

Subjective And Objective Assessment Of Video Game Context Factors

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Abstract—The recently published ITU-T Recommendation G.1032 proposes a list of factors that may influence cloud and online gaming Quality of Experience (QoE). This paper provides two practical evaluations of proposed system and context influence factors: First, it investigates through an online survey ($n = 488$) the popularity of platforms, preferred ways of distribution, and motivational aspects including subjective valuations of characteristics offered by today's prevalent gaming platforms. Second, the paper evaluates a large dataset of objective metrics for various gaming platforms: game lists, playthrough lengths, prices, etc., and contrasts these metrics against the gamers' opinions. The combined data-driven approach presented in this paper complements in-person and lab studies usually employed.

PREFACE

This paper was originally written in 2018 as a collaboration between colleagues from the University of Duisburg-Essen and University of Vienna, but was never published. It was intended as a continuation of the work started in “The Prospects of Cloud Gaming: Do the Benefits Outweigh the Costs?”, to explore the reasons why someone would choose a specific video game platform or service. We think, the results of this survey might today still give interesting insights into the world of engagement and context factors of playing video games, especially when one intends to investigate QoE. We are also still engaged in this line of research, and we strive to continue this work in the future.

Therefore, we wanted to preserve this work in the form it was originally prepared in 2018, with updated affiliations, restored links, and this preface. Past reviewers of this manuscript mostly criticized the lack of a clear research question and definition of context. The focus on a very narrow set of context factors could also have been extended to a broader range of factors, especially social factors, and subjected to a deeper analysis. On the other hand, reviewers praised the relevant topic and its investigation through a comparatively large online survey.

I. INTRODUCTION

Among computer applications, video games occupy a special spot. In contrast to many other software applications, they are almost exclusively used in a leisure context. In contrast to consuming media like video (movies, series) and audio (music, audio books), they are also interactive. Even for small, independent developers it is possible to develop successful

video games. This is mainly due to the availability of third-party engines and game assets, but also not least because of the shift to digital distribution platforms that is already well underway. The result is a large and fast-growing catalog of video games. But what is less clear are the motivational and engagement factors surrounding the consumers of such video games. Why, for example, is one game picked up over another? More often than not this has less to do with technical details but relies on, e.g., social factors (e.g. all your friends are already playing the game). So, in order to appropriately determine Quality of Experience (QoE) of video games such factors, including context but interactivity as well, need to be regarded in addition to a proper classification of video games by their gameplay aspects. The recently published ITU-T Recommendation G.1032 [1] follows this notion and discusses influence factors on gaming QoE.

This paper explores such subjective motivational aspects of video gamers by means of an online survey, and contrasts them with utility metrics derived from objective data from several gaming platforms. The survey results underscore that users value experience-related characteristics for picking their purchase, and prefer individual choice over curated catalogs. While an attractive price is an important reason for buying games in general, personal interest (or lack thereof) and social aspects might be equally important, if not even more so. The objective data provides insight into the offerings of STEAM, a digital distribution platform for PC games, and both PLAYSTATION NOW and GEFORCE NOW, which are cloud gaming services offered by Sony and NVIDIA, respectively. Of specific interest as utility and engagement metrics are, e.g. the number of games on offer, their lengths, and review scores. The paper provides a broad view of current-day gaming hardware, software, and utility metrics (§ III), evaluates the online survey (§ IV-A), and discusses the offers of three gaming platforms (§ IV-B).

II. RELATED WORK

Recently, and very much in line with this paper, the ITU-T published recommendation G.1032 [1], [2], dealing with influence factors on gaming QoE. The recommendation emphasizes that gaming QoE depends on multiple influence factors, several of which this paper studies, particularly the category of context influence factors. The recommendation lists these factors, but

does not evaluate them. This paper does so, both through a survey among video gamers (for subjective factors) and a study of game platforms (for objective factors).

