International Journal on Advanced Science Engineering Information Technology

Vol.11 (2021) No. 3
ISSN: 2088-5334

Evaluations of Software Developed as Research Tools to Analyze Trends of Educational Videogames Characters

Nayeth I. Solorzano Alcivar[a,*], Lissenia I. Sornoza Quijije[a], Diego A. Carrera Gallego[b]

[a] *ESPOL Polytechnic University, Escuela Superior Politécnica del Litoral, Km. 30.5 Vía Perimetral, 09-01-5863, Guayaquil, Ecuador*
[b] *UPM, Universidad Politécnica de Madrid, Avda. Complutense 30, Madrid, Spain*
*Corresponding author: *nsolorza@espol.edu.ec*

***Abstract*— Children's use of educational videogames is a growing at-home trend and has become a relevant classroom supporting tool in the teaching-learning process. The increased attachment to video games has hastened the creation of "learning through play" applications. The development of these applications requires the creative production of content using characters (avatars) playing distinct roles to engage people with the game. Evaluation tools need to be designed to understand and improve this engagement. This study aims to explain the design and development structure of research tools such as online personalized questionnaires and dashboard platforms used to populate data in a cloud for evaluating games' usability and avatars' preferences. The paper revises the applicability of three research tools tested to analyze five different graphic lines games series and the archetype of their designed avatars. The MIDI-AM educational videogames series for mobile applications is the case study examined. The need to evaluate the avatar preferences before or after playing the games to find correlations with the usability trends is present. Comparative results between the three designed research tools will help solve issues about different viewpoints between designers and producers concerning graphic lines used in educational games production and the correlation with game use preferences. The research is relevant for graphic designers, producers, and creative experts to develop well-informed styles and avatars for children's digital games. Also, the practicality of using the proposed research tools to analyze videogame and characters' preferences is confirmed.**

***Keywords*—Software evaluation; digital games; serious games; dashboard; JSON; MIDI-AM; graphic lines; cartoons; survey tools; active learning; children education; cloud services.**

Manuscript received 5 Jul. 2020; revised 26 Mar. 2021; accepted 23 Apr. 2021. Date of publication 30 Jun. 2021.

I. INTRODUCTION

Educational videogames or Serious Game for mobile devices are applications designed to support the teaching-learning processes rather than entertainment only [1], [2]. Especially ludic digital games in children in the early years of elementary school, for regular learning or specific requirements, have come widely use [1], [3]-[5]. In this regard, technological tools are becoming essential support instruments for the traditional education system and special education towards a more innovative teaching-learning process [1], [5]-[7]. Thus, using these digital game applications (apps) in classrooms is a desirable alternative because of the children's massive acceptance of technological devices [8]. Although educational digital games are not part of the daily school routines, there are festive opening doors for using video games in education [6]. Thus, teachers are gradually incorporating these games proposed as independent educational activities, with some of the multimedia world [9]'s [1], [8] advantages [9]. Studies revealed that children associate technological devices, like Tablets with ludic apps, as game time. Hence, the gadgets ease the teaching process due to the students' positive attitude towards playing while studying [1], [8]. Also, video games have the educational potential to keep the students immersed in the narrative (content). They characterize graphic adventures and the medium's basic properties (game level), proposing a series of challenges, missions, or obstacles that the player must overcome [9]. Thus, the development of educational games apps involves working with interdisciplinary groups of professionals, including software developers, designers, video producers, psychologists, and pedagogues. The intention is to fill the gap between computer science, psychology, design, artificial intelligence, and other disciplines related to digital game production [9]-[11]. Thus, the development of educational games apps involves working with interdisciplinary groups of professionals, including

software developers, designers, video producers, psychologists, and pedagogues. The intention is to fill the gap between computer science, psychology, design, artificial intelligence, and other disciplines involved in digital game production [10], [11]. In the case of videogames for young learners as they are starting to read, solving visual communication issues in mobile apps is the primary concern of the referred professionals.

An attractive design of the game is crucial considering they can increase the children's engagement level facilitating their awareness in their learning perception [1], [3]. Learning takes place with the use of images, illustrations, animations, or digital interactions. The designers play a crucial role during this stage since they are responsible for "the world's visual setting." Their part is to make ideas visible, tangible, and inform, considering that the game's virtual characters' appearance strongly influences user experience [12].

Virtual characters are crucial parts of virtual environments but especially computer games. The interaction between these characters and human players directly impacts the application's credibility and engagement [10]. In this visual setting, creating characters involved in a game's animation is a complicated task. It implies defining the cartoon character's formal representation animated with visual and physical aspects, including facial expressions and movements, vital to these interactions that make an attractive identity for young learners [10]. Animated characters can improve children's experience, increase concentration, bring motivation, and accomplish more effective outcomes related to the use of the game [7], [12].

The design task includes phenotypes, archetypes, racial characteristics, biometric and anthropometric maneuvers, costume proposals, and accessories [13]. Furthermore, the designer must be sure that characters and scenarios in the games reflect the reality and feelings of prospective users, including facial expression related to the game situation [10]The design task includes phenotypes, archetypes, racial characteristics, biometric and anthropometric maneuvers, costume proposals, and accessories [13]. Furthermore, the designer must be sure that characters and scenarios in the games reflect the reality and feelings of prospective users, including facial expressions related to the game situation [10].

For more than a decade, a multidisciplinary group of researchers, developers, designers, and pedagogues has worked to design and produce ludic digital applications to complement the elementary school curriculum [11]. These authors consider that the analysis and evaluation of usability, trends, and characters' game preferences are imperative for assuring the referred type of applications' adoption. In this sense, they find the need to consider any correlation of virtual characters' preferences among factors such as frequency of game's use or graphic line choices. The evaluations must include young learners and adults (such as their parents and teachers) related to the children playing the games. These individuals have considered the perspectives of videogames using "learn by playing" strategies [1]. Nowadays, sound literature considers educational videogame relevance in regular and inclusive education [3], [7], [14]-[17]. However, a scarcity of literature identifies research tools used to analyze and evaluate game design, character trends, and correlation preferences between children's and adults' opinions.

In this regard, a question arose concerning identifying trends and preferences of the visual aspects, design, and production of educational games ecosystems, including their virtual characters and graphic line styles. This study seeks to explain the design structure of two developed dashboard platforms for games and one online questionnaire used as research tools to collect data in the cloud to analyze and evaluate videogames usage and their character's preferences. The researchers use for examination the educational game series branded as Mobile Applications for Children's Interactive and Didactic Multimedia, MIDI-AM (Spanish acronym). These digital game series apply five different graphic lines created for its apps.

