing the types and numbers of games, it can be concluded that there are so many of them that they reach a wide group of recipients, and the preferences of players are quite different.

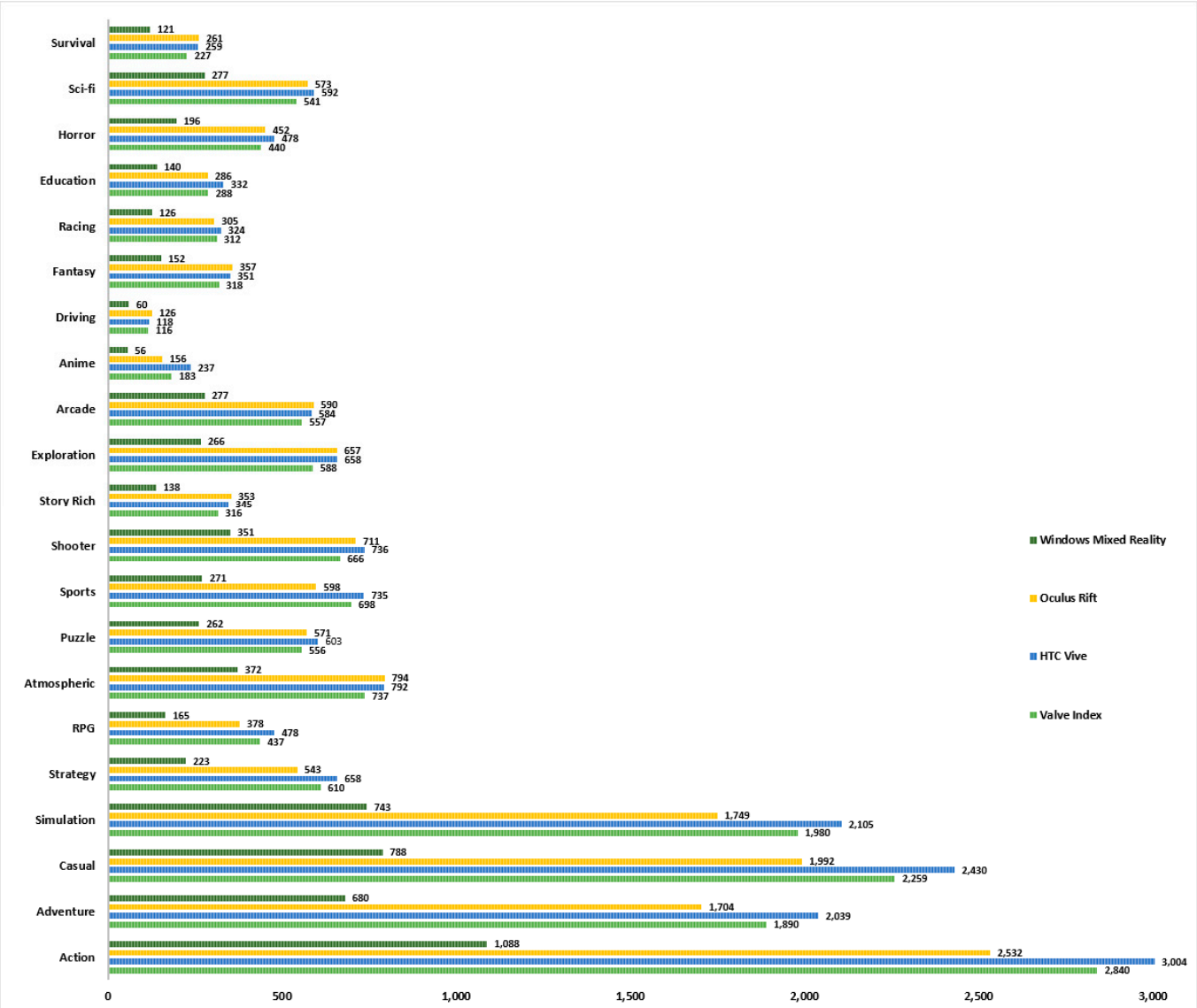

Figure 3. The number of VR applications for a given headset based on the genre on Steam [author's own study based on data from [35].

VR applications require more movement from players than in the case of PC games. Usually, users stand while using a VR headset. However, it is also possible to sit while playing. Table 4 presents the number of VR applications based on the play area. Some apps can be played both ways.

Table 4. The number of VR applications based on the play area [state on 6 July 2022].

Play Area	VR Applications [Number]
Seated	3764
Standing	4917

Source: Author's own work based on data from [35].