Literature on video game QoE is often based on direct measurements of game and network parameters. However, the rich variety of video game contents makes it difficult to generalize the results. This paper's attempt to better understand said variety, and the consumers' views of it, is thus an endeavor to support future research into video game and gaming QoE. Work supporting this view [3], [4] analyzed single specific games from different genres and different game sub-scenarios within them, complementing MOS value studies with questionnaire-based assessments of delay detection, quality acceptance, difficulty, annoyance etc.

Research efforts of the past were often centered around network QoS, e.g. on the network delay component of the end-to-end (E2E) lag for both online games and cloud gaming. The results, however, remain inconclusive. Past studies of multiplayer games also often focused on a single genre, namely First-Person Shooters (FPSs), with titles such as *Quake 3* [5] or *Unreal Tournament 2003* [6]. Concerning cloud gaming, Chen et al. [7] find very high and variable delay values even when neglecting the network delay. Furthermore, [8] gives some insights on the delay requirements of streamed games and the implications for data center distance as well as placement. Image quality represents a further QoE factor. Gaming adds another dimension to typical image quality assessments, as most games allow for changes to their graphical fidelity. As an example, the work in [9] takes a look at different encoding parameters for cloud gaming. An overview of some further QoE taxonomy and influence factors especially for mobile games is given in [10].

For video streaming applications, QoE context monitoring and context-based QoE management has proven to be worthwhile [11]. The factors are grouped by their source, i.e. the gamer, the hardware/software/network system, and the context (including the gamer's social embedding, novelty, and game service factors).

III. BACKGROUND

This section introduces system influencing factors and service factors of current gaming systems: It presents the hardware and software platforms and ecosystems for different types of gaming, introduces utility metrics for games, and describes the data sources used for the evaluations in this paper. Furthermore, the gamer survey is described. All costs are from an European, specifically German, perspective. If a product is not available in this region, the prices are converted using the most recent currency exchange rates.

A. Gaming Hardware

1) *Gaming PCs*: Hardware viable for Personal Computer (PC) gaming starts at about €500 but has practically no upper limit for enthusiasts. The Graphics Processing Unit (GPU) is a cost driver, and it is essential for modern PC gaming. This poses a certain financial barrier for customers to start

PC gaming, which is however compensated by an increased flexibility and longevity of hardware.

2) *Video Game Consoles*: Dedicated consoles represent the classical approach to video gaming. The price for (non-portable) consoles varies but usually lies between €300 and €400 for the latest console generation, i.e., *Switch*, *PlayStation 4*, and *Xbox One*. While priced lower than many PCs, console hardware is not built from user-serviceable components and not upgradeable.

3) *Cloud Gaming Hardware*: One of the main claimed benefits of cloud gaming is its low requirements on end user hardware. Thus, a less powerful PC may suffice to use a cloud gaming service as long as the network connection to the service provides an adequate latency and bandwidth. Sony's PLAYSTATION NOW cloud gaming service was originally available only for their PlayStation 3 and 4 consoles, and a line of their TV sets. The latter option has since been removed, and streaming to PCs enabled instead. Companies also experiment with devices that focus primarily on streaming cloud gaming content. The most recent standalone game streaming device currently in the market is NVIDIA's *SHIELD* which starts at €230 and is bound to their cloud gaming service, GEFORCE NOW. Here, too, a stream-to-PC option has become available recently (as a US-only beta program).

B. Gaming Ecosystems

Below, currently active (cloud and non-cloud) gaming platforms are examined with regards to pricing models, other requirements, and costs. The information presented was collected between July 2015 and October 2017.

1) *PC Gaming*: The rise of easy-to-use digital distribution platforms and the independent ("indie") game scene reinvigorated PC gaming just a few years ago. Today, PC gaming is dominated by digital marketplaces, with STEAM being the largest. The platform has about 10 million concurrent users at most times of the day. It periodically offers large, often seasonal, sales of recent games at greatly reduced prices (rebates of 75 % for a year-old game are not uncommon). In addition, many resellers offer digital codes for other platforms, often at much lower prices. Major releases on PC are usually priced between €50 and €60. However, due to the competition between the vendors, the digital retail prices are significantly lower even at launch, and also drop more quickly. Another recent trend are game bundles, which especially prevail in the indie games scene, commonly offered with a pay-what-you-want model. *Humble Bundle*¹ is a prominent example.

