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EVALUATION OF PERCEIVED QUALITY BY VIDEO GAME PLAYERS USING NEURAL NETWORKS TO IMPROVE DEVELOPMENT PROCESSES

AVALIAÇÃO DA QUALIDADE PERCEBIDA PELOS JOGADORES DE VIDEOGAMES POR MEIO DE REDES NEURAIS PARA MELHORAR OS PROCESSOS DE DESENVOLVIMENTO

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Abstract
The article considers that the quality perceived by video game players is a complex factor to measure, which sets the tone for this research to use neural networks, as they are a system capable of processing information, recognizing patterns, and approximating an appropriate response, which is a critical point in an industry that has one of the highest annual growth rates in the world. The methodology used is based on exploratory research with descriptive and correlational elements, which were defined using the following reference criteria: published

Resumo
O artigo considera que a qualidade percebida pelos jogadores de videogame é um fator complexo de se medir, o que define o tom desta pesquisa para o uso de redes neurais, pois elas são um sistema capaz de processar informações, reconhecer padrões e aproximar uma resposta adequada, o que é um ponto crítico em uma indústria que tem uma das maiores taxas de crescimento anual do mundo. A metodologia utilizada baseia-se em pesquisa exploratória com elementos descritivos e correlacionais, que foram definidos utilizando os seguintes critérios

studies, market analysis, and industry financial reports. These were applied in questionnaires that classified elements of quality and level of impact, which were answered by video game players to estimate the value of perceived quality with the help of neural networks. The results obtained from the titles evaluated showed acceptable reliability, which will support the development process and monitor the performance of a video game during its useful life, providing information that can facilitate and guide processes in continuous improvement cycles for future video games.

Keywords: Videogames Players. Quality Criteria. User Experience Evaluation. Neural Networks. Game Development Processes.

de referência: estudos publicados, análises de mercado e relatórios financeiros da indústria. Estes foram aplicados em questionários que classificavam elementos de qualidade e nível de impacto, os quais foram respondidos por jogadores de videogame para estimar o valor da qualidade percebida com a ajuda de redes neurais. Os resultados obtidos a partir dos títulos avaliados mostraram confiabilidade aceitável, o que apoiará o processo de desenvolvimento e monitorará o desempenho de um videogame durante sua vida útil, fornecendo informações que podem facilitar e orientar processos em ciclos de melhoria contínua para futuros videogames.

Palavras-chave: *Jogadores de Videogame. Critérios de Qualidade. Avaliação da Experiência do Usuário. Redes Neurais. Processos de Desenvolvimento de Jogos.*

1 INTRODUCTION

To interpret the quality of a video game, it is necessary to consider the elements that compose it and its interactivity with the user, where each element has specific attributes of greater or lesser pleasure for players; such as music, gameplay, character design, script, among others (Sacranie, 2010; Yoshida & James, 2010; Sobocinsky, 2019). The measurements are considered qualitative but can be graded on a scale and create a common numerical framework.

Traditionally, quality can be understood as the level of compliance of a product or service with respect to some specification or, alternatively, as the overall fulfillment of a consumer's expectations when using a product or service (Feigenbaum, 1982; Garvin, 1987). In the field of video games these definitions are difficult to apply, because they are a mixture of technical and creative elements. For example, content and presentation emerged as the main success factors of video games, where users rate high quality graphics as a determining factor (Heidenreich *et al*., 2023). Evaluating them technically ignores the content, while rating them as a creative product is complicated due to the large number of subjective criteria they contain, a solution is to consider both aspects (Sobocinsky, 2019; Alexander & Hidayat, 2022). Having a good perceived value of a video game can trigger feelings toward the brand, establishing a good relationship;

however, no research has provided a detailed answer on how each perceived dimension affects the quality of the brand relationship (Haowen, 2023).

EGoh, Al-Tabbaa & Khan (2023), mention that the video game industry is a highly innovative and rapidly growing sector, which has become the dominant force in the entertainment industry, with significant economic and social implications, and that despite the growing attention that academics and practitioners have paid, the literature remains fragmented and lacking in research works on the subject.

The complex and holistic nature of the analysis of the quality of a product as complex as a video game, are the elements that motivated this work, where exploring the relationship between them is a complex task by traditional methods, finding in neural networks an ideal tool for this type of problems, as they are designed to mimic human behavior with respect to processes of classification and / or weighting of multiple factors.

Therefore, the objective of this work is to propose a graphical model through neural networks, which allows to support the development process by monitoring the perceived quality of a video game by users (Mexico case), providing information that facilitates and guides the continuous improvement processes of future video games.

2 LITERATURE REVIEW

The video game industry began in the 70's, although its origins date back to the 50's with the work of Alexander S. Douglas, creator of what many consider the first video game “Nought and crosses” (Belly & López, 2008).

Between the 50's and 70's the industry grew slowly, but in the late 70's and early 80's the popularization of games like Pac-man, Asteroids and frogger, started a subculture focused on this new form of entertainment, the games were console games and worked with joy-stick and a button (Dillon, 2011; Belli & Lopez, 2008; Gonzalez, 2000).

In the 80's there was accelerated growth, which caused a crisis in the sector due to market saturation. Thus, in June 1982, several U.S. companies dedicated to the production of video games declared bankruptcy, including Atari, who was the most important company in the sector, thus initiating the decline of the industry (Zamora, 2013).

In 1985 Nintendo launched its NES (Nintendo Entertainment System) console, marking the resurgence of the video game industry. During the rest of the decade, other companies joined the market following Nintendo's success and model, and it is during

this period that the first attempt of quality "measurement" by Nintendo arose, by implementing the use of a seal of approval that certified the quality of its video games (Dillon, 2011).