The Steam platform was founded in the USA, but it is popular around the world. Hence, not only different language versions of the Steam website are available, but there are also VR applications in different languages, not only English. In this stage of the research, the author searched the Steam platform with the language key. Figure 4 shows the summary of the language analysis. It presents a number of VR apps in each

language (Figure shows the languages with at least 100 applications). Naturally, the most apps were in English (6551). They accounted for 98% of all VR apps on Steam. Simplified Chinese was in the second place (21.1%), and French the third (18.7%). What is more, German, Japanese, Spanish, and Russian are among the languages with more than 1000 applications. The rest of the data is available in the following figure.

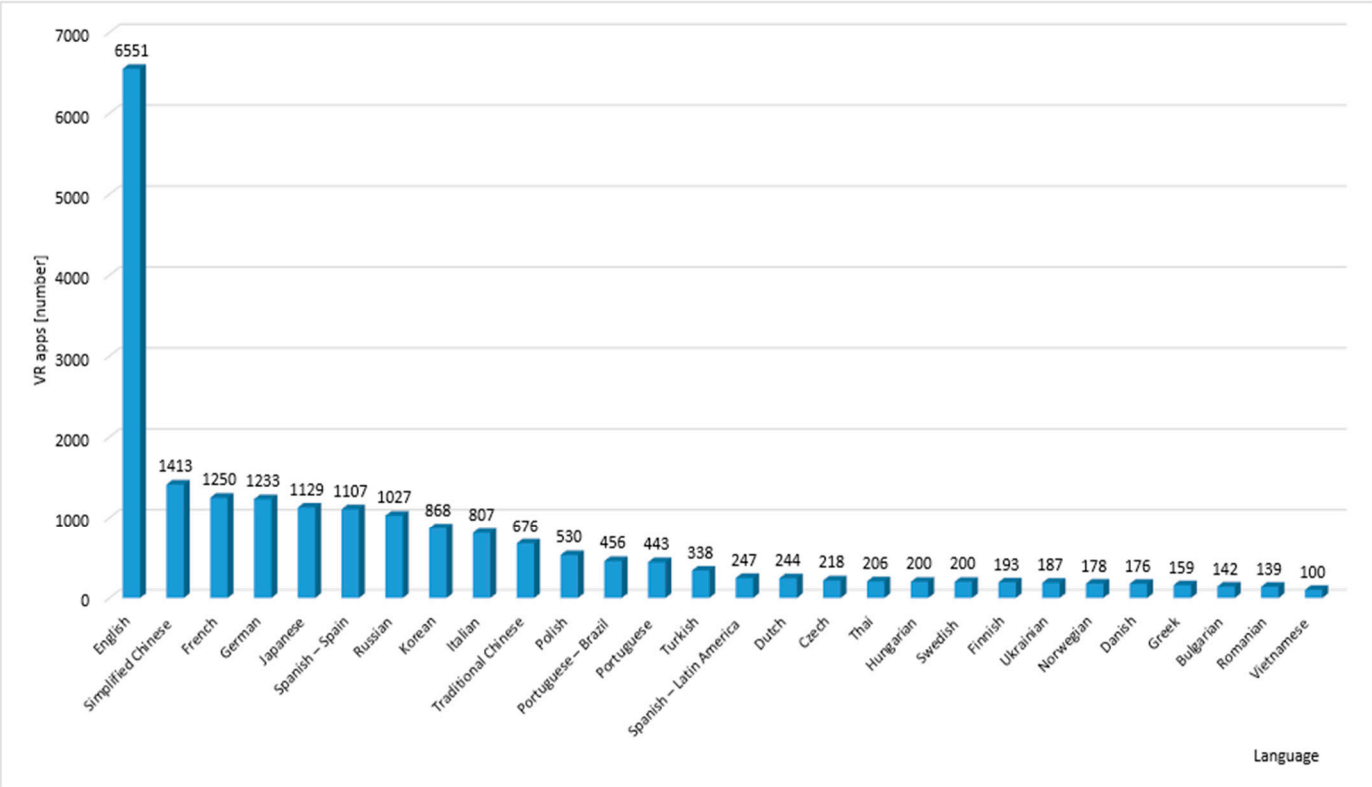

Figure 4. The number of VR applications in each language (languages with at least 100 apps) on Steam [author's own study based on data from [35] [state on 6 July 2022].