2) *Video Game Consoles*: New, major game releases are mostly priced at either €60 or €70. Once on the market, the game prices decrease rather slowly. In recent years, retail stores have been complemented with console-specific, proprietary digital distribution services that also offer the latest game at the full price. These official stores are usually exclusive vendors for digital game codes where competitors are excluded. Subscription fees often apply for the multiplayer

¹<https://www.humblebundle.com/>

mode of games, e.g., *PlayStation Plus* or *Xbox Live Gold* with annual prices of €50 and €60, respectively. These services also include access to a small, monthly changing palette of older titles.

3) *Cloud gaming Ecosystems*: NVIDIA's cloud gaming platform GEFORCE NOW is available in North America and select European countries. In Germany the service currently offers 55 PC titles for a monthly subscription fee of €10. An additional per-game one-time fee is charged for the access to 63 other games. The service is delivered from six specialized data center locations (Dublin and Frankfurt in Europe).

The service requires a rather steep $50 \frac{\text{Mbit}}{\text{s}}$ for a full 1080p60 stream. Streaming is exclusive to *SHIELD* devices. The GEFORCE NOW for PC beta program streams to PCs, and costs \$10 to 20 per hour of usage depending on the desired visual quality.

PLAYSTATION NOW, Sony's cloud gaming service, offers to stream titles from previous PlayStation generations, as the latest console generation lacks backwards compatibility. The service offers 432 games for a monthly flat rate of €17. This is in addition to the device cost: the service is available on PlayStation 4 and 3 consoles and, recently, PCs. Streaming is performed at a resolution of 720p60 requiring a $5 \frac{\text{Mbit}}{\text{s}}$ connection.

C. Utility Metrics

Utility metrics help to estimate the value of a service for a customer. It should be noted that no single metric is likely of value by itself, yet all metrics combined can absolutely influence customer decisions.

The first basic metric is the number of games offered. A larger number means more choice for the customer, but "spam" phenomena need to be considered, as large offers might include many games of sub-par quality. Second, the number of players already owning a game can be a motivating factor for other customers to choose the same game. One may interpret this as a form of preferential attachment. This is particularly interesting for decidedly online games, i.e. such where players interact in the game environment over the network, so that more interactions are possible if more players are online.

Then, games are priced differently, both within and across platforms. Many games are offered completely free of charge. Some are funded indirectly through in-game purchases. On the other end of the spectrum, titles whose development was expensive and for which the audience anticipation is high might sell for a higher price. Furthermore, game lengths come to mind. Games range from very short (on the order of minutes) to tens, or even hundreds, of hours (for games with an extensive storyline), but need not be limited at all (e.g. exploration or "open world" games). Overall, neither mode intrinsically offers higher utility.

Next, the age of games (per their original release date) is of interest. Some players favor the newest games, others prefer "classics", which additionally often implies a preference for a specific aesthetic (e.g. "8-bit" graphics); any focus or combination thereof will likely attract specific proportions of

customers. Also, newer games tend to also be featured in the media (and in advertising, increasing their publicity), offer a greater diversity in game mechanics and control, and improved technical aspects (resolution, scene complexity).

There also exist considerable amounts of secondary literature about games in the form of reviews. These can be viewed as social factor, in that gamers might be drawn to positively-reviewed titles more strongly, or rather stay away from less favorably reviewed ones. Some media aggregate reviews from many outlets and are thus of particular interest for an analysis. Many other utility metrics are imaginable, including combinations of the metrics mentioned above.

D. Objective Data Sources

In order to investigate the utility metrics described, data was collected from multiple sources and merged into a data base. In the interest of repeatability and reproducibility, all of the data reported on in this work, as well as the code used to collect and process it, can be found in public repositories². Data were joined on game names and platforms (where appropriate). The different data sources are described in the following. For STEAM, the public REST API was used to fetch the name and current price of each game at different points in time. This data was combined with API data from the 3rd-party site *SteamSpy*³, which parses all publicly visible STEAM user profiles and estimates statistics on the size of the player base and the time each player spends with a title. *SteamSpy* also provides a heuristic projection of the total number of owners of each listed title on STEAM. For GEFORCE NOW, game names and prices were screen-scraped manually. Game names for PLAYSTATION NOW is available from the PlayStation website⁴. Thus, the platform portfolios can be compared.