In the 90's the sector underwent important changes, derived from technological advances; such as computer graphics, CD and more powerful chips, so that at the beginning of the 21st century the video game industry achieved great economic potential with the launch of consoles such as: PlayStation 2, Game Cube and Xbox (Solórzano, Moscoso & Elizalde, 2019; Dillon, 2011).

From 2000 to date, video games occupy a relevant place in people's daily lives, where 3 manufacturers dominate the market: Sony (Play Station), Nintendo (Wii) and Microsoft (Xbox) (Lee, Lin, & Yu, 2017; Dillon, 2011; Raposo, 2008; Chang, Kim & Kim, 2007). It is estimated that currently more than 32% of the world's population is in constant contact with this industry and are actively or passively part of it, where in 2022 the video game industry reported revenues of $184 billion, with a projected trend for 2026 of $205.4 billion, representing a growth of 11.6% (Newzoo, 2023), where the global market by segment (billions of dollars) is structured as follows:

- Console games (29%) = 53.1
- Browser PC games (1%) = 1.9
- Downloaded PC games (21%) = 38.4
- Mobile games (49%) = 90.5

3 CONTEXT OF VIDEO GAMES

3.1 Development process

Aleem, Capretz & Ahmed (2016a), mention the importance of improving the video game development process, which is a problem faced by organizations, where high quality is needed to remain competitive and achieve their financial goals, which can be achieved by introducing new perspectives, new game modes, new combinations of genres, improved graphics or new characters. Therefore, almost all games must be novel, and their success depends on their overall quality.

A video game is mainly developed in three stages, which shape the original idea as follows:

1. Pre-production. Focuses on the conceptualization and development of the philosophical, artistic and technical elements that are the basis for future parts of the production process.
2. Production. Starts with what was created in pre-production and is built horizontally, so that many of the sections such as music, art, technical prototypes and script are developed in parallel.
3. Post-production. It focuses on the supervision of the project from the moment it is released to the market until the last day of technical support, including supporting activities such as software updates, development of extra content and customer service. When the last extra content and the last video game update is released, post-production becomes a process of user support and project documentation, known as Closing kit.

These stages are mentioned as part of the development process in various sources (Game Designing, 2021; Hernández, 2017; González, 2011; González, 2010; Aleem, Capertz, & Ahmed, 2016b;) and also in the different records and development diaries of projects such as “Hellblade: Senua's Sacrifice” developed by Ninja Theory (2022), post-release development plans and various interviews with video game directors in specialized media.

3.2 Competitiveness in the video game sector

This industry sector uses an approach to competitiveness similar to the one defined by Porter as strategic competition, which focuses on developing the unique aspects of a company in order to stay relevant and competitive (Magretta, 2016). There are many competitors, so development companies face constant pressure to keep consumers in continuous contact with their products (Lee, Lin, & Yu, 2017), this environment has originated business models such as console generations, where they seek to create hardware that is valid for 5 to 7 years, and that is profitable for both hardware companies and developers by reducing prices through economies of scale, establishing the largest possible user base and recovering the investment with software sales. This model has proven to be successful and allows standardizing the technical capabilities of developers, achieving certainty and reliability in that the software developed has an identical technical performance among consoles of the same model, as well as guaranteeing that the experience acquired generates more sophisticated videogames than their predecessors over time.

According to research by Abbasi *et al*. (2021), video games are designed to have an interactive interface to attract consumers, where a mediating mechanism of absorption, immersion and pleasure seeks to turn participation into addiction.

Once video games are launched on the market, a race against the clock begins to stay relevant, which has generated specific business models, such as extra content, software updates and multiplayer modes. Some developments have opted for models where the video game is understood as an evolving service (continuous updating), with mobile video games being the most visible representative of this approach as explained below:

- Creation of videogame series/sagas. Initially a proposal emerges that is improved through different iterations, creating a product who is technical and narrative development accompanies the player as time goes by. This model seeks to create user loyalty, increasing the likelihood that they will consume what is related to this video game. In this case, it is necessary to maintain a productive line in the publishing company that allows launching a video game every 1 or 2 years. In this format, development periods overlap and it is common to see different studios working on different iterations of the videogame.

- Creation of videogames every 3 or 5 years. The main attraction is the innovation that the new release has over its predecessor, generally the studios that opt for this model launch videogames that represent the state of the art of the industry. This model seeks to have the greatest impact from the feedback of previous releases, so that the next videogame feels totally new and represents another standard within the series or the industry.
- Microtransaction model. The video game is technically free, but has sections of access through small payments, with this model the exposure to the public is maximized and profits are created from a constant income throughout the life of the video game.

Video game development companies introduce user participation in the process. Prystupa & Starostka (2015) mention that it is necessary to find the balance between the creativity of artists and the commercial nature of a product, and that more advanced techniques of user involvement can interfere with that balance, so it is important to understand the needs of consumers and be able to read between the lines.

The economic success and failure of video games, as well as the survival of development companies, are multi-variable, depending on a large number of qualitative, temporal, social and strategic factors. Among others, genre, game engines, business models and protagonist characteristics can have a major impact on the reception and economic achievements of a game (Pfau *et al*., 2022).

3.3 Quality in the video game industry

The classic definitions of quality represent a challenge when transferring them to the video game sector, because they are focused on physical products or service delivery, where the main characteristic is that they are measurable and comparable with established specifications, while, in digital products, they are diverse and unique in terms of the experiences they offer, so it is complicated to assign quality characteristics. Despite the obvious importance of challenge for games, little research has been conducted to explore exactly how players perceive challenge, where players refer to three main types: performative, cognitive and emotional (Denisova *et al*., 2020).