According to Marshal et al. [66], video game players find brutal games compelling. Often, games are designed to be violent, or they cause aggression in players. In this paper, the author decided to study if VR apps on Steam have some features that make them unsuitable for some groups, for example, children or sensitive people. For this purpose, the author searched the platform for VR apps that included tags such as "violent", "sex", "blood" and many more. The tags that were searched for were looked through keywords that were intuitive; however, the results of the study allowed the establishment of groups of repeating tags. Repeating tags and the number of applications with the given tags are presented in Table 5. Based on the results, it can be claimed that the number of tags indicating that a given app may be inappropriate for certain groups is not yet that alarming—the most numerous are apps with the "violent" tag and they are 8.5% of all VR apps. However, the interpretation of this number can be different depending on preferences. Despite "violent", the often-appearing tags are "gore", "psychedelic", "blood", and "jump scare". What is more, there are apps with sexual implications, and they are tagged as "nudity" and "sexual content".

Table 5. The number of VR applications with tags unsuitable for some groups of people [state on 6 July 2022].

Tag	VR Applications [Number]
Violent	565
Gore	427
Nudity	327
Sexual content	310
Psychedelic	115
Blood	26
Jump scare	7

Source: Author's own work based on data from [35].

4.3. Top-Rated VR Applications on Steam

In the next stage of analysis, top-rated games were analyzed. The author searched the Steam platform to identify and classify the best-rated virtual reality applications. The Steam platform gives users the possibility to rate games and apps. Every user can choose "thumb up" or "thumb down" to give feedback. Steam regularly updates the data. Every application receives a status based on the sum of user reviews. The status comes from the scale that is based on the percentage of positive reviews (number of 'thumbs up') relative to the total number of reviews. The highest score has a name of "overwhelmingly positive". This status can be given to the application that has a minimum of 95% positive feedback of all given feedback. On the basis of this key, the author of this paper decided to analyze the highest evaluated applications. Firstly, the author searched the Steam platform to find apps that on 6th of July had "overwhelmingly positive" status. Then, the author divided them based on genres. Subsequently, for every genre, the author organized the apps in descending order of their scores. Tables 6–9 show the effects of the mentioned stage of collected data organization and analysis.

Table 6. VR applications with "overwhelmingly positive" reviews in the category of action VR apps [state on 6 July 2022].

Title	%
Half-Life: Alyx	98
VTOL VR	97
Hot Dogs, Horseshoes & Hand Grenades	97
Compound	97
Beat Saber	96
Blade and Sorcery	96
I expect you to die	95
Until you fall	95
The Thrill of the Fight—VR Boxing	95
Space Pirate Trainer	95
The Lab	95
Jet Island	95

Source: Author's own work based on data from [35].

In the group of action VR applications, there were 12 apps with an 'overwhelmingly positive' status. Only one of them received 98% positive reviews, and that was the highest score. The name of the app was Half-Life: Alyx. Three applications received 97% positive feedback, two received 96%, and six received 95%.

Adventure apps included nine top-rated apps. Similarly, there was only one 98% positively evaluated app—the same as in the action group. This app was classified into two genres. However, there was only one application with a result of 97% positive feedbacks, two with 96%, and five with 95%.

Table 7. VR applications with "overwhelmingly positive" reviews in the category of adventure VR apps [state on 6 July 2022].

Title	%
Half-Life: Alyx	98
The Room VR: a Dark Matter	97
I expect you to die 2	96
Blade and Sorcery	96
The Lab	95
I expect you to die	95
Until you fall	95
Jet Island	95
Google Earth VR	95

Source: Author's own work based on data from [35].

Table 8. VR applications with "overwhelmingly positive" reviews in the category of casual VR apps" [state on 6 July 2022].

Title	%
Walkabout Mini Golf VR	98
Beat Saber	96
Jet Island	95
Aircar	95
Ragnarock	95
The Lab	95
Google Earth VR	95
Eleven Table Tennis	95

Source: Author's own work based on data from [35].

Table 9. VR applications with "overwhelmingly positive" reviews in the category of simulation VR apps [state on 6 July 2022].

Title	%
Hot Dogs, Horseshoes & Hand Grenades	97
VTOL VR	97
Blade and Sorcery	96
Jet Island	95
Eleven Table Tennis	95
The Lab	95
Google Earth VR	95
I expect you to die	95

Source: Author's own work based on data from [35].

The next two groups, casual and simulation apps, included eight apps each. In the case of causal apps, there was only one app whose score was 98%—Walkabout Mini Golf VR. Then, there was an app with 96% of positive reviews; however, the most numerous groups included apps with a result of 95%, of which there were six apps. In the case of simulations apps, the highest score was 97%, and two apps received it. Their names are Hot Dogs, Horseshoes & Hand Grenades and VTOL VR. Then, there was one app with a 96% evaluation and five apps with 95%.