Game publishers seldom publish intended playthrough length of games, and not all games necessarily have one. However, players may self-report their experienced playthrough times on sites like HOW LONG TO BEAT⁵, which was web-scraped for this analysis⁶. Lastly, the age of a game is computable from its release date. To this end, the METACRITIC⁷ page which aggregates reviews of video games (and other media) was scraped⁸.

E. Subjective Data

The subjective data for this paper was collected through an online survey using the SOSCI SURVEY web tool. The link was shared in the authors' social networks, and posted in various sub-forums on the REDDIT online community web page. The survey included 9 demographic questions, 12 questions about the participants' personal gaming habits and history, and 7

²The repository resides at <https://github.com/mas-ude/cost-of-cloud-gaming>

³<https://steampy.com>

⁴<https://www.playstation.com/de-de/explore/playstation-now/ps-now-games/>

⁵<http://howlongtobeat.com/>

⁶<https://github.com/mas-ude/gamelengths-scraper>

⁷<http://www.metacritic.com/>

⁸https://github.com/mas-ude/metacritic_scraper

service/system influence related questions, not all of which are evaluated in full in this paper. In order to keep the time to completion reasonable, most questions were stated either as yes/no questions, or showed predefined answers to be ranked on a five-level Likert scale, e.g. from “extremely important” to “not important at all”. The complete questionnaire and anonymized responses are reproduced in the repository above. The survey was completed by 488 participants.

The context influence factors surveyed include social context (such as the importance of online aspects in games and the influence of friends and social media on buying decisions), novelty (in the sense of new, recently published games), and service factors (referring to properties of online marketplaces with respect to the utility metrics discussed before.) Furthermore, system influence factors such as the preferred gaming hardware platform and available input devices are studied.

IV. EVALUATION

This section presents the results of the online survey (§ IV-A) and investigates the properties of the actual games offered on the various platforms (§ IV-B). The survey covers context influence factors including social, novelty and service-related ones. The platform study scrutinizes service aspects.

A. Online Survey Results

The online survey was completed by 488 participants (91 % self-identified as male, 8 % as female), reporting ages between 13 and 70 years (quartiles 21, 26, 32; mode 31). All responses were logged in a time frame of four days in early 2018.

1) *Gaming Demographics*: Around 85 % of participants started playing video games before they were ten years old. Over 50 % of participants play for 1–3 hours per day. 44 % and 36 % spend \$ 0–20 and \$ 21–50 on games per month, respectively. Almost 50 % of participants own between 101 and 500 games, and about 15 % report to own 11 to 50 and 501 to 1000 games, respectively. More than 40 % of participants bought 3 to 10 games in the last twelve months; slightly more than 45 % claim to have bought 10 to 100 games.

2) *Social Context Factors And Novelty*: When asked to mark all ways of learning about new games, respondents most prevalently selected “news on gaming sites”, “reviews”, and “friends” (about 60 % each). Other popular factors include “live streams”, “recommendations in online stores”, and “gaming bundles” (with 40 %, 30 %, and 20 % each). Retail stores are hardly mentioned. The popularity of games on *Twitch* (a website dedicated to live streaming of video games) or with game critics is judged as not important to over 70 % and over 60 % of participants, respectively.

3) *System Influence Factors*: Almost all participants (97 %) own a PC, the two other most prevalent gaming systems are smartphones (30 %) and Sony’s PlayStation 4 (26 %). Nintendo’s Switch and 3DS as well as Microsoft’s XBox One are reported by between 18 % and 11 % of participants. 93 % report the PC to be their favorite gaming system, with consoles favored by 29 %.

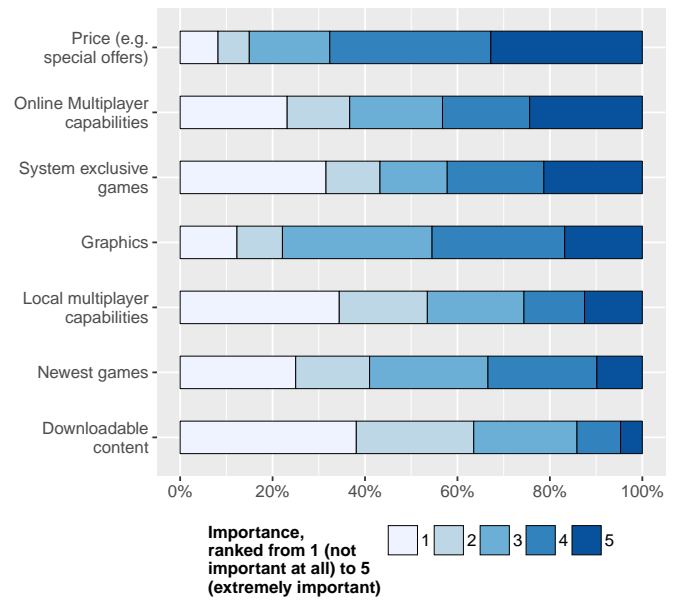


Figure 1: Respondents’ assessment of factors important for buying new gaming systems.

4) *Service Factors*: Digital gaming stores (and among these, STEAM) are reported as the most popular ways of obtaining games. About 85 % of respondents use digital storefronts. The other proposed selections reach far lower values: “third-party key sellers” hits 35 %, and both “physical games from online stores” and “physical games from retailers” are capped around 25 %. 90 % of participants use the STEAM platform; *Humble Bundle* and *GOG* are very popular (almost 60 %) as well. *Origin* at 38 % is a relatively distant fourth already. None of the other proposed selections, including the console-specific digital stores (PlayStation Network/Store, Nintendo eShop, XBox Store), exceed 25 %.

Figure 1 shows the respondents’ assessments of factors important for buying new gaming systems, grouped by importance. As can be seen, system prices are a motivator for almost 70 % of survey participants. Online multiplayer capabilities, system-exclusive games, and graphics are important or very important for more than 40 %, each. On the other side, local multiplayer capabilities, the mere recency of games, and available downloadable content are deemed relatively unimportant factors for a buying decision.

The survey also asked about buying hindrances for newly released games, i.e. reasons that speak against buying them. More than 70 % of participants declare a lack of interest that hinders them. Financial reasons play a role for roughly a third of respondents, and a similar proportion has a substantial backlog of games awaiting to be played, whereas only 15 % declared their hardware to be lacking support for the latest games.

B. Game Platform Properties

To complement the subjective gamer results and also provide an inter-platform comparison, the attention now turns

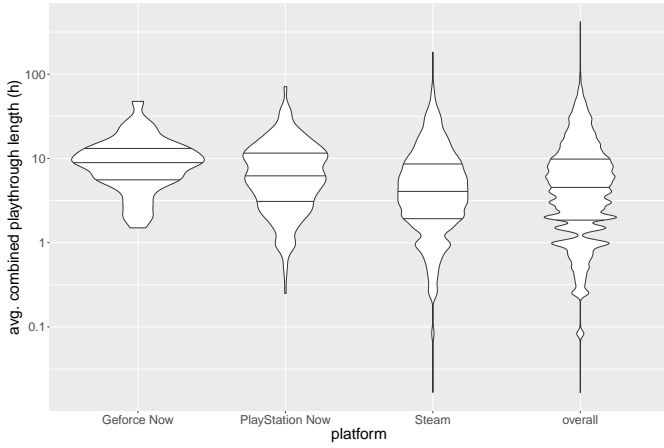


Figure 2: Violin plot of the per-platform average game lengths from HOW LONG TO BEAT. Quartiles indicated by horizontal lines.

to the service factors of three gaming platforms: STEAM, GEFORCE NOW, and PLAYSTATION NOW. Table I provides an overview of the data collected, showing the number, age, length, and review scores across platforms.

1) *Number of Games*: The two cloud platforms offer a very limited number of games when compared to the games available on STEAM, which itself again only represents a subset of all games available either on the PC platform (METACRITIC lists 26 420) or across all platforms (57 308). Two possible, simple explanations for the low game count on the cloud platforms come to mind: One is that they were launched relatively recently (2015) in comparison to STEAM (2003), leaving little time for the range of games to grow. Secondly, the choice of games for a cloud gaming platform is most likely curated by the platform operator for compatibility and performance reasons. This usability burden shifts to the end user for digital storefronts like STEAM, allowing these platforms to offer a larger variety of games, including ones that are very demanding on the hardware.

2) *Game Ages*: The average game ages appear to be relatively high for all of the investigated platforms, and particularly so for PLAYSTATION NOW. It might be considered a special case, as it is specifically advertised as a backwards compatibility for older, pre-PlayStation 4 games that do not run on the latest Sony platform any more. For STEAM, the distribution is significantly skewed towards recent titles: A quarter of games are less than a year old, and the median is at 21 months. The distribution’s tail extends beyond 25 years due to re-releases of “classic” games on the platform.

3) *Game Lengths*: Figure 2 shows the distribution of aggregated game lengths for the three platforms under investigation, and an “overall” distribution that includes further platforms and gaming systems. Among the three platforms, the median reported game length is largest for GEFORCE NOW. In contrast to the curated choice of games on the Cloud systems, STEAM also offers shorter and longer games.

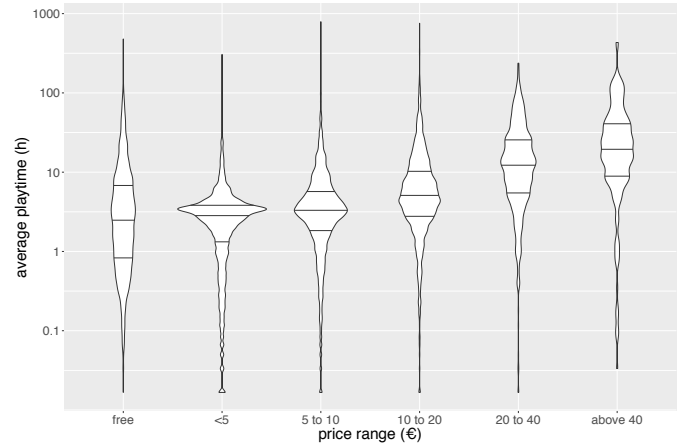


Figure 3: Violin plot of the average playtime of STEAM games, broadly categorized by their price ranges. The number of games per bin are 1541, 5269, 4019, 2445, 658, and 188. Quartiles indicated by horizontal lines.

4) *Game Prices*: Trying to compare the prices per game is a difficult endeavor, due to the mixed approach of the gaming platforms. The GEFORCE NOW subscription gives customers access to a subset of its catalog that can be extended by purchasing additional games; GEFORCE NOW for PC on the other hand requires the customer to buy games on their own and pay for the time spent playing. PLAYSTATION NOW and PLAYSTATION NOW on PC have a flat rate for all of their catalog. At least for STEAM, unit prices can be discussed. Between mid-2015 when the authors started monitoring STEAM’s catalog, and late 2017 when the last measurement was taken, its average price has decreased from \$10.11 to \$8.83. In the same timeframe, the number of games more than doubled, from 5996 to 14 120. The prices vary a lot over time, for instance due to seasonal sales periods.

5) *Price versus Playtime*: Again focusing on STEAM, Figure 3 breaks down the distribution of average playtimes per game price range. The game price ranges are chosen so as to roughly separate the prevalent modes of the price distribution. Playtime is defined as the time game owners spend playing a game, as recorded by the STEAM platform and scraped from *SteamSpy*. Playtimes of “free” titles span almost the whole playtime range. For games that cost less than €5, the mode is around 3.5 h of playtime, and values are concentrated around it. This recent trend only manifested itself in datasets in the last twelve months: The number of games in this price category grew by a factor of 2.4 in that timeframe, whereas they increased by only 37% in the free price range, and roughly doubled in the other price ranges.

Other than that, the median playtime increases with the price range; unfortunately, the data does not explain the cause: E.g., more expensive games might have more playable content, causing the playtime to increase. Conversely, higher upfront costs may incite players to spend more time regardless of game quality, thus avoiding regret for the expense.

Table I: Game characteristics on the investigated platforms. Title counts from Web/API scraping, lengths from HOW LONG TO BEAT, ages and review scores from METACRITIC.

Service	Titles	Age μ	Age σ	Length μ	Length σ	Score μ	Score σ
GEFORCE NOW	118	3.1 yrs	± 2.3 yrs	10.7 h	± 8.2 h	73.9	± 10.1
PLAYSTATION NOW	432	4.8 yrs	± 2.4 yrs	8.8 h	± 8.8 h	71.9	± 12.0
STEAM	14, 120	2.5 yrs	± 3.3 yrs	7.3 h	± 10.2 h	70.6	± 11.0

6) *Review Scores*: The final characteristic presented from the data are game review scores as given by professional gaming media outlets. This relies on the METACRITIC dataset. This set covers review scores for all current and historic gaming platforms. The review scores are aggregated to average scores ranging between 0 and 100. Some METACRITIC-internal weighing factors are applied to express the importance of some media outlets over others. The average scores exceed 70 across all services, albeit with a slightly lower σ for GEFORCE NOW.

C. Subjective Assessments Of Utility Metrics

Finally, the survey also included questions that directly target the utility metrics of platforms described above. To put prices and playtimes into perspective, the survey asked whether 5 to 10 hours of gameplay were enough for a price of \$60. More than 50 % of participants strongly disagreed, and more than 20 % disagreed. This demand-side rejection clearly fits the picture of Figure 3, where less than a quarter of games that cost more than €40 are played for less than 10 hours.

The absence of game recency as a motivational factor was discussed above already; other motivational factors that respondents strongly agreed to were preferences of gameplay over graphics, and gaming experience in general (both reaching almost 80 % importance ratings). Also, over half of the respondents value replayability, i.e. to be able to play a game more than once.

A result relevant for the curated offers of cloud gaming platforms is that almost 80 % of respondents are not interested in exchanging flat-rate access fees for buying individual games. Other responses from survey participants indicate a multitude of interests and motivations for and against platforms, including statements like “I buy only games with Linux support”, or hints at the availability of “pirated” games.

V. CONCLUSION AND FUTURE WORK

This paper investigates context influence factors for video gaming through an online survey among 488 gamers, and an evaluation of game platform offers from the STEAM, PLAYSTATION NOW, and GEFORCE NOW systems. The results provide a practical evaluation of influence factors described in the recent ITU-T Recommendation G.1032 [1].

The subjective data from the online survey provide an insight into the gaming demographics of survey participants. Social context factors influence their buying decisions in the form of recommendations and news about games, as do technical and economical aspects. Respondents buy games mostly from digital storefronts these days, with STEAM as

a virtually ubiquitous mention. Furthermore, Other important service factors, i.e. context factors that relate to the online platforms offering and operating games, are investigated.

The objective data are combined from a number of sources: Game titles are scraped from the platforms (GEFORCE NOW, PLAYSTATION NOW, and STEAM), game lengths from HOW LONG TO BEAT, and summarized review scores from METACRITIC. The datasets partially covers a span of two years and is available from the authors’ public repositories. The utility metrics evaluated include the number of games, playtimes, prices, review scores, and combinations of these, plus some historic aspects. For example, the STEAM ecosystem grew from roughly 6000 to roughly 14 000 games offered between mid 2015 and late 2017.

Lastly, the survey also asked for subjective assessments of objective platform properties. Perhaps unsurprisingly, a large variety of motivations was reported there. An insight applicable to the size of gaming offers is that respondents prefer to choose and buy their games individually rather than having flat-rate access.

Overall, the subjective and objective data about context influence factors relevant for video gaming presented in this paper are but one step towards a practical evaluation of these factors. Many extensions of this study come to mind: For instance, many other utility metrics, and particularly combined ones, might be investigated and evaluated in subjective tests.