Data processing and analysis could use software developed for collecting observational, experimental, or computational data from stakeholders. Also, computational can facilitate virtual character creation in any game by creative minds in the industrial world of videogames [18]. Hence, researchers must define strategies for interpreting the results obtained from the data processed by the software. It is essential to a standardized data structure that designers and developers can process and understand quickly. For example,

Create tools to store data for metric valuation, including learner engagement and collaboration with peers as suitable inclusive learning indicators [14]. Also, create computational tools for gathering pathway information storage in the cloud to analyze the observed behavior of using educational videogames, trends, and preferences concerning the games and their features. These tools also embrace embodied cognition principles and use them as implementation requirements for new videogames [11], [18]. These tools also welcome incorporated cognition principles and use them as implementation requirements for new videogames [11], [18]].

The production of educational games used for active learning encloses multidisciplinary knowledge and skills from practitioners and stakeholders involved [10], [19]. Thus, the practice of utilizing software as research analysis tools or as part of techniques to evaluate the design and use of this type of game is a challenge. In this matter, triangulation data analysis tools can increase the confidence of outcomes validity in the combination of qualitative and quantitative data analysis. The problem is finding a common denominator for qualitative and quantitative data for meaningful comparisons and, in some cases addressing the complexities inherent in utilizing triangulation processes [20], [21].

Authors recommend computer-assisted tools to collect and analyze data better to understand collaborative research outcomes [20], [21]. The importance of various software to be used as research tools, the same as data analytics and visualization, is relevant for researchers to make a clear results interpretation. For example, several serious games, like the MIDI-AM series, count with web-browser dashboards designed to send out traces while a user is playing. The dashboards help monitor the game's activity, usage behavior, and playability [2], [5], [22]. Moreover, observations and online surveys using the Google database repositories can complement the data analysis triangulation to evaluate games' usability and features. Triangulated instruments can provide researchers relevant information about users' performance and preferences to validate a digital game design (for children) in different case studies [2].

Several authors state that video games can be applied to develop the infant stage [11], [13], [15]. The MIDI-AM applications include cartoon series and interactive digital games about Natural and Social environments and nutrition linked to the curricular programs determined by the Ministry of Education and Culture of Ecuador [8], [11]. These types of applications, related to the curricular school programs, are considered an appropriate reference for the content preparation for children taking the first three-level in elementary education [11], [13]. The authors consider MIDI-AM as an excellent case evaluated for identifying trends of games usage, features, and character preferences by testing the proposed computer-assisted research tools created.

II. Materials and Methods

A. Methodology

Multidisciplinary research involves multiple stages, such as designing, developing, and validating educational video game usage. For interdisciplinary studies, applying pragmatic mixed-method or pluralistic methodologies is becoming more relevant, considering that it mainly focuses on the results rather than using a particular method [23], [24]. The qualitative-quantitative mixed-method uses multiple types of data analysis techniques commonly referred to as triangulation [20], [21]. A triangulated data analysis combining qualitative and quantitative research tools is applied to this research, opening the evaluation criteria' possibilities.

Firstly, using qualitative strategies, the authors apply observation techniques to work with a focus group of children's playing a game titled 'Lethos' (which is linked to a dashboard to monitor characters' preferences). The focus groups took place in different elementary schools of Guayaquil city. Children were asked to select and paint favorite characters using the 12 primary colors of the chromatic rose. As part of the MIDI-AM research project, the data collected in the cloud had the parent's or guardian's permission. Using the 'Lethos' game as an evaluation tool combined with the observation technique helps the researchers understand the preferences for game characters and their features.

Secondly, using quantitative techniques, educational games linked to metrics collected in the MIDI-AM dashboard (named MidiAPI) are examined. MidiAPI can send out traces while children or any user are playing. The intention is to analyze usability, playability, and other technology adoption factors to analyze game use trends [11].

Thirdly, a survey questionnaire was designed for adults (parents, teachers, and caretakers) to gather opinions about the preferences they believe their children have. For example, the survey collected information regarding virtual characters' choices, the favorite games for their children, among other data required.

Overall, the purpose is to evaluate the practicality of two developed applications and one Google questionnaire designed as research tools for online data collection to analyze digital games and virtual characters' preferences from a qualitative and quantitative point of view (see Fig. 1).

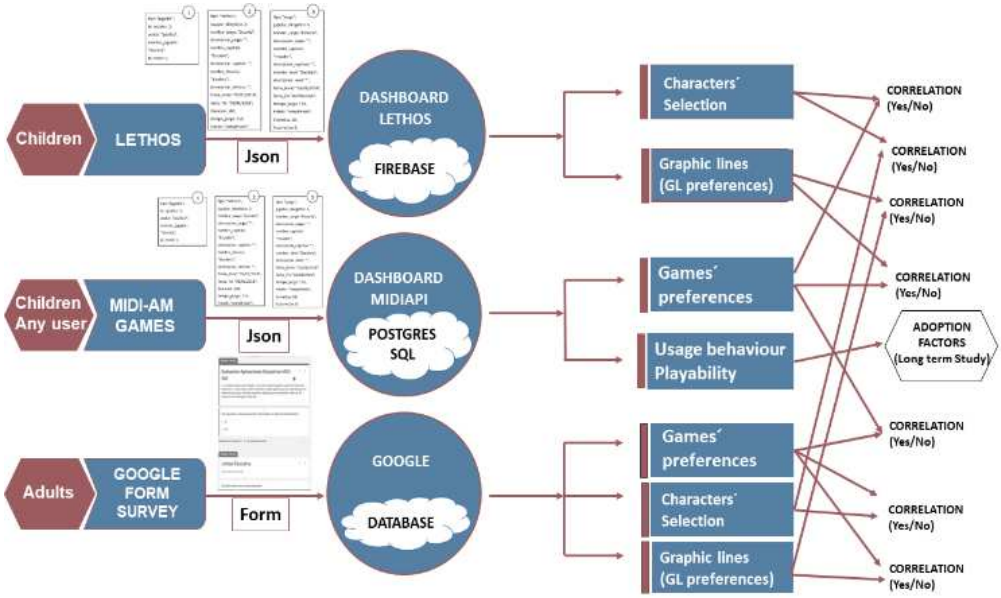

Fig. 1 Data Analytic Structure of Research Tools.

A. The MIDI-AM series and the participants

The MIDI-AM game series applications (apps) used in mobiles for Android are the case study applied to examine the validity of the designed research tool in data games evaluation. The design structure of the games includes the transmission of traces while a child is playing. This data is stored in an online database in the cloud monitored by a dashboard [5], [22].

The study participants: children, parents, caretakers, teachers are considered the primary stakeholders of the MIDI-AM apps. The users examined are the children between four to eight years old from four elementary schools located in low-income neighborhoods of Guayaquil, Ecuador. In this regard, the analysis criteria include studying MIDI-AM characters' archetypes preferences and games played by the selected users. The intention is to identify possible correlations between Graphic Line (GL) style preferences

related to each game's characters and the trend regarding the games most played. The authors evaluate choices between children's usage behavior and adults' opinion (parents, teachers, and other adults related to the children), reporting what they think their children prefer. The favorite characters, their features, and their GL style preferences are identified from the evaluation tests.

B. The Research Tools Designed and Tested.

1) Preferred Game Structure - MidiAPI: The MIDI-AM apps connected to the MidiAPI dashboard system send out traces in real-time data transmission while children are playing (see Fig.2). The MidiAPI web architecture took as reference the TechTown metrics for the web application proposed by Whalen, Moss [25], and other adoption theories adapted to measure usability and playability for the MIDI game series [22]. The technical resources for the dashboard are two: the backend, using a NODE environment programming based on JavaScript and the Sails.js framework, and the frontend developed using Angular. The database implemented is in PostgreSQL, and the file lightweight data-interchange format is on JavaScript Object Notation (JSON). The general architecture of the system captures user registration and gaming information of the session about app played which chapter (content) and in which scenario situation (room) (see Fig.2 left). Solorzano, Sornoza [26] explain that each game, executed from a mobile device (Tablet), sent data about learning story seeing or game level played to a database server. The data stored are game level played, stories (animated chapter) completed, avatar selected (as user ID icon), timely completion of a game level, time running the stories, number of correct and incorrect answers between others. The transmission of the information uses POST requests.

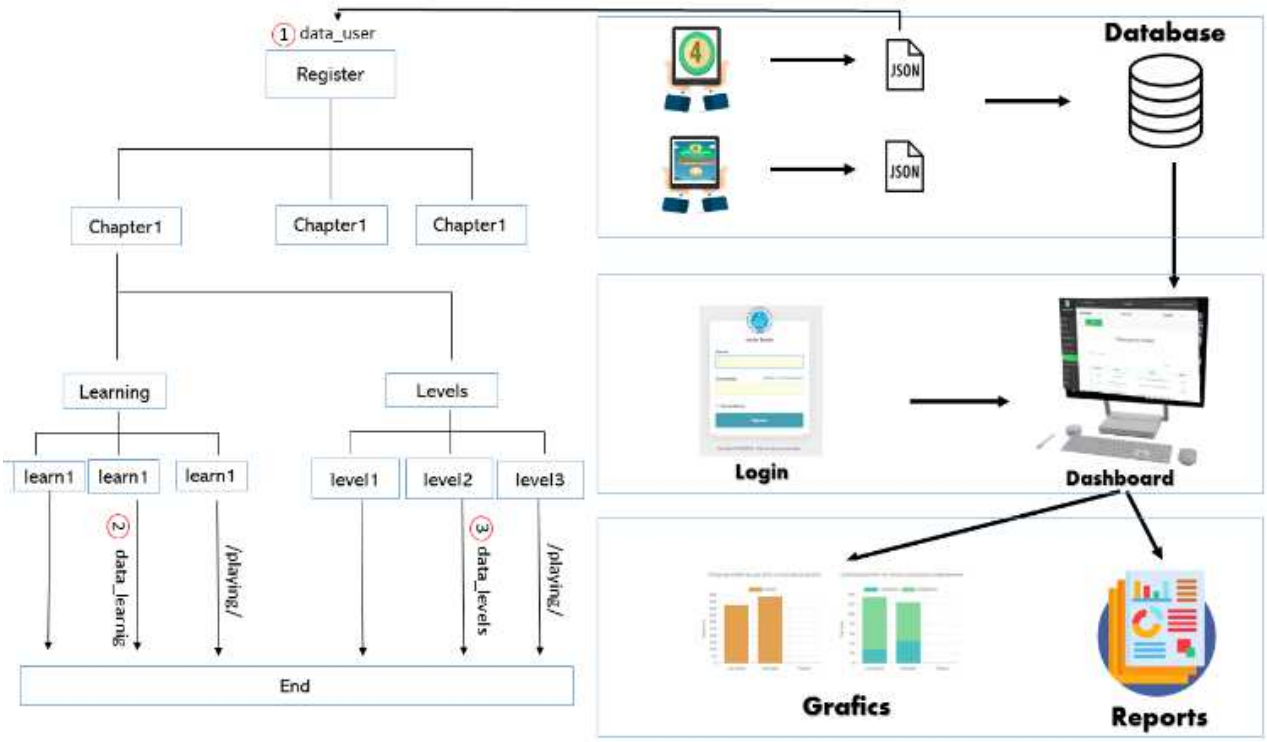

Fig. 2 MidiAPI dashboard structure with its JSON and post request.

The use of the MidiAPI dashboard starts in the login section of the web application, and it encompasses all the information processed, ready to be analyzed, including the structure of the database and the main CRUD (reading, writing, updating, and deleting data) operations. The dashboard application presents bar or pie charts according to the selected filter. For example, to show the frequency of most accessed apps. The use of Chart.js a node.js library allows the implementation of all kinds of graphics, automatically adapting the web page's space (responsive). The reports use filtered levels to provide general information or any specific requirement. Phantom.js is used to render the web page in memory and then make a screenshot. Node Js library html-pdf is used to format the PDFand download the file directly (see Fig.2).

2) Adult stakeholder's online questionnaire instrument: a questionnaire for parents, teachers, or caretaker relatives was designed and implemented in the Google forms platform. The questionnaire is accessible from the MIDI-AM Website to any adult included in the survey. This instrument had mostly closed questions related to the topic, and it contains 16 sections, showing a set of five characters illustration from the five different GL used for the games apps. The measures use the Likert scale, where one is the least attractive and five the most attractive. The questionnaire is in Spanish, the native language of the respondents surveyed. In several questions, the respondents had to weigh each graph according to their visual appreciation.