In the next stage, every application with an 'overwhelmingly positive' status was subjected to a more detailed analysis. For every application, the author collected the data on the tags describing the app. The goal of this stage of the research was to recognize the features that describe the highest evaluated VR apps on the Steam platform. Thanks to this, it was possible to characterize the preferences of world users in terms of the features of VR apps on the basis of a large amount of up-to-date data that have been collected for a given application since its release to the market to today. The number of tags varies depending on the application, so it can be concluded that there is no rule on the number. The most

tags that an application has is 20, and the least is 6. The tags were collected and presented in Table 10. The table contains apps from all categories with an 'overwhelmingly positive' status; therefore, without repetitions, the total number of applications is 19. It is worth noting that no VR application received 99% of positive reviews. However, there are two apps with the result of 98% positive feedbacks. This is very interesting because those apps are quite different when it comes to character and features. Half-Life: Alyx, the action and adventure app, is a shooter, described as horror with zombies, while Walkabout Mini Golf VR is a casual, minimalist sport application. Four apps received 97% positive reviews. They are The Room VR: A Dark Matter (puzzle app), VTOL VR (flight simulation app), Hot Dogs, Horseshoes & Hand Grenades (gun-shooting simulation app), and Compound (pixel-graphic shooter). The group with a 96% score includes three apps. They are Beat Saber (fast-paced music app), Blade and Sorcery (adventure fantasy app) and I expect you to die 2 (puzzle and mystery app). The other nine applications received 95% positive reviews. The summary of tags is presented in the following table.

Table 10. VR applications with "overwhelmingly positive" reviews and the tags describing them—summary [state on 6 July 2022].

Title	Positive Reviews [%]	Tags [Number]	Collected Tags
Half-Life: Alyx	98	20	VR; FPS; Story Rich; Horror; Female Protagonist; Shooter; First-Person; Singleplayer; Action; Zombies; Sci-fi; Atmospheric; Beautiful; Adventure; Aliens; Futuristic; Psychological Horror; Memes; Great Soundtrack; Gore
Walkabout Mini Golf VR	98	19	Golf; Mini Golf; PvP; VR; 3D; First-Person; Historical; Casual; Colorful; Minimalist; Stylized; Fantasy; Pirates; 6DOF; Atmospheric; Nature; Multiplayer; Physics; Singleplayer
The Room VR: A Dark Matter	97	11	Adventure; Puzzle; VR; Mystery; Investigation; Lovecraftian; Singleplayer; Atmospheric; Horror; Indie; Escape Room
VTOL VR	97	19	Flight; VR; Combat; Simulation; Jet; Military War; Action; Realistic; Physics; Vehicular Combat; Artificial Intelligence; Naval Combat; 6DOF; Singleplayer; Level Editor; Futuristic; First-Person; Sandbox; Multiplayer
Hot Dogs, Horseshoes & Hand Grenades	97	20	VR; Gun Customization; Simulation; Sandbox; Shooter; Action; FPS; Realistic; Funny; Early Access; Physics; Singleplayer; Indie; America; First-Person; Destruction; Atmospheric; Memes; Multiplayer; Hentai
Compound	97	13	Action; Roguelite; Indie; VR; Retro; Early Access; Shooter; FPS; 3D; Pixel Graphics; First-Person; Action Roguelike; Roguelike
Beat Saber	96	20	VR; Rhythm; Music; Great Soundtrack; Moddable; Fast-Paced; Indie; Singleplayer; First-Person; Difficult; Multiplayer; Swordplay; Action; Sports; Futuristic; Casual; Music-Based Procedural Generation; Early Access; Anime; Sexual Content
Blade and Sorcery	96	20	VR; Swordplay; Action; Gore; Moddable; Violent; Simulation; Magic; Sandbox; Physics; Fighting; Medieval; Adventure; Singleplayer; Fantasy; First-Person; Early Access; Indie; RPG; Games Workshop
I expect you to die 2	96	13	Puzzle; VR; First-Person; Stylized; Cold War; Singleplayer; Comedy; Mystery; Adventure; Investigation; Retro; Soundtrack; Escape Room
Jet Island	95	6	VR; Action; Adventure; Indie; Casual; Simulation
I expect you to die	95	20	VR; Puzzle; Strategy; Action; Immersive; Simulation; Funny; Comedy; Retro; Adventure; Singleplayer; Cold War; First-Person; Stylized; Soundtrack; Indie; Short; Difficult; Open World; Hidden Object
Until you fall	95	20	VR; Swordplay; Roguelite; Hack and Slash; Arcade; Fighting; Combat; Action; First-Person; Soundtrack; Singleplayer; Fantasy; Magic; Roguelike; Action Roguelike; Indie; Adventure; Fast-Paced; Early Access; Great Soundtrack
The Thrill of the Fight – VR Boxing	95	6	Sports; Action; 3D Fighter; VR; Boxing; Fighting