Second, on the subjective side, online surveys might lead to further insight into other opinion-based matters of video gaming, and bootstrap practical in-person studies for further investigation of gaming quality factors. The platform-wide perspective provided by the methods used in this paper could be combined with in-depth, qualitative interviews with video gamer focus groups. This could establish relationships between expert domain knowledge and more broadly applicable engagement metrics.

REFERENCES

- [1] “ITU-T recommendation G.1032: Influence factors on gaming quality of experience,” Oct. 2017.
- [2] S. Moller, J.-N. Antons, J. Beyer, S. Egger, E. Nunez Castellar, L. Skorin-Kapov, and M. Suznjevic, “Towards a new itu-t recommendation for subjective methods evaluating gaming qoe,” in *Quality of Multimedia Experience (QoMEX), 2015 Seventh International Workshop on*, May 2015, pp. 1–6. DOI: 10.1109/QoMEX.2015.7148155.

- [3] S. Schmidt, S. Zadtootaghaj, and S. Möller, "Towards the delay sensitivity of games: There is more than genres," in *2017 Ninth International Conference on Quality of Multimedia Experience (QoMEX)*, May 2017, pp. 1–6. DOI: 10.1109/QoMEX.2017.7965676.
- [4] A. Sackl, R. Schatz, T. Hossfeld, F. Metzger, D. Lister, and R. Irmer, "Qoe management made uneasy: The case of cloud gaming," in *2016 IEEE International Conference on Communications Workshops (ICC)*, May 2016, pp. 492–497. DOI: 10.1109/ICCW.2016.7503835.
- [5] G. Armitage, "An experimental estimation of latency sensitivity in multiplayer quake 3," in *Networks, 2003. ICON2003. The 11th IEEE International Conference on*, Sep. 2003, pp. 137–141. DOI: 10.1109/ICON.2003.1266180.
- [6] T. Beigbeder, R. Coughlan, C. Lusher, J. Plunkett, E. Agu, and M. Claypool, "The effects of loss and latency on user performance in unreal tournament 2003," in *Proceedings of 3rd ACM SIGCOMM Workshop on Network and System Support for Games*, ser. NetGames '04, Portland, Oregon, USA: ACM, 2004, pp. 144–151. DOI: 10.1145/1016540.1016556.
- [7] K.-T. Chen, Y.-c. Chang, H.-J. Hsu, D.-Y. Chen, C.-Y. Huang, and C.-H. Hsu, "On the quality of service of cloud gaming systems," *Multimedia, IEEE Transactions on*, vol. 16, no. 2, pp. 480–495, Feb. 2014. DOI: 10.1109/TMM.2013.2291532.
- [8] S. Choy, B. Wong, G. Simon, and C. Rosenberg, "The brewing storm in cloud gaming: A measurement study on cloud to end-user latency," in *Proceedings of the 11th Annual Workshop on Network and Systems Support for Games*, ser. NetGames '12, Venice, Italy: IEEE Press, 2012, 2:1–2:6.
- [9] I. Slivar, M. Suznjovic, and L. Skorin-Kapov, "The impact of video encoding parameters and game type on qoe for cloud gaming: A case study using the steam platform," in *2015 Seventh International Workshop on Quality of Multimedia Experience (QoMEX)*, May 2015, pp. 1–6. DOI: 10.1109/QoMEX.2015.7148144.
- [10] J. Beyer and S. Möller, "Assessing the impact of game type, display size and network delay on mobile gaming qoe," *PIK - Praxis der Informationsverarbeitung und Kommunikation*, vol. 37, no. 4, pp. 287–295, Dec. 2014. DOI: 10.1515/pik-2014-0030.
- [11] T. Hoßfeld, L. Skorin-Kapov, Y. Haddad, P. Pocta, V. Siris, A. Zgank, and H. Melvin, "Can context monitoring improve QoE? a case study of video flash crowds in the internet of services," in *Integrated Network Management (IM), 2015 IFIP/IEEE International Symposium on*, May 2015, pp. 1274–1277. DOI: 10.1109/INM.2015.7140480.