A Systematic Mapping on Machine Learning Algorithms and Gamification Applied to Education

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Abstract: Machine learning algorithms and gamification applied in educational environments promote more accurate information gathering as students interact with games. They allow you to evaluate and analyse data from how to improve gamified tools to stimulate teaching, retain student attention and interest, and optimize learning. This paper has performed a systematic mapping to identify how machine learning algorithms are applied at each game level.

1 INTRODUCTION

The use of games in educational environments improves the learning process, encouraging students to improve their skills in various areas, in addition to shaping behaviour using techniques and elements in environments not related to games (Kapp, 2012; Lopes et al., 2018; Mora et al., 2017) as is the case gamification. Gamification uses the dynamics and mechanics of games as a tool to motivate and increase commitment in the educational field (Cordero-Brito and Mena, 2018) and promotes motivation and engagement (Lee and Hammer, 2011).

Machine learning (ML) algorithms when used in education games provides an automation of tools and facilitates data analysis, in which playful experiences can be measured through multidisciplinary interactions (Cowley et al., 2014).

This paper summarized, by means of a systematic mapping based on the method of Kitchenham and Charters (2007), the state of the art of how the machine learning and gamification algorithms are being used in educational games levels. The systematic mapping was carried out from 2003 to 2020 and used 5 digital repositories.

2 RELATED WORK

Considering the existing studies in the literature on games or gamification in education, a common practice is to carry out literature reviews in a more systematic way. This contributes to assess the area of research in which it is desired to propose a solution not yet measured. To understand the application of gamification in education, we sought to identify in the literature the mapping or systematic review related to games in education, and to select them by the subject of gamification applied to education using the following search strings: “education” and “gamification” and “systematic review” or “systematic mapping”. The works were searched in the Elsevier (Science Direct), ACM, IEEEXplore, Scopus and Google Scholar repositories.

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132 studies were found and 14 of these were removed because they were duplicated, leaving a total of 121. Of these, 28 studies were related to review or mapping involving: Gamification and Education. The subjects addressed through the mappings or systematic reviews found were analyzed to determine their objective.

It was found that some papers were focused on identifying how gamification is applied and at what levels of education, such as: Morelock (2013), Dicheva et al. (2015), Alanne (2016), Bodnar et al. (2016), De Avila dos Santos and Luis Castro de Freitas (2017), Ortiz-Rojas et al. (2017), Subhash and Cudney (2018), Alhammad and Moreno (2018), Souza et al. (2018), Borges et al. (2018), Cordero-Brito and Mena (2018) and Gentry et al. (2019). There are other works focused on the use of tools, learning theories or environments in which gamification is applied: De Sousa Borges et al. (2014), Truong (2016), Stevenson et al. (2017), Brito and Madeira (2017), Tenório et al. (2018), Trinidad et al. (2018) and Lara et al. (2019). Other papers focus on the review of how the gamification project is developed and reused as described in Peixoto and Silva (2015), Seaborn and Fels (2015), Mora et al. (2017), Calderón et al. (2018) and Kamunya et al. (2019). In addition to the systematic reviews that address application, use of tools, learning theories, environments in which gamification is applied and projects for the development of gamified software that was previously presented; there are also studies on gamification and multidisciplinar and new guidelines for the use of gamification, such as: Osatuyi et al. (2018), Bozkurt and Durak (2018), Rodrigues et al. (2019) and Inocencio (2018), respectively.

In the research it was noted that there was an increase in studies related to systematic mapping that describe gamification in education (in 2018 there were 7 papers). Analyzing the number of experiences of gamification applied in educational levels, higher education has a greater frequency with 6 works, followed by 5 works in various levels (basic education, high school and higher education), 16 without information and 1 in high school, elementary school and teaching for the intellectual disabled.

The analysis of related works showed that higher education concentrates most applications of gamification in education in all years, and this educational level also falls into several levels (basic education, high school and higher education). In 2015 two studies were retrieved, one in higher education and the other which does not reveal information on which educational level the gamification context was applied to. In addition, only in the year 2017 there are publications of gamification applied to high school and teaching for the intellectual disabled. An important factor is that the student's development can be carried out in an individualized or customized way, knowing their difficulties, skills and potential (Mora et al. 2017). It was found that the works address many aspects related to gamification and games applied in education, but do not show how machine learning algorithms are applied at educational game levels.

3 REVIEW METHODOLOGY

Based on the literature, studies involving games in education were found with the application of machine learning algorithms. The method used in this work to carry out systematic mapping was that of Kitchenham and Charters (2007). The authors Martins and Gorschek (2016) define that their work is a reference for those who wish to carry out systematic reviews and mappings; and report that this approach covers several steps to generate comprehensive research.

The systematic mapping was carried out by the authors of this work: 1 in the area of software engineering, 1 in the area of artificial intelligence, 1 in the area of education and 1 in the area of technology and management, 1 doctoral student in Science, Technology and Teaching and 1 master's student in Computer Science. It includes studies from 2003 to 2020 on the subjects of games and machine learning algorithms aimed at education. The proposed work carried out the research contemplating games, as there could be works containing gamification within the process of this systematic mapping.