Table 10. *Cont.*

Title	Positive Reviews [%]	Tags [Number]	Collected Tags
Space Pirate Trainer	95	10	VR; Action; Space; First-Person; Shooter; Great Soundtrack; Pirates; Sci-fi; FPS; Arcade
The Lab	95	20	Free to Play; VR; Action; Singleplayer; First-Person; Adventure; Funny; Sandbox; Casual; Sci-fi; Family Friendly; FPS; Shooter; Puzzle; Strategy; Memes; Archery; Atmospheric; Simulation; Comedy
Aircar	95	7	Free to Play; Casual; Indie; VR; Flight; Cyberpunk; Relaxing
Ragnarock	95	20	Rhythm; VR; Multiplayer; Music; Racing; PvP; Casual; Arcade; Mythology; Naval; First-Person; Stylized; Rock Music; Sports; Atmospheric; Indie; Soundtrack; Singleplayer; Colorful; Vikings
Google Earth VR	95	13	VR; Free to Play; Simulation; Open World; Casual; Adventure; Exploration; Realistic; Singleplayer; Psychological Horror; Walking Simulator; Sexual Content; Nudity
Eleven Table Tennis	95	6	Sports; Simulation; VR; Casual; Tennis; Multiplayer

Source: Author's own work based on data from [35].

All tags characterizing the top-rated apps have been subjected to quantitative analysis. The author decided to investigate whether the tags of the best-rated apps are repeated, and if so, which tags constitute the most numerous groups. Due to this analysis, features of the VR application most liked by players can be identified. The data was collected in an Excel file. The total number of tags was 283. Using the COUNTIF function in Excel, the author created the table with the count for every tag. It turned out that there were 106 different tags after grouping the data. Then, the data were presented in relation to the total number of top-rated applications. In 100% of the applications, only one tag was repeated—it was a "VR" tag, which was natural. Two tags took the second place: "first-person" and "singleplayer". They appeared in 68% of the applications' descriptions (13 of 19 apps). It can thus be claimed that players prefer to play first-person rather than third-person VR apps, which could be interpreted as the following: players can empathize more with a given character, and they feel as though they are that character (higher immersion). In 63% of the applications, there was an 'action' tag. Therefore, it can be claimed that the genre of action is the most desired. The last tag that appeared in more than half of the applications was 'indie', which was 53%. At this point, the meaning of 'indie' should be explained. As Lattore [67] claims, indie games, often equated with independent games, often involve hybridizations and ambiguities between the alternative and the mainstream [67]. According to Ruffino [68], indie games are usually made without the help of a publisher, have a limited budget, but are also groundbreaking and beyond what the mainstream industry proposes. "Adventure" was placed in almost half of apps' tags—47%. In 42%, 'casual' and 'simulation' tags occurred. Then, there were two tags: 'atmospheric' and 'multiplayer' (32%), and three tags: 'early access', 'FPS' (FPS is an acronym for frames per second), and 'shooter'. In slightly more than 1/5 of apps (21%), the following tags appeared: 'great soundtrack', 'physics', 'puzzle', 'sandbox', 'soundtrack', 'sports', and 'stylized'. Figure 5 summarizes the results of the conducted analysis; it shows the number of VR applications with a given tag of the 19 top-rated VR apps and the results in tags that appeared for more than 15% of the apps.

Subsequently, the author decided to analyze every tag in relation to all tags. Therefore, the author determined the count of each tag appearing among all 283 tags. Figure 6 presents the pie chart with the data on the individual tags. The tags whose share was equal to or greater than 1.3% of all tags were presented on the chart individually, but the rest of them are included in the gray area—the biggest pie slice. The most numerous tag ('VR') occurred in 6.7% of all tags in total. "First-person" and "singleplayer" tags accounted for 4.6%. The rest of the results are presented in Figure 6.