Fig. 3 shows an example of a question, including the character's illustration GL and the given scale. In the designed questionnaires, questions and characters' illustrations can be modified depending on the games tested. The questionnaire also was delivered through a link via WhatsApp or by email. The survey questionnaire is host through the MIDI-AM

website. An alternative way to provide the questionnaire was face-to-face or virtually assisted by a computer to help participants complete them. Parents, teachers, and caretakers whose related children have used MIDI-AM apps in the selected schools receive a link to answer the questionnaire. As the criteria used, the children already knew the MIDI-AM apps. The researchers categorized the responses and analyzed the results (see Fig. 3 survey fragment example).

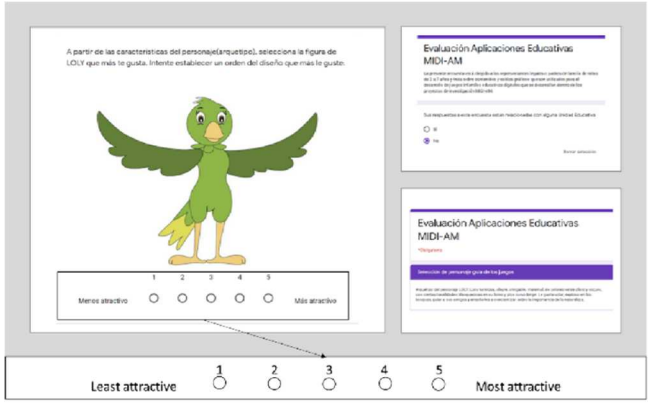

Fig. 3 Level of acceptance - Google questionnaire fragment in Spanish.

3) Lethos-the dashboard game structure – for children's data collection: The mobile application (Lethos) for Tablets is an art game designed for selecting, painting, and dressing their favorite characters. Hence, the children played with Lethos, and it collected information about gaming preferences. The graphic application uses Adobe Illustrator and Photoshop. Unity was the video game engine used for the development and programming of the application. Lethos's dashboard operates in Javascript with an HTML interface connected to a Cloud Firestore as NoSQL databases used for massive data (see Fig. 4).

The mobile app was implemented with Unity using C# and saving the data within the Cloud Firestore of Google's Firebase. The data is sent through a JSON and stored in Firestore. A dashboard can operate the data from JavaScript and HTML. The dashboard shows all the data captured within the application and, in turn, exposes the children's favorite character. The dashboard outcomes also offer the children's colors for the different parts to make up the character [27] (see Fig. 4). The Lethos app structure of the game with its JSON post request is like the MidiAPI dashboard structure (see Fig.2).

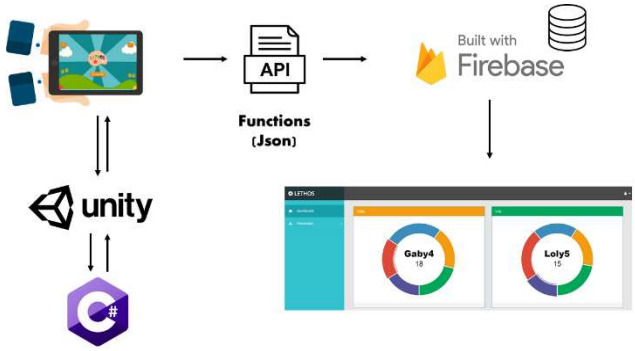

Fig. 4 Lethos's architecture proposed by [27).

4) Lethos's features: Children can choose their favorite character illustration and the shape (avatar graphic line) they want to color (see Fig. 5). Then, they are free to paint the avatar chosen with several colors and decorate them.

Fig. 5 Example of the characters set and GL shape illustration per avatar (Lethos app images).

The primary Lethos's palette includes the color range used on MIDI-AM cartoon characters and avatars. Besides, different shades of primary colors were available for choosing according to chromatic rose. The intention is to give the children all the freedom to paint according to their taste. The researchers then analyze these features if the selected colors matched the designed characters' colors (see Fig. 6 example).

Fig. 6 Example of the characters selected and painted by a child (images taken from Lethos app).

A character's personality is linked to its social behavior, defining its body's morphological and chromatic characteristics. The clothing and accessories placed are considered as part of their personality [11]. The replication of emotions in virtual characters reliant on events is regarded as part of their nature [10]. Within visual development, representing a character, accessories, clothing, and personality are defined. These elements are seeking to create an emotional link between the virtual characters and users.
The Lethos game gives the children the ease to choose character alternatives as their favorite avatar. Then, place colors and accessories to the character selected to play with them (see Fig. **6** left example). Besides, a virtual character's facial expression can be chosen according to the child's emotion to transmit. The game includes three of the five basic emotions in character expressions (neutral, upset, happy) for each character (see Fig. 7 example).

Fig. 7 Character's illustration Gaby avatar.

C. The Archetypes-Characters Graphic Lines for Evaluation Tools

According to the communication theory, archetypes come from psychology used for categorizing people, considering their roles and characteristics [11]. The archetype concept or

universal forms is present in any culture, including pervasive and traditional archetypes of "mother, lover, trickster, spiritual, temporal leader, devil, and others" [28]. The personification of objects, brands, music, or anything representing a role helps to empathize with the classic archetypes a user is inclined [28], [29]. Therefore, the importance of archetypes in mobile applications lies in communicating and seeking a high degree of acceptance from its users.

In MIDI-AM digital games, each character has an archetype with physical characteristics and personalities according to their role. The illustration and description of archetypes are from Solórzano, Elizalde [11] and included in the questionnaire for adults available on the MIDI-AM website. Table 1 shows the illustrations of the characters classified by the graphic lines styles.

TABLE I
MIDI-AM GRAPHIC LINES (GL1 TO GL5) OF CHARACTERS REPRESENTING FOUR ARCHETYPES [11]

Loly's Graphic lines	Kike's Graphic lines	Gaby's Graphic lines	Oscar's Graphic lines
Loly GL1	Kike GL1	Gaby GL1	Oscar GL1
			
Loly GL2	Kike GL2	Gaby GL2	Oscar GL2
			
Loly GL3	Kike GL3	Gaby GL3	Oscar GL3
			
Loly GL4	Kike GL4	Gaby GL4	Oscar GL4
			
Loly GL5	Kike GL5	Gaby GL5	Oscar GL5
			

III. Results and Discussion

From the three research tools designed to analyze data and provide results, we aimed to identify correlations between:

- The most played apps by children versus those selected by the adults as their children's favorite are similar.
- The chosen archetype characters from children's and adults' opinions as to their children's favorite.
- The GL selection by children and the ones selected by adults as their children's preferences.
- The most played games versus the GL selected and archetype characters preferences.

The examined outcomes are considered criteria examples of how to evaluate relevant data from stakeholders and researchers. However, these results are not determinant, and they can vary concerning the sample size and the type of the social group of schools analyzed.

A. The estimated sample size.

The researchers considered the number of students from initial to 2nd grade (children from 3 to 8 years old) of four elementary schools of Guayaquil city. The teachers from schools chosen were asked to use the MIDI-AM apps as complementary learning tools in their classes and ask the children to play with them in the house. Four schools with a total of 684 students were part of the population examined together with their parents. Applying the Statistical Equation for Population Proportions (1), the estimated representative sample size is 246. In this "finite" population formula, Z is the value of the standard Normal distribution, and generally, with a confidence level of 95%, its value is 1.96. p is the proportion of the population that meets a specific characteristic, example 50% of the children population attend school. Then, q complements of p, percentage of the population q does not have the attribute. , For example, 50% do not attend schools. E is the estimation error; generally, 1%, 3%, or 5% is used according to the researcher's need. N is population size targeted.

$$n = \frac{z\text{^}2(p*q)}{e\text{^}2+\frac{(z\text{^}2(p*q))}{N}} \quad (1)$$

Nevertheless, the number of surveys completed by adults related to children was 135 due to difficulties in contacting the parents or caretakers. Therefore, the sample size surveyed and closely evaluated represents just a level of confidence of 93%, which is also representative (see Table 2). The sample obtained was considered suitable for hypothesizing the games and avatar preferences and testing the proposed tools.

TABLE II
SCHOOLS IN THE ECUADORIAN COAST AND STUDENT'S POPULATION

Schools of Guayaquil City	Number of children	Sample size used
Fermin Vera Rojas	280	55
Academia Naval Almirante Illingworth	264	52
Sagrada Familia Jesus de Nazareth	90	18
Nuestra Señora de Lourdes	50	10
TOTAL	684	135

B. Apps Most Played by Children versus the Ones Selected by the Adults as their Children's Favorite

The results of a data analysis obtained from the MidiAPI dashboard provided information about the most accessed MIDI-AM games available online by children. In this case study, the researchers observed that the game "Animales" ("Animals") got the highest access number. Thus, "Animales" was the preferable MIDI-AM game chosen for children. The study considers the "all-access" column results between the days observing the access to the games for playing the games or seeing the cartoon stories' content (see Table 3).

On the other hand, for adults, the result analyzed uses the data summary presented in google forms from the same period (see Fig. 8). Researchers observed that the games "Animals" closely followed by "Seres" ("Animals" and "Beings") were similarly selected as parents indicate they were the most view by their children.

TABLE III
THE MOST PLAYED GAMES FROM THE MIDIAPI DASHBOARD AND GOOGLE FORMS SURVEY DATA

MIDI-AM	Access game played %	Access stories viewed %	All-access	All-access %	GL use by game
Seres (Beings)	29.3%	11.0%	421	40.3%	GL2-GL3
Animales (Animals)	42.4%	10.3%	551	**52.7%**	GL4
Plantas (Plants)	4.5%	0.0%	47	4.5%	GL3
Escuela (School)	0.6%	1.9%	26	2.5%	GL1
Total			1045	100%	

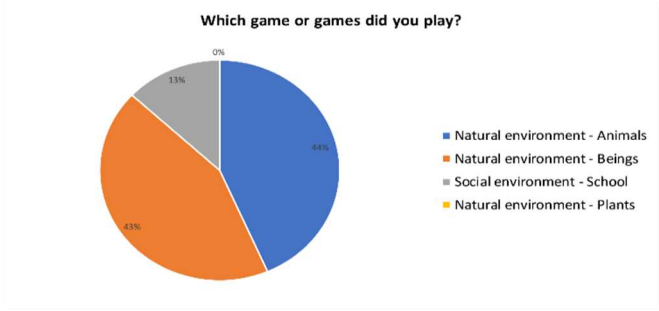

Fig. 8 Adults' game selection, Google questionnaire results in Spanish.

In both cases' data results, the researchers observed that children's most played apps versus the most selected apps by adults have the same choice ("Animales") as the most used game. The values of absolute frequency help normalize a comparison criterion, due to the population sample size, children's and parents' response were different (see Table 4).

TABLE IV
GAMES MOST PLAYED/ACCESSED BY CHILDREN AND ADULT'S CORRELATION

MDI-AM	All-access children	All, Access parents
Seres (Beings)	40.3%	43,4 %
Animales (Animals)	**52.7%**	**43,8 %**
Plantas (Plants)	4.5%	0 %
Escuela (School)	2.5%	12,5 %

In the example, we noted a correlation between preferences order but mainly in games "Animales" and "Seres." However, this is just a sample related to the group schools; therefore, the results are not considered conclusive.

C. *The Archetype Characters' Preferences of Children and Adults as their Children's Favorite*

1) Lethos results of archetype children's preferences: A test was conducted with four focus groups of children between three to eight years old from the selected school who had already played four of the MIDI-AM games analyzed. Different groups of three students at the time received a tablet for evaluating characters to play a game. The game Lethos played allows the children to select MIDI characters as children's avatars and painting them. The children played for an estimated time of 10 minutes per group. The absolute frequency was calculated from the data shown in the Lethos dashboard regarding the game played during the selection process. The archetype "Gaby" from the GL5 was determined as the favorite summarizing the focus group sessions (see a summary example of a focus group in Fig. 9).

Fig. 9 "Lethos" dashboard autotype (avatar and GL) children's preferences.

2) Google forms results: The adults selected archetype characters' preferences as their children's favorite: parents, caretakers, and teachers responded to questions about which archetype characters they would like to see more in new MIDI-AM games relations to what they think their children prefer. The "Loly" archetype shows the highest preference of adults as their beliefs are their children's favorite with 41%, followed by "Gaby" with 29% (see Fig. 10).

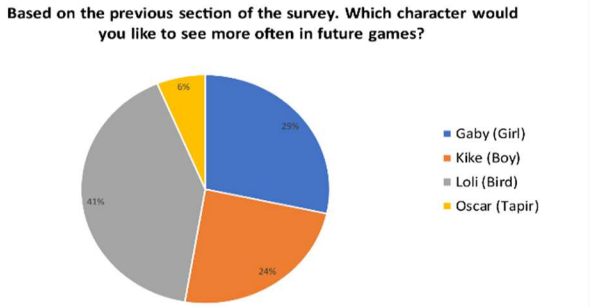

Fig. 10 Adults' opinion from Google questionnaire results in Spanish.

For this case, no correlation was identified between the archetype selection of characters about parent and children's choices. Nonetheless, the researchers recommend continued evaluation considering these results may vary with a bigger sample size an in relation to schools.

D. *The GL Selecting by Children and the Ones Chosen by Adults as their Children's Preferences*

1) Lethos results of GL children's preferences: From the focus group undertaken, the data obtained in Lethos' dashboard indicates that the character "Gaby" from GL5 was the most selected with 14% overall the 20 virtual characters of the archetypes. This selection is between the four archetypes multiply by five GL styles. Concerning "Kike" and "Loly," the archetype GL style selected was GL4, presenting a similar medium percentage of preferences with 5.3% and 5.4% correspondingly. In the case of "Oscar," the GL selection was low for all of them, indicating that this archetype was not selected as a favorite for most children while playing with Lethos (see Fig. 11).

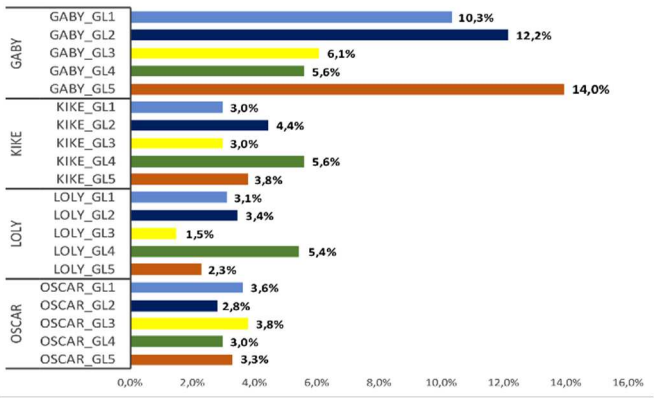

Fig. 11 Comparison of "Lethos" results from children's intuitive selection (Calculated percentage of the selected times of an archetype among all characters).

Even though the GL5 and GL4 obtained the highest and medium percentage, the researchers identified that children do not prefer a specific GL for all the character archetypes. They do not present uniformity in choosing the four archetypes related to a specific GL style with an all-sample standard deviation of 0.0335 (see Table 5).

TABLE V
CHILDREN´S AND ADULTS´ COMPARATIVE RESULTS

		Adults opinion	
MIDI-AM Characters archetype	**GL Style**	**Archetype selection between all characters %**	**GL selection per archetype %**
Gaby	GL1/GL3	6.0%	23.0%
Kike	GL4	6.0%	23.3%
Loly	GL3	6.3%	24.1%
Oscar	GL3	5.1%	23.3%
STDEV		0.0052	0.0047
STDEV all Sample		0.0080	
	Children intuitive selection		
Gaby	GL5	14%	*29.0%*
Kike	GL4	6%	*28.3%*
Loly	GL4	5%	*34.4%*
Oscar	GL3	4%	*23.0%*
STDEV		0.0460	*0.0466*
STDEV all-sample		0.0335	

2) Google forms questionnaire results in GL selected by adults as their children's preferences: The median was the statistical central tendency measure for the opinion about GL characters' opinion by adults, as they believe are children's preferences. The results indicate a trend on GL3 selection for almost all the archetype characters of MIDI-AM games "Gaby," "Loly," and "Oscar," except "Kike". Thus, the adults surveyed show uniformity in selecting archetype characters related to the GL 3 style. Also, the results indicate that the character "Loly" from GL3 was the most selected with 6.3% overall the 20 characters of the archetypes, with a slight difference from the other three archetypes of the same GL style (see Fig. 12).

From this analysis, no correlation was identified between children and adults about GL preferences and a specific archetype of character preferences with a Standard deviation of 0.0052 on adults and 0.046 on children selection. Moreover, children do not tend to uniformity to select a specific GL style for all the archetypes with a standard deviation of 0.0466; among adults does with a standard deviation of 0.0047 (see Table 5).

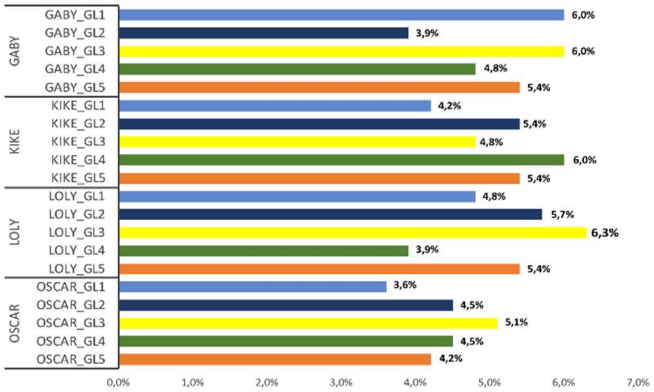

Fig. 12 Adult's opinion from Google form questionnaire (selection of archetype among all the characters and their graphic lines)

E. The Most Played Games versus GL Archetype Characters Preferences

Based on the results obtained from Lethos, MidiAPI, and Google Surveys research tools, a correlation between adults and children was identified between the opinion and intuitive preference of games usage. However, the researchers did not identify related selection about GL style either archetype character. For the focus groups test, the researchers included a new graphic line style (GL5) for the four archetypes do not use yet in any MIDI-AM game (see Table 1) but proposed in the Lethos tool to play with more characters freely. The researchers note that the children frequently selected GL5 archetype characters to play, observing that they were more inclined to the details in the "Gaby" GL5. Also, a tendency to choose more for painting the little girls represented by "Gaby" (see Fig. 11). This tendency was confirmed by revising children's standard deviation with 0.0466 versus adults with 0.047 about the GL style selected by archetype (Table 5). Thus, it implies that children do not follow any standard relating to GL style's favorite characters while playing a game. However, a trend to select the archetype of sweet little girls as "Gaby" was noted (see Fig. 11).

TABLE VI
CHILDREN'S PREFERENCES: MOST ACCESSED GAMES, GL, ARCHETYPES

MDI-AM Children's intuitive selections			
MDI-AM Games apps	**All-access Game usage %**	**GL use in Chapters**	**Archetype favorite character**
Seres (Beings)	40,3%	GL2-GL3	
Animales (Animals)	52,7%	GL4	
Plantas (Plants)	4.5%	GL3	
Escuela (School)	2,5%	GL1	
Design for future games production		GL5	Gaby
MDI-AM Adult's opinions			
Seres (Beings)	43,4%	GL3	Loly
Animales (Animals)	43,8%	GL4	
Plantas (Plants)	0%	GL3	
Escuela (School)	12,5%	GL1	
Design for future games production		GL5	

For adults, the selection of favorite games was the same as children's "Animales." However, contrary to the children, the characters GL style by games and the preferred archetypes were different but with a uniformed selection regarding for almost the four archetypes of characters examined. The archetype selected by adults as a favorite was "Loly," a friendly parrot avatar who give instructions to use the resources in the four games examined and the GL3 (Table 6). Adults also noted that two series of games used the same GL3, so they chose it twice. This selection evidenced a trend with a low standard deviation of 0.0052, indicating that adults follow the standard on selecting games with guiding resources they believe are useful for their children, but the children did not necessarily freely choose the same characters (see Table 5 and Table 6).

IV. Conclusion

The development of online technological tools like educational videogames or serious games requires identifying trends and preferences. This information is useful for game developers and designers as they will have an idea of what to do based on results. Hence, the benefits are enriching when several research tools are available for obtaining, cross and evaluate data from different sources.

Data from a game production have been examined, allowing a broader view of game preferences, graphic line styles, and character archetype design. The results and trends help designers, producers, and other experts to identify games and archetypes as avatar's preferences regarding graphic lines and game usage. Thus, this helps propose well-informed graphic designed styles and character archetypes to produce new educational games.

By analyzing sample data collected through the MIDI-AM series of educational digital game apps, the researchers examine the relevance of evaluating various criteria to identify a correlation between preferences and trends of using certain games and preferences for graphic line styles characters archetype. A correlation between game usage preferences between children and adult's selection was identified. The children's favorite game' selection identified was "Animales." regarding the MIDI-AM series. However, no correlation was determined between the preferences of graphic line styles and character archetype selection from children's perspective and what parents think their children prefer.

This article also is relevant for teachers, parents, and caretakers. These stakeholders can better understand children's motivation and their attraction to educational videogames and their features for learning purposes. The designed research tools used to analyze digital games' usability, characters, and graphic styles can be repeatedly used to examine which games and character for the games should be more used to motivate educational video games for encouraging more entertained teaching-learning process.

The study results allow stakeholders to study trends about the visual interpretation of graphic line styles, characters archetype, and game usage preferences front the point of view of adults and children. However, the outcomes obtained for the MIDI-AM series game used as the case examined, for example, may vary with a bigger sample size. Therefore, more representative data collection is recommended for a well-tested preference of game use and trends of character archetypes styles. Nevertheless, further investigations of MIDI-AM videogames and other children's digital games proposed can be continually evaluated using the proposed research tools developed for this study.

Acknowledgment

The authors acknowledge ESPOL Polytechnic University for sponsoring the presentation of this research work. We also recognize the contribution of the group of researchers, academics, and students from the Art, Design, and Audiovisual Communication Faculty (FADCOM), the Electric, Electronic, and Computer Science Faculty (FIEC), and the ESPOL Society Link Unit (UVS). Notably, we thank Ph.D. Denise Rodríguez, MSc. Lenny Párraga, MSc. Elizabeth Elizalde, MSc. Da-Hee Park, MSc., Carlos Gonzalez, and the FADCOM students Paul Valle and Yander Santana, for their technical input to this study.

References

[1] Masood F, Dar M, Shakir MS, Ahmed M, Kabir I, Shafiq MH, et al. Enhancing usability and user experience of children learning by playing games. In: Ahram TZ, editor. AHFE 2018 International Conferences on Human Factors and Wearable Technologies, and Human Factors in Game Design and Virtual Environments, 2018: Springer Verlag; 2019. p. 403-9.

[2] Cano AR, Fernández-Manjón B, García-Tejedor ÁJ. Using game learning analytics for validating the design of a learning game for adults with intellectual disabilities. British Journal of Educational Technology. 2018;49(4):659-72. DOI:10.1111/bjet.12632.

[3] Ramos-Vega MC, Palma-Morales VM, Pérez-Marín D, M. Moguerza J. Stimulating children's engagement with an educational serious videogame using Lean UX co-design. Entertainment Computing. 2021;38. DOI: 10.1016/j.entcom.2021.100405.

[4] Benavides-Varela S, Zandonella C, Fagiolini B, Leo I, Altoè G, Lucangeli D. Effectiveness of digital-based interventions for children with mathematical learning difficulties: A meta-analysis. Comput Educ. 2020;157. DOI:10.1016/j.compedu.2020.103953.

[5] Solorzano NI, Sornoza LE, Carrera DA. Adoption of children's educational video games monitored with dashboards in the cloud [Adopción de videojuegos educativos infantiles, monitoreada con tableros de control en la nube]. Iberian Journal of Information Systems and Technologies RISTI [Revista Iberica de Sistemas e Tecnologias de Informacao]. 2019;2019(19):146-60.

[6] Núñez-Barriopedro E, Sanz-Gómez Y, Ravina-Ripoll R. 'Videogames in education: Benefits and harms' [Los videojuegos en la educación: Beneficios y perjuicios]. Revista Electrónica Educare. 2020;24(2):240-57. DOI: 10.15359/ree.24-2.12.

[7] Paillacho DF, Solorzano NI, Paillacho JS. LOLY 1.0: A Proposed Human-Robot-Game Platform Architecture for the Engagement of Children with Autism in the Learning Process. Adv Intell Sys Comput. 2021;1273 AISC:225-38.

[8] Carrera DA, Solórzano NI, Guerrero AC, Gonzalez C, E., Elizalde ES, Cabello LA, et al. 'Mobile Applications for the development of core competencies of children first year of basic education' [Aplicaciones móviles para el desarrollo de competencias básicas de niños de primer curso de educación general básica]. In: Tomalá Wong MA, editor. Community service projects, an experience to share UVS ESPOL Project 2018 - 2019 [Los proyectos de servicio comunitario, una experiencia para compartirla UVS ESPOL Proyectos 2018 - 2019]. Reportes anuales UVS-ESPOL. Camara Ecuatoriana del Libro, 2019: Escuela Superior Politécnica del Litoral; 2019. p. 139-53.

[9] Adell F, Aguilar L, Corrales-Astorgano M, Escudero-Mancebo D, editors. 'Educational innovation process in special education: Teaching of prosody for communication purposes with the support of an educational video game' ['Proceso de innovación educativa en educación especial: Enseñanza de la prosodia con fines comunicativos con el apoyo de un videojuego educativo']. Proceedings of the I Congreso Internacional en Humanidades Digitales 2018; Valladolid, Spain.

[10] Alsaggaf W, Tsaramirsis G, Al-Malki N, Khan FQ, Almasry M, Serafi MA, et al. Association of game events with facial animations of computer-controlled virtual characters based on probabilistic human reaction modeling. Appl Sci. 2020;10(16). DOI: 10.3390/app10165636.

[11] Solórzano NI, Elizalde ES, Carrera DA, Park DH, Sornoza LI. MIDI-AM Model to Identify a Methodology for the Creation of Innovative Educational Digital Games: A Proposed Serious Game Methodology Based on University Research Experiences. In: Ariana Daniela Del P, Nuria Lloret R, editors. Improving University Reputation Through Academic Digital Branding. Hershey, PA, USA: IGI Global; 2020. p. 133-67.

[12] Sierra Rativa A, Postma M, Van Zaanen M. The Influence of Game Character Appearance on Empathy and Immersion: Virtual Non-Robotic Versus Robotic Animals. Simul Gaming. 2020;51(5):685-711. DOI: 10.1177/1046878120926694.

[13] Díaz VM, Martín-Párraga J. Can we use video games for the development of the curriculum for the childhood stage? [¿ Podemos utilizar los videojuegos para el desarrollo del currículo de la etapa de infantil?]. New approaches in educational research. 2014;3:21-7. DOI: 10.7821/naer.3.1.20-25.

[14] Hughes-Roberts T, Brown D, Boulton H, Burton A, Shopland N, Martinovs D. Examining the potential impact of digital game making in curricula based teaching: Initial observations. Comput Educ. 2020;158. DOI: 10.1016/j.compedu.2020.103988.

[15] Marín-Díaz V, Sampedro-Requena BE, Muñoz-Gonzalez JM, Jiménez-Fanjul NN. The possibilities of gamifying the mathematical curriculum in the early childhood education stage. Mathematics. 2020;8(12):1-15. DOI: doi.org/10.3390/math8122215.

[16] Baldassarri S, Passerino L, Ramis S, Riquelme I, Perales FJ. Toward emotional interactive videogames for children with autism spectrum disorder. Univers Access Inf Soc. 2020. DOI: 10.1007/s10209-020-00725-8.

[17] Hermans RCJ, Van Den Broek N, Nederkoorn C, Otten R, Ruiter ELM, Johnson-Glenberg MC. Feed the Alien! the Effects of a Nutrition Instruction Game on Children's Nutritional Knowledge and Food Intake. Games Health J. 2018;7(3):164-74. DOI: 10.1089/g4h.2017.0055.

[18] Llobera J, Boulic R. A tool to design interactive characters based on embodied cognition. IEEE Trans Games. 2019;11(4):311-9. DOI: 10.1109/TCIAIG.2017.2755699.

[19] Solorzano NI, Loor R, Gonzabay S, Vintimilla B. Statistical Representations of a Dashboard to Monitor Educational Videogames in Natural Language. The 2nd ACM Chapter International Conference on Educational Technology, Language and Technical Communication - ETLTC2020. 2020;77:05003. DOI: 10.1051/shsconf/20207705003.

[20] Morrison A, Viller S, Heck T, Davis K, editors. Workshop: Mixing quantitative with qualitative methods. current practices in designing experiments, gathering data and analysis with mixed methods reporting. 29th Australian Computer-Human Interaction Conference, OzCHI 2017; 2017: Association for Computing Machinery.

[21] Oleinik A. Mixing quantitative and qualitative content analysis: Triangulation at work. Quality and Quantity. 2011;45(4):859-73. DOI: 10.1007/s11135-010-9399-4.

[22] Solorzano NI, Gallego DC, Quijije LS, Quelal MM. Developing a dashboard for monitoring usability of educational games apps for children. 2nd International Conference on Computers in Management and Business - ICCMB 2019. 2019:70-5.

[23] Creswell JW, Creswell JD. Research design: Qualitative, quantitative, and mixed methods approaches. Third Edition ed. Los Angeles . London . New Delhi . Singapure: Sage publications; 2017.

[24] Harrison RL, Reilly TM, Creswell JW. Methodological Rigor in Mixed Methods: An Application in Management Studies. J Mixed Methods Res. 2020;14(4):473-95. DOI:10.1177/1558689819900585.

[25] Whalen C, Moss D, Ilan AB, Vaupel M, Fielding P, Macdonald K, et al. Efficacy of TeachTown: Basics computer-assisted intervention for the intensive comprehensive autism program in Los Angeles unified school district. Autism. 2010;14(3):179-97.

[26] Solorzano NI, Sornoza LI, Carrera DA. Adoption of children's educational video games monitored with dashboards in the cloud. Rev Iberica Sist Tecnol Inf. 2019;2019(19):146-60.

[27] Santana YM, Valle JPR. "Construction of a mobile application prototype to validate trends in graphic lines used in video games aimed at children aged 4 to 7 years." ["Construcción de un prototipo de aplicación móvil para validar tendencias de líneas gráficas utilizadas en videojuegos dirigido a niños de 4 a 7 años."] [Design and Development Project]: Escuela Superior Politécnica del Litoral; 2019.

[28] Adams BJ, Morris C. Vocal Traditions: Acting and Singing with Archetypes. Voice Speech Rev. 2020;14(3):335-41. DOI: 10.1080/23268263.2020.1684633.

[29] Roberts C. Exploring Brand Personality through Archetypes [Electronic Theses and Dissertations]. USA: East Tennessee State University; 2010.