Quality plays a preponderant role in the success of a video game, it seeks high levels of satisfaction and repeated exposure that develops consumer loyalty, which can

be defined as: the evaluation of the conscious and unconscious, objective and subjective relationships that consumers have about a product or service (video game), based on objective first-hand experiences and data obtained by their subjective perceptions (expectations). This concept of quality focused on video games, corresponds to one of the 8 dimensions of quality proposed by Garvin (1987), which corresponds to the eighth, which is the perceived quality; which in this case is formed by a series of elements and objective and subjective relationships that express the expectations about the degree of satisfaction of the player.

It is critical for developers and managers of video game companies to understand consumer perceptions about the quality of virtual products and improve their actual quality. From a managerial perspective, video game companies should focus on developing and maintaining high quality virtual products. To this end, developers and managers of video game companies should frequently visit online gaming communities and social networking sites to conduct research on consumer complaints, needs, and expectations Kim (2021).

Quality monitoring represents a priority for the industry in the struggle to maintain currency, competitiveness and leadership.

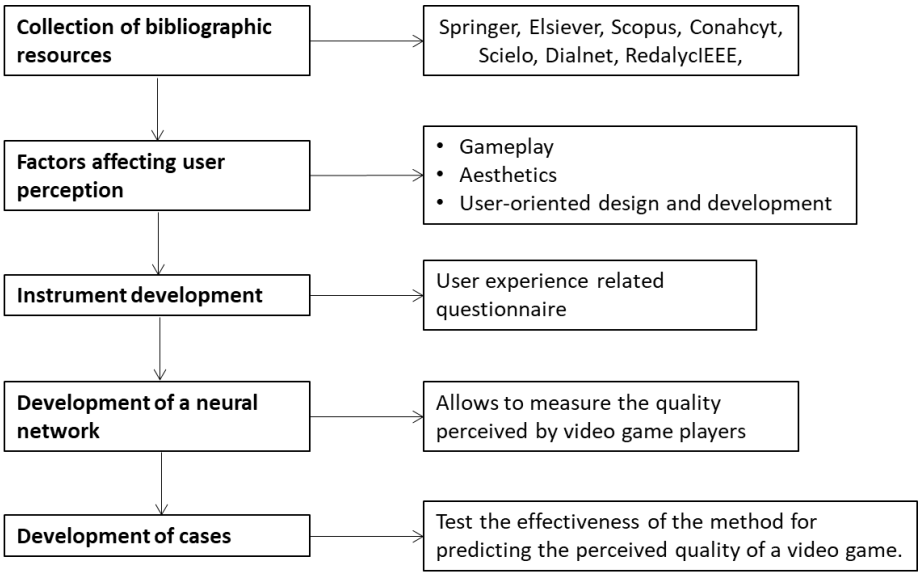
4 MATERIALS AND METHODS

4.1 Methodology

This research presents a case of qualitative and quantitative approach, where the relationship between the factors that affect the quality perceived by the player of a video game and the transformation of this information for its measurement is analyzed. Regarding the scope and type of study, it is of an exploratory nature with descriptive and correlational elements, which implies the proposal of a new study approach for the perception of the quality of a video game. The methodological process is structured in 5 stages, as shown in Figure 1.

Figure 1

Methodology



Source: Own elaboration

For the development of the research in its different stages, bibliographic resources, information regarding market analysis and financial reports of the video game industry, information gathering tools (questionnaires), google forms, metacritic platform and Matlab were used.

4.2 Materials

- Collection of bibliographic resources

Few academic research works related to quality applied to the perception of video game users were found, so statistical and commercial reports from video game development companies were included, as well as the specialized press in the sector.

- Factors Affecting User Perception

The factors affecting user perceptions were determined based on an analysis of the industry sector, processes of criticism and review of video games, research developed on the subject and characterization of the player's experience in specific and measurable aspects (Alexander & Hidayat, 2022; Sobocinski, 2019; Lozano, Montaño & Corona, 2019; Solórzano, Moscoso & Elizalde 2019; González, 2010; Sacranie, 2010; & González, 2010), which are typified in 3 headings with attributes that allow their quantification:

1. Playability: Responsiveness, immersion, progression systems, fun, learning curve, estimated hours of content, difficulty, variety in content and consistency.
2. Aesthetics: Narrative, music, graphic art, cinematic look and feel and identity.

User-oriented design and development: Experience free of programming errors or technical problems and user interface design.

- Development of the instrument

It was designed based on the user's experience, composed of two sections: 1) Registration of the control variables of the population, with data on consumption and use of video games that allows describing the surveyed population, and 2) Likert scale questions, designed to evaluate the individual and measurable aspects of each of the dimensions of perceived quality in video games. It was limited to a specific video game genre, thus isolating possible differences between genres and the experiences they generate in users.

The questionnaire was carried out in Google forms and was applied to a voluntary non-probabilistic sample, through invitations and promotion at events and video game conventions. The characteristics requested from the respondents were:

- Experience playing video games of the “action” and/or “shooter” genres.
- Interest, curiosity, academic or personal affinity about the research work and video games.
- Age ranges from 17 to 27 years old.

The criteria were defined according to information from different market analysis and financial reports of the industry, both nationally and internationally, as is the case of annual reports generated by recognized organizations and companies in the industry (Entertainment Software Association, 2020; Activision-Blizzard (2021); Newzoo (2020), which are as follows:

- The chosen video game genre is the most popular and the one in which most players are likely to have experience.
- Affinity to the research topic improves the likelihood that the surveys received will be as analytical and objective as possible.
- The age range is considered ideal for Mexico, according to statistical data on video game consumption, coupled with the need for the respondent to have the capacity for objective analysis.

– The nature of neural networks requires that the information collected is adequate to be trained correctly, which makes it essential that this information comes from specific individuals within the population, which is why it was decided to do a voluntary non-probabilistic sampling.

From the universe of questionnaires, 124 were selected and completely answered. The information was processed in spreadsheets, to form a database appropriate for Matlab and the neural network training process, which are structured as follows:

1. Descriptive statistics

– Geographic location of the surveys: Central Mexico.
– 89.5% of respondents are male.
– 50.8% are between 18 and 23 years old.
– The preferred platform for gaming is Xbox One with 41.9%, followed by the computer with 39.5% and PlayStation 4 with 10.5%.
– The preferred genre of the respondents is First person shooter (FPS).
– The average monthly expenditure is less than 500 pesos in 57.3% of the cases.
– The average time spent playing is 10 hours per week.

2. Macro and microenvironment variables

– Macroenvironment.

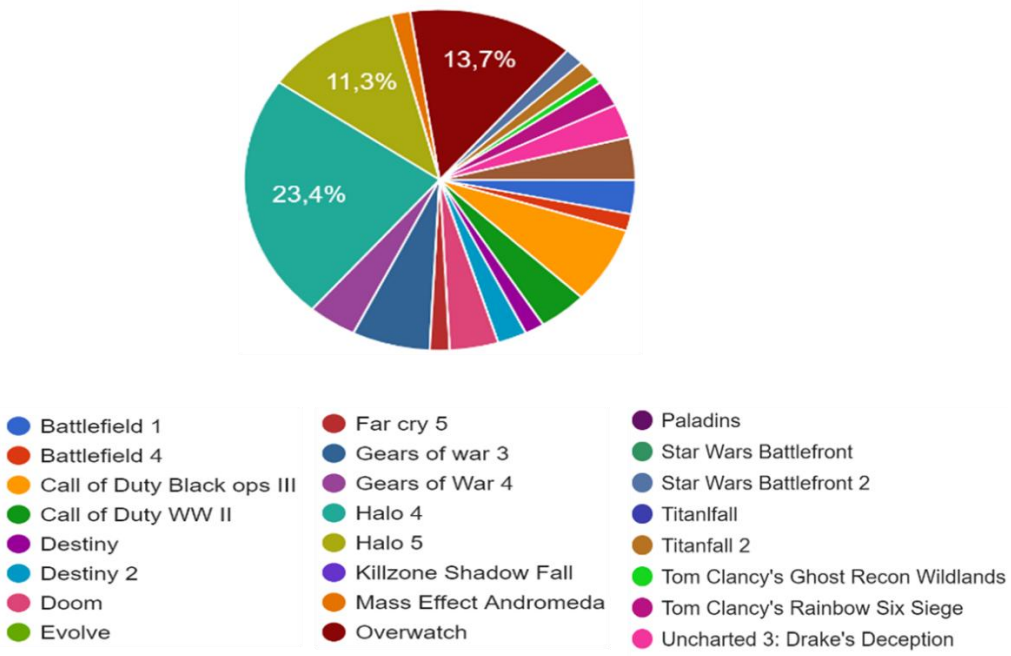
Elements outside the video game that may have an impact on the perception of quality, such as the presence of artists or personalities, technology integration and marketing strategies, among others, are considered.

– Microenvironment

Aspects directly related to the video game and the user experience are considered, which are distributed in 16 dimensions of perceived quality, which are analyzed in the neural network. For the research, the video games evaluated were varied, but with clear trends (Figure 2).

Figure 2

Video games evaluated by the players



Source: Own elaboration

From Figure 2, it is observed that a significant percentage of players evaluate the video games of the Halo series, so the results obtained are influenced by the criteria that players consider most important in that franchise. Likewise, the results indicate that there is a sufficient amount of data on 11 different games, thus achieving an adequate variety among them for use in the analysis method based on artificial neural networks.

Table 1

Selected video games

No.	Video games
1	Halo 4
2	Halo 5
3	Overwatch
4	Call of Duty Black ops III
5	Gear of war 3
6	Uncharted 4: A Thief´s End
7	Call of Duty WWII
8	Uncharted 3: Drake´s Deception
9	Gear of war 3
10	Destinity
11	Destinity 2

Source: Own elaboration

– Artificial neural network development

The general model of an artificial neural network is mathematically represented by the following equation:

$$f_{activation}\left(\sum_{j=1}^{n} x_j w_{ij}\right) = y \qquad (1)$$

An equation capable of estimating the perception of the quality of a video game can be developed, based on the opinions of individual users and generalizing their preferences, which is described below and represented the 16 impact factors in Figure 3.

$$Responsiveness * Weight_1 + Immersion * Weight_2 + Progression\ system * Weight_3 + \cdots$$
$$+ User\ interface\ design\ (UID) * Weight_{16} = Percived\ quality \qquad (2)$$

Generalizing each of the variables as factors Fn and the weights as wn, the expression can be represented as:

$$F1w1 + F2w2 + F3w3 + F4w4 + F5w5 + F6w6 + F7w7 + F8w8 + F9w9 + F10w10 + F11w11$$
$$+ F12w12 + F13w13 + F14w14 + F15w15 + F16w16 = Percived\ quality \qquad (3)$$

And reduced to its most compact form:

$$f_{activation}\left(\sum_{j=1}^{16} x_j w_{ij}\right) = perceived\ quality \qquad (4)$$

where:

Fi represents the 16 factors or variables of perceived quality in video games at the micro-environment level.

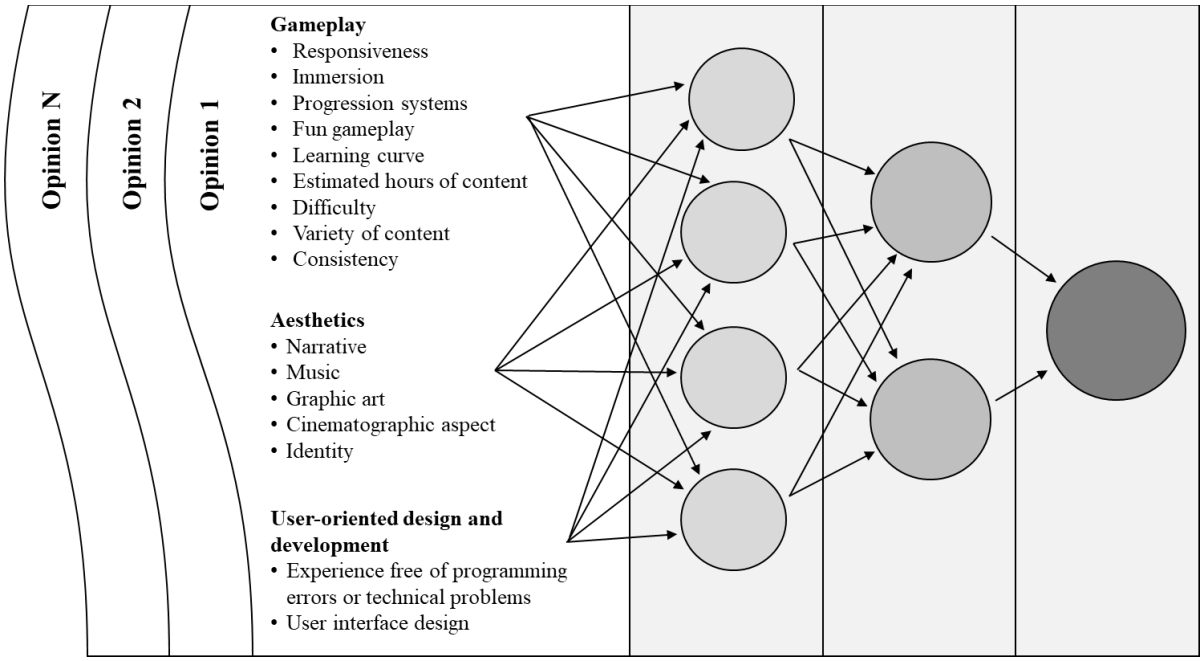
wi represents the weights assigned by training the neural network and whose function in practical terms is to adjust all the factors of the system to match the network input to the network objectives.

Perceived quality is represented on a scale of 1 to 10, where 1 represents the lowest and 10 the highest.

$f_{activation}$ represents the mathematical tool that adjusts the summation to the desired output, in this case it is the neural network and all its training process, which allows to delimit the behavior and adjust the result of the summation on a scale from 1 to 10.

Figure 3

Representation of the neural network for measuring perceived quality in video games

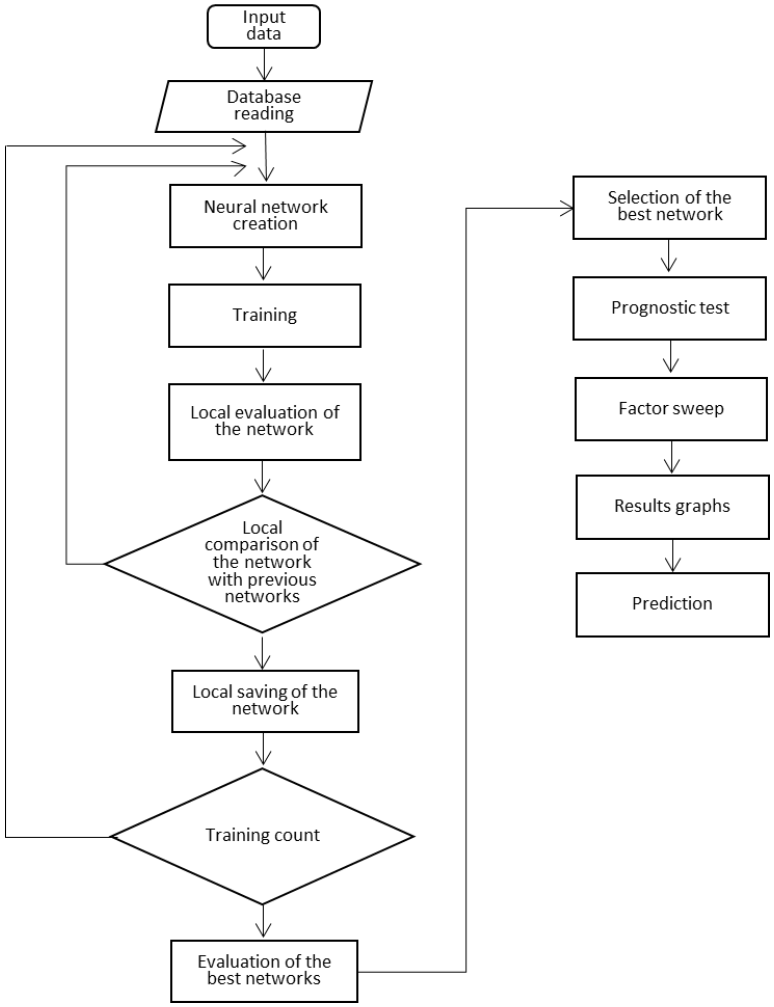


Source: Own elaboration

Based on the information gathered, a series of neural networks are trained and evaluated in Matlab, capable of interpreting the results of the survey and determining the value of perceived quality of any other video game similar to the one evaluated and with which the network was trained (Figure 4). The process is automatic and at the end the information rated as the best among hundreds of similar networks is obtained in a graphical interface. The general objective value used is based on data obtained from the metacritic platform, where thousands of users evaluate video games according to their criteria, and an average value of these evaluations is displayed.

Figure 4

Neural Network Programming Algorithm



Source: Own elaboration

The criteria to determine which neural network is the best compared to others, are modifiable and depend on indicators such as performance, MSE (mean square error) or R^2 (coefficient of determination) of prediction and objective values, based on the following equations (Geyikci *et al*., 2012):

$$\mathrm{RMSE} = \left(\frac{1}{n}\sum_{i=1}^{n}(V_{pre} - V_{act})^2\right)^{1/2} \quad (5)$$

$$R^2 = \frac{\left(\sum_{i=1}^{n}(P_{act} - \overline{P_{act}})(P_{pre} - \overline{P_{pre}})\right)^2}{\sum_{i=1}^{n}(P_{act} - \overline{P_{act}})^2 (P_{pre} - \overline{P_{pre}})^2} \quad (6)$$

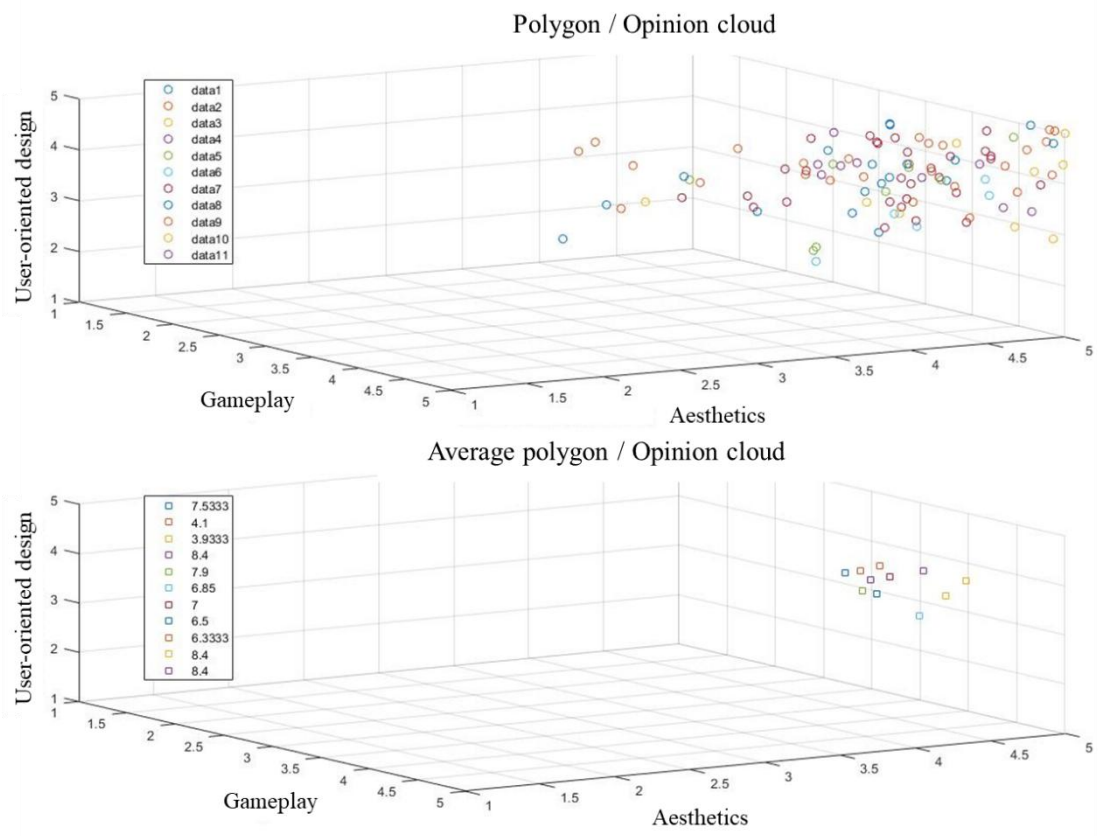
Where *n* is the number of values analyzed, P_{pre} is the value predicted by the ANN, P_{act} is the value used from the information collected in Google Forms, and the terms $\overline{P_{pre}}$ y $\overline{P_{act}}$ indicate the average of the predicted and actual values respectively.

To facilitate the reading and interpretation of the neural network results, a graphical interface was created with the most relevant aspects of the information processing, which consists of 6 sections:

1. Isometric graph. Its axes correspond to the 3 classifications of the evaluated variables of the microenvironment: playability, aesthetics and design called "polygon or cloud of opinion", which represents the collective of all the opinions analyzed in a three-dimensional space, and theoretically a perfect game will be represented by a single point at the upper end of the coordinate axes, and the worst game will be represented by a point at the lower end.
2. Average of the evaluated data. It allows us to find in the center of the polygon of the graph the trend of the data and the general perception of quality of the surveyed players. At the same time, it represents the input data of the neural network and when used in real scenarios, these data would be completely new to the network.

Figure 5

Polygons of the neural network graphical interface

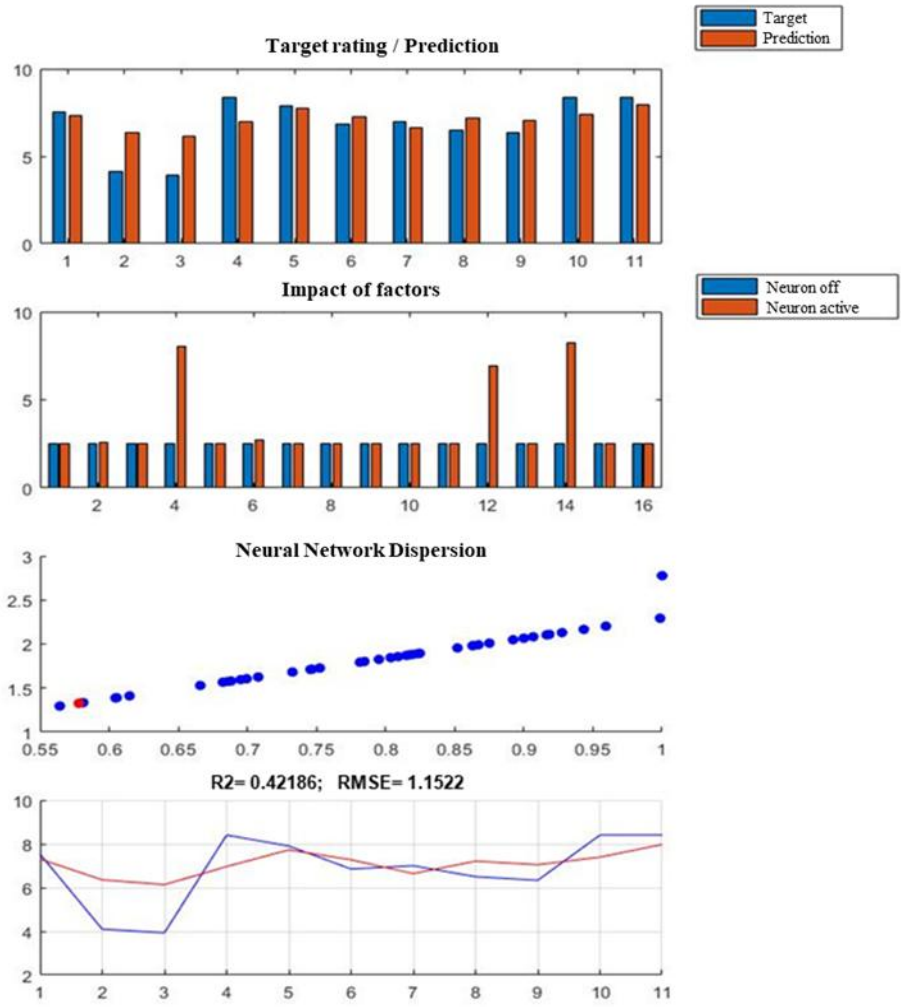


Source: Own elaboration

3. Objective values compared with the prediction of the network in each video game evaluated.
4. Sweep and impact level of each of the 16 factors in the neural network. The impact level can be positive or negative and is interpreted as the absolute difference between the value obtained by the factor, when the network is "off" it receives as data values of 0 and when the network is "on" it receives maximum values.
5. Scatter plot with different evaluation criteria. It shows the variability of the obtained networks and identifies the general behavior of the network with respect to the measurement of the network error. This plot can be manipulated to contain the performance, MSE and R^2 on any of the x,y axes, depending on the network selection criteria, or if a specific pair of these metrics is to be compared.
6. Goodness-of-fit of prediction and targets graphically. Consider the sets of values as a function and evaluate the fit of both "functions" or data sets.

Figure 6

Target values, impact, dispersion and fit



Source: Own elaboration

Depending on the modifications made to the parameters of the training algorithm and neural network selection, the results may vary. Likewise, another factor that affects the effectiveness of this method is the composition of the database.

4 RESULTS

Two cases were developed that prove the effectiveness of the proposed method, being able to predict the perceived quality of a video game with an acceptable degree of accuracy.

4.1 Case 1

Training: 5 hidden layers, 5 neurons per layer and 10 trainings, evaluation based on performance and MSE.

The results of the graphical interface, says that the prediction of the neural network has ± 13.41% percentage deviation with respect to itself. With this value, the degree of accuracy of the network can be determined by using the prediction value and determining the lower and upper limits, where the prediction can be considered as correct (Table 1).

Table 2

Results of Case 1

Video game evaluated	Objective values	Network prediction	Absolute % deviation (respect to prediction)	Average Absolute % Deviation	Prediction upper bound	Prediction lower bound	Prediction success	Percentage of accuracy
1	7.5333	7.3052	3.12%		8.2849	6.3254	Success	
2	4.1	6.3554	35.49%		7.2077	5.5030	Failed	
3	3.9333	6.1359	35.90%		6.9588	5.3129	Failed	
4	8.4	6.9618	20.66%		7.8955	6.0280	Failed	
5	7.9	7.7266	2.24%		8.7628	6.6903	Success	
6	6.85	7.2693	5.77%	13.41%	8.2442	6.2943	Success	63.64%
7	7	6.6419	5.39%		7.5326	5.7511	Success	
8	6.5	7.2096	9.84%		8.1765	6.2426	Success	
9	6.3333	7.0479	10.14%		7.9931	6.1026	Success	
10	8.4	7.3934	13.61%		8.3849	6.4018	Failed	
11	8.4	7.9724	5.36%		9.0416	6.9031	Success	

Source: Own elaboration

The level of accuracy of the neural network is 63.64%, assuming that it will evaluate a video game on a scale of 0 to 10, where the prediction is 7 successes out of 11 video games analyzed.

By implementing a minimum value or a threshold value, it is possible to discard results that by the nature in which the network relates to the factors would always be failures in the prediction.

To determine the minimum value or threshold from which the result of the neural network can be considered useful, the successful prediction with the lowest value is used, in this case it corresponds to video game 7 with 6.6419. The usefulness of the network is established from this value, discarding video games 2 and 3, and reevaluating, the accuracy of the network increases to 77.77%.

4.2 Case 2

Training: 5 hidden layers, 5 neurons per layer and 5 trainings, evaluation based on goodness-of-fit R^2 and MSE.

Unlike case 1, one of the selection criteria changes the performance to the R^2 value, in order to create a series of different conditions in the training algorithm and neural network selection that could generate different results.

In this case, the average percentage deviation is 15.33% with respect to the value predicted by the network, this percentage acts as a tolerance band of prediction, delimiting the lower and upper limits. The accuracy of the predictions is 54.55%, which means that it had 6 successes out of 11 attempts, which places it below the network obtained from case 1.

Table 3

Results of Case 2

Video game evaluated	Objective values	Network prediction	Absolute % deviation (respect to prediction)	Average Absolute % Deviation	Prediction upper bound	Prediction lower bound	Prediction success	Percentage of accuracy
1	7.5333	6.1731	22.03%		7.1192	5.2269	Failed	
2	4.1	5.7331	28.49%		6.6118	4.8543	Failed	
3	3.9333	6.1546	36.09%		7.0979	5.2112	Failed	
4	8.4	7.621	10.22%		8.7890	6.4529	Success	
5	7.9	7.8192	1.03%		9.0176	6.6207	Success	
6	6.85	5.7325	19.49%	15.33%	6.6111	4.8538	Failed	54.55%
7	7	6.9847	0.22%		8.0552	5.9141	Success	
8	6.5	6.9547	6.54%		8.0206	5.8887	Success	
9	6.3333	7.3548	13.89%		8.4820	6.2275	Success	
10	8.4	6.8279	23.02%		7.8744	5.7813	Failed	
11	8.4	7.8091	7.57%		9.0060	6.6121	Success	

Source: Own elaboration

Applying the criterion of the threshold value of 6.9547, a significant improvement in accuracy is achieved with respect to case 1, where any prediction whose value is higher than this threshold has 83.33% accuracy.

In relation to the impact of individual factors this network is more general, as most of these have a significant impact. This indicates that this neural network takes into

account many more factors than the previous one to determine the quality, which makes it more holistic and accurate compared to the network obtained from case 1.

These 2 cases were selected as the best results, due to their level of accuracy and variety in their differences, which show the importance of the threshold value and illustrate different scenarios, in addition to the fact that they are comparable and manage to predict quite closely the perception of quality in each of the tested games.

5 CONCLUSIONS

The proposed methodology proves to be viable for the measurement of the perceived quality of a video game, where the application of the measurement instrument allows representing the perceived quality of each title, as well as in each of the major classifications of the evaluated variables, through the opinion polygon and each factor at an individual level by means of the sweep of the factors.

The neural network resulting from this methodology must be interpreted and weighed correctly to ensure that the information obtained is applied effectively. The results obtained show a mostly positive trend with respect to the perceived quality of the titles evaluated, suggesting that they can be considered of good quality.

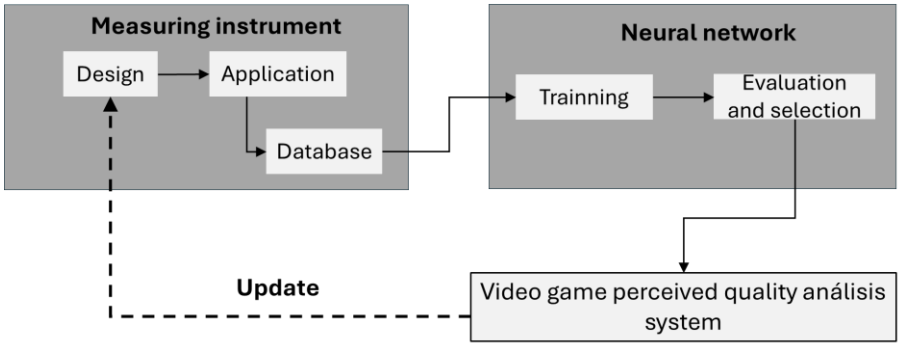
It is remarkable the level of importance that the database has for the training of the neural network, because a biased database can hinder its training and consequently not reach the expected results.

Neural networks proved to be an area of opportunity within the analysis, because they can be considered as a specialized tool that with good treatment allows reaching the objective of measuring the quality perceived by the users of video games.

The above is established in a general model with update of cycles for the video game quality analysis system, to ensure that the database is generated based on market consumption trends and player perception (figure 7)

Figure 7

Cycle model for perceived quality in video games with neural network assistance



Source: Own elaboration

With the selection and composition of the database, networks with different applications can be created, from the general purpose as the ones evaluated in the work, to specialized networks to qualify specific aspects in video games.

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All authors contributed equally to the development of this article.

Data availability

All datasets relevant to this study's findings are fully available within the article.

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