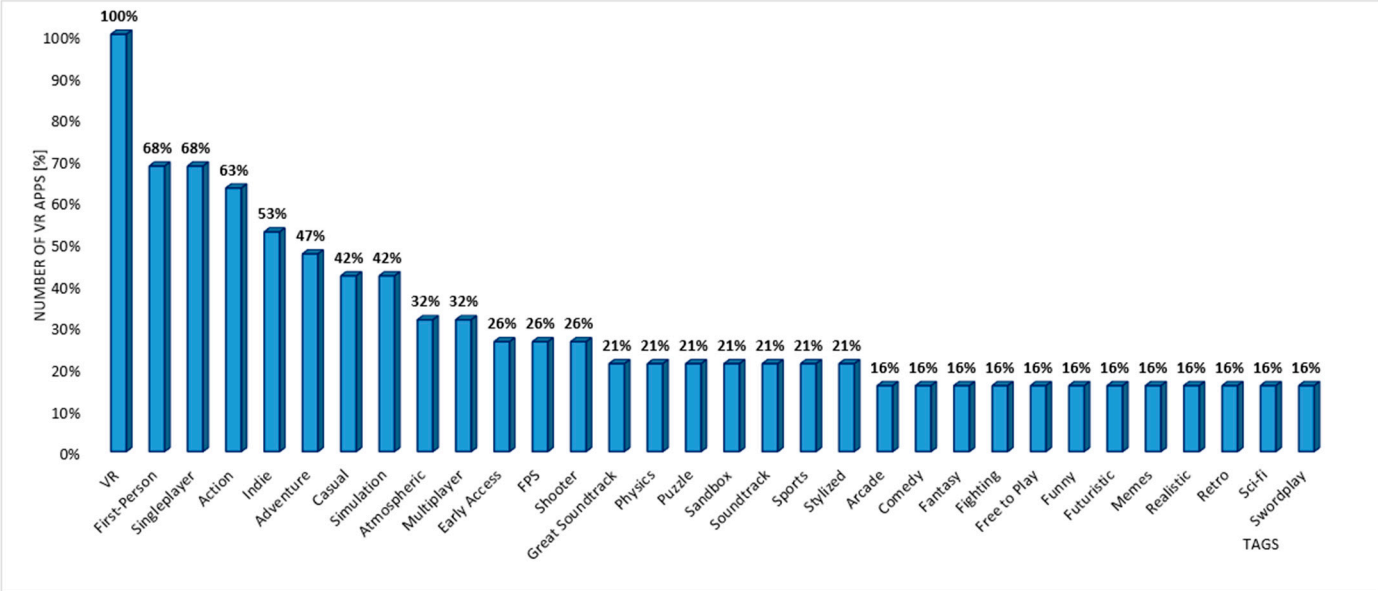

Figure 5. The number of VR applications with a given tag (results for tags that appeared in more than 15% of VR applications) of the 19 top-rated VR applications on Steam (author's own study based on data from [35]) [state on 6 July 2022].

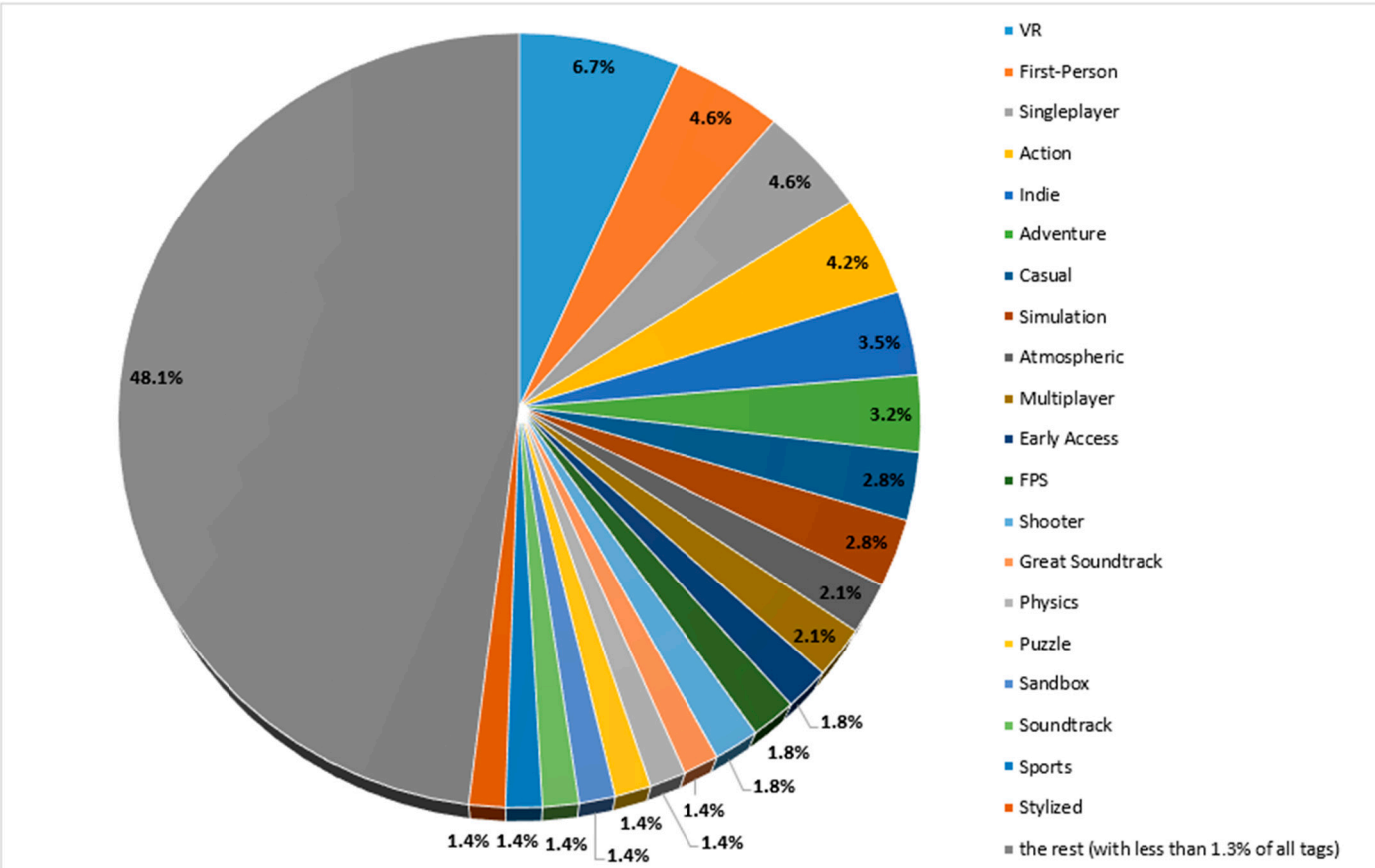

Figure 6. The number of a given tag of all tags for 19 top-rated VR applications on Steam (author's own study based on data from [35]) [state on 6 July 2022].

5. Discussion

The results obtained from the research can be discussed in terms of the results of other studies. However, it should be noted that according to the literature review result, there are just a few papers that study the same subject from a similar perspective. This is due to the fact that the subject of the analysis of virtual reality applications on the market has not yet been explored scientifically. However, at first, I can compare the analysis of my research with the data from Mondal's game report [3]. However, it should be noted that this report reveals the results regarding video games, and in my research, I analyzed the results in a narrower scope, which were virtual reality applications. Nevertheless, I found similarities between these results and mine. According to this report, casual singleplayer games are the most played type of video game worldwide and, moreover, casual singleplayer games were played by 87.9% of those surveyed, more than any other type of game. According to my research, the most repeated tags, describing the top-rated VR apps, included (despite the 'VR' tag, which occurred for 100% of the top VR apps) the tags 'first person' and 'single player'. They appeared in 68% of applications' descriptions (13 of 19 apps). Thanks to this, it can be concluded that most of the players in the world prefer to play individually, not with other players. On the other hand, according to the results of my research, the most numerous group of all apps and games is in the action games category (42.33%), then casual games (37.32%), and the third place is occupied by adventure games (36.79%). In the case of VR apps, the most numerous group is also action apps. They account for more than half of all VR apps (51.22%). There are then also casual games (40.78%). Thus, the results can be claimed to be quite consistent with the aforementioned report when it comes to casual games. It is worth adding that, according to the report, popular casual video games include Candy Crush Saga and Clash of Clans. Singleplayer casual games were the top genre across the board in all surveyed countries. India (93.8%), China (93.6%), and Vietnam (92.6%) had the highest approval ratings for this type of game. Faisal and Peltoniemi [41], in turn, analyzed the evolution of video game genres from 1979 until 2010. They concluded that sports racing, strategy, and action have become the most prevalent genres. In the part of action genre, these results are consistent with the results I developed.

When it comes to the analysis of the most popular categories (genres) of virtual reality applications, I found one such article in the literature, an article by Foxman et al. [59]. The authors performed an analysis of the most frequently downloaded and highest-rated virtual reality application genres. According to the authors, action, shooter, and simulation are the most frequently downloaded genres. Another conclusion of this research was that the action and music/rhythm genres are the most highly rated. According to the results of my research, the largest number of virtual reality applications is also in the group of action games; this applies to both the categories of VR apps and VR-only apps. However, my research showed a very high number of applications in the adventure and casual genres, as opposed to the results mentioned by the authors. The fourth most numerous group is the simulation apps. However, when it comes to the top-rated applications that have received the 'overwhelmingly positive' status on Steam, I also received interesting results. In the group of action VR applications, only one of them received 98% positive reviews—the highest score. The name of this application was Half-Life: Alyx. Three applications received 97% positive feedback (97% of the reviews were positive—"thumb up"), two received 96%, and six received 95%. Among the adventure apps, there was also only one 98% positively evaluated app. This was Half-Life: Alyx, and it is worth noting that this app was classified into two genres. Subsequently, there was only one application with the result of 97% positive feedbacks, two with 96%, and five with 95%. Among the causal apps, there was only one app whose score was 98%—this was Walkabout Mini Golf VR. Subsequently, there was one app with 96% positive reviews and six apps with a result of 95%. In the case of simulation apps, the highest score was 97%, and two apps received it: Hot Dogs, Horseshoes & Hand Grenades and VTOL VR. Then, there was one app with a 96% evaluation and five apps with 95%. Generally, based on the conducted analysis, it can be concluded that players prefer emotional and more adventurous customs in games.

Furthermore, the authors of the paper mentioned above concluded that simulation and music/rhythm occur at a statistically higher rate in VR compared to non-VR. They also found that VR experiences are less likely to receive positive ratings than 2D games.

Interesting research on top-rated virtual reality applications was carried out by Smutny [53]. However, unlike my research, the author focused only on applications in the field of education. This study analyzes the market for VR educational applications in 2019–2021, but also development trends in their offerings, content, and parameters. Another goal was to analyze the user evaluation of VR educational applications to see which applications users appreciate the most. The results revealed that more than half of the sample applications are available free of charge; they mostly use English as the communication language; and users' best-rated applications are from the areas connected to nature, space, medicine, art, and history. Relating these results to the results of my research, it can be confirmed that, in fact, most virtual reality applications are available in English. On the Steam platform, 98% of VR applications were in English. Simplified Chinese was placed in second place (21.1%), and French in the third place (18.7%). When it comes to the mentioned terms, including nature, space, medicine, art, and history, it should be noted that in the tags I analyzed, these concepts, as well as the concept of education, did not appear. This means that the market of VR applications includes most applications focused on pure fun and entertainment, while education is a small part of these applications, and educational elements do not appear in top-rated apps.

6. Conclusions

This paper and the results of the practical research presented in it allowed the filling of the research gap in the field of the quantitative analysis of data on virtual reality applications available on the market. The author identified the research gap based on the literature review and analysis of trends in the innovative gaming market. The field of virtual reality applications has hardly yet been explored, taking into account the rapid development of the virtual reality market. The article presents data on the development of the gaming industry, including virtual reality applications markets, and also refers to the open innovation model of games and applications distributing digital platforms. The market of games and applications introduces rapid and large changes in technology, distribution, offers, products, and services; however, as the author of this article noticed, there are no scientific papers on analyses, discussions, and research that would present the most important and most recent data in the mentioned field, especially on the virtual reality applications available on the market. Due to the above, the author conducted an analysis of the market of virtual reality applications available on Steam—which is one of the digital platforms, well known worldwide and used by millions of people, as it was presented in this paper. Practical research included statistical analysis of data and interpretation of the market and its trends based on the features of the top virtual reality applications.

The presented approach to the study of the virtual reality application market has both theoretical and practical contributions. The theoretical part of the research in the first subsection reviews the subject of open innovation models and digital platforms, and in the second subsection it reviews the scientific papers on analyses of virtual reality applications available on the market. The practical contribution includes a quantitative analysis and presentation of virtual reality applications available on the Steam digital platform. Especially, the paper provides and systematizes knowledge about the VR applications environment and identifies the up-to-date top-rated VR applications and their features.

The added value of the research of this article provides the results of the analysis of the modern innovative market that operates in the model of open innovation, shares and exchanges informatics solutions and knowledge, and introduces and explains concepts from the gaming environment. Thus, it organizes knowledge as well as provides new knowledge about the virtual reality applications market in the example of Steam.

The results and the discussion of them presented in the article are addressed to a wide audience, including scientists, businessmen, companies operating in the gaming industry

(including game developers), users (players) of the Steam platform (but not only Steam), non-players, and for everyone interested in innovations available on the game, especially the virtual reality application market.

The study has some research limitations. They result from the analysis of applications available on one distributing platform. It can be estimated that the results can be slightly different taking into account more different digital platforms. However, the steam platform is considered to be one of the most popular platforms, and hence, it was found by the author as a representative one. This limitation requires more thorough research; however, this creates a wide perspective for the author for further research in the future. It should also be emphasized that the data and trends of a highly dynamically changing industry of video games and virtual reality applications are changeable; therefore, the presented research should be updated regularly.

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