At first, as predicted by the systematic mapping method, the protocol was defined by the authors in order to bring to the researcher a quantity of information about: authors of works, relevance of each work and their real contribution to the community and research problems. In this protocol, research questions, search bases and their specific forms of search, search strings, keywords and filters were defined, presented in the next sections. Figure 1 shows how the process of systematic mapping was conducted. In the planning process, the objective of systematic mapping was identified to verify the educational games that apply machine algorithms in order to check how it can help for a sustainable education. The definition of the protocol used an electronic spreadsheet for filling in information on the work to be analyzed. In the selection of studies, the search bases, search strings were defined and questions were elaborated to be answered in the systematic mapping.

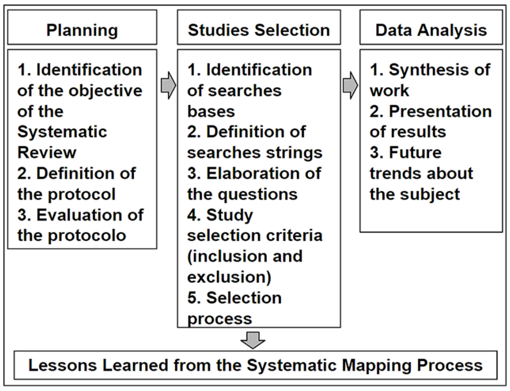

Figure 1: Research Methodology Adopted.

Then, the inclusion and exclusion criteria were defined to select the desired works and form the protocol with information from the articles so that the questions could be answered. With the protocol formed it was possible to synthesize the data, present the results and verify future trends on the subject.

3.1 Research Questions

The central objective of the research was to list the main tools and methods used in the researched subjects. The following questions were elaborated:
QR1) What are the games styles, the area and the level of education (special or not)?
QR2) How the games architecture is built?
QR3) What kind of machine learning algorithms and techniques are used in the games?

3.2 Inclusion and Exclusion Criteria

The researchers who performed the systematic mapping were the evaluators of the collected primary works. Initially, an inclusion criterion ware studies that presented in their Title, Keywords or Abstract information related to the research topic and that were within the time period determined for systematic mapping.

The application of the inclusion and exclusion criteria followed the steps: i) Reading the titles, keywords and abstract, excluding works that are not related to the inclusion criteria; ii) Dynamic (superficial) reading of the study considering the inclusion and exclusion criteria and iii) Documentation of each study in short paragraphs. Five search databases were defined to perform the researches: Google Scholar, Science Direct, ACM, IEEEXplore and Scopus. The choice of the cited bases was because they had a greater number of publications related to this work's research.

3.3 Search Strings and Keywords

Several search terms had already been thought and discussed among the researchers, which facilitated the process of composing the keywords. After some tests, expressions restricted to the theme were used, such as "artificial intelligence algorithm" AND "gaming" AND education", "machine learning" AND "digital games", "childhood" AND "education" AND "machine learning" AND "games", "Machine learning algorithm" AND "education games" AND "artificial intelligence", "machine learning algorithm" AND "education" AND "digital games", "machine learning algorithm" AND "education" AND "games".

Using the before mentioned strings the number of results was low or in some cases no results were returned. With that, a refinement of the search string was carried out, and the combination that returned the most results was "machine learning algorithm" AND "education" AND "games" to obtain publications of systematic mapping articles. A total of 382 articles were found using a set of keywords defined for searching works related to games in education applying machine learning algorithms. Table 1 shows the number of works obtained per repository. However, 13 duplicate works were eliminated: 3 from the Scopus database, 1 from the Google Scholar database, 4 from the Science Direct database, 2 from the ACM database and 3 from the IEEEXplore database, remaining 369 papers.

Table 1: Quantity of work by repositories.

String	
“machine learning algorithm” AND “education” AND “games”	
Repositories	
Google Schoolar	78
Science Direct	169
ACM	13
IEEE	22
Scopus	100
TOTAL	382

After realizing the proposed exclusion criteria were eliminated 328 works by the reading of the title and the abstract, resulting in 41 articles for detailed reading. The 41 works were read entirely because they are more focused on the objective of this research. However, from 41 articles, 36 articles were eliminated because they applied classification algorithms or were not directly related to games in education, remaining 5 works. The 5 works were selected because they applied machine learning algorithms at each game level.

4 RESULTS

This section presents the results related to the answers for the previous sections.

4.1 What Are the Games Styles, the Area and the Level of Education (Special or Not)?

The games that apply the machine learning algorithms are quite diverse. Some of them were developed in a specific way to attend the study, such as MCP Quest and Skill Tree (Barata et al., 2016) in the computer sciences area, and Romeo and Juliet (Siu et al., 2018) in the languages area. Other works used games available on the market such as Super Monkey Ball 2 in the work of Cowley et al. (2014) in the area of psychophysiology, games available on Google Play in several areas such as sports, action, strategy and Role-Playing Game (RPG) in the study of Bharathi et al. (2016) and the Pacman game used in Llorens-Largo et al. (2016) work. The last two games mentioned were used in the area of computer science. The computer science area concentrates most of the application of machine learning algorithms in educational games. Table 2 presents the application areas of games with machine learning algorithms.

Table 2: Games used in the areas and educational levels by the authors.

Game	Area	Educational level	Author
Super Monkey Ball 2	Psycho-physiology	Higher education	Cowley et al., (2014)
MCP Quest and Skill Tree	Computer Science	Higher education	Barata et al. (2016)
Various games from Google Play	Computer Science	Multiple Levels	Bharathi et al. (2016)
Pacman	Computer Science	Higher education	Llorens-Largo et al. (2016)
Romeo and Juliet	Languages	Multiple Levels	Siu et al. (2018)

Cowley et al. (2014) carried out in the area of psychophysiology describes a new method to integrate player preferences, experimental data and game design patterns in a single framework, Play Patterns and Xperience (PPAX). The framework explored the patterns of gameplay and physiological reactions of the players' faces, resulting in information on reaction patters, moves and the personality of each player.

In the work by Barata et al. (2016), the experiment characterized data to predict the type of student at the beginning of the master's course in computer science at the University of Lisbon. For this, it used machine learning algorithms to classify student data from one period and predict the type of student in another period. Through the inclusion of games in the teaching grid, they created the games MCP Quest and Skill Tree to expand interactivity and created a ranking to reward the progression of levels and the experiences acquired by students.

In the work of Bharathi et al. (2016), in the area of computer science, several games and applications installed on smartphones were analyzed to identify and list design characteristics and gamification elements such as challenges, feedbacks, rewards, objectives, characters, badges, punctuation, levels, ranking and dynamics of game states. These elements of gamification can promote student motivation to interact with the game more often and gain new knowledge.

The work of Llorens-Largo et al. (2016) in the area of computer science, developed the LudifyMe system to assess the potential of gamification as a means of improving learning. The main contribution is in the application of games in the teaching of artificial intelligence in order to improve motivation, performance and student satisfaction.

In the work of Siu et al. (2018) in the area of languages for learning the English language, they developed a game platform based on the story of Romeo and Juliet, which analyses the scores obtained by the student to verify the progression and mastery of the language. The purpose of the platform is to predict whether the student has the capacity to achieve an average score in the tests.

The systematic mapping verified and identified that the educational levels of application are for higher education, basic education and various levels (basic to higher education), however, none of the games was used for special education. However, there is a predominance of works in higher education, and analysing the amount of works at each level, there are 3 works related to higher education and 2 works that fall into various levels (basic to higher education).

4.2 How the Games Architecture Is Built?

The games are divided according to type, for example, serious games, racing, puzzle, strategy, gamified web platform and RPG (Role Playing Game). In the work of Barata et al. (2016) serious games were developed containing stages and missions. As the missions are carried out, a more complex one is presented and the players receive scores when they finish, however the missions can be executed in several ways as long as all objectives are fulfilled. In the game MCP Quest, for example, it is an online treasure hunt in which students access a page containing a multimedia artifact that must be edited and manipulated to unravel the clue to access the URL of the next page. As the missions are completed the player earns experience points and is able to access a more difficult mission.

Similarly, the game Skill Tree (Barata et al. 2016) presents a tree of missions to be performed. At the root of the tree, three initial missions are presented and enabled and, in their branches, there are other disabled missions. After completing the first missions, the player receives the experience points and new missions are enabled from the tree for execution. If the player does not have enough experience points, new missions of a more complex level are not enabled. The architecture of this game is server client, in which students access the game through the pages provided and perform activities on the platform. Thus, the data of all performed activities are recorded in a database for later application of the machine learning algorithm to understand the students' behavior.

The LudifyMe study by Llorens-Largo et al. (2016) used the Prolog language to teach artificial intelligence about the Pacman game. The game is divided into difficulty levels according to the mazes, amount and speed of movement of the main character's enemies. As one level is overcome, the next has the level of difficulty increased, and so on. In this work, the labyrinth creation activities of the game were carried out on a gamified web platform, in which students must program the rules and relations of the game and send for evaluation in a prediction system. The architecture is composed by the gamified platform, a database of events in which the characteristics of the created labyrinths are extracted, and an evaluation of the predictive system that presents the results.

After the student submits the code for evaluation on the platform, the information is sent to an event database for further processing of the developed labyrinths' characteristics by the students. The prediction system applies machine learning algorithms to the database and presents the mazes' results. With that, students and teachers can evaluate the results and optimize the maze according to the information provided in graphs.

Cowley et al. (2014) developed a framework, called Play Patterns And eXperience (PPAX), to analyze a set of data containing psychophysiological information about the player's facial expressions such as tension, alertness, joy, upset, stress, calmness, relaxation, etc., and video data containing plays that were made.

The game used to apply the framework was Super Monkey Ball 2, whose main mechanics is to roll a ball, containing a monkey inside, on platforms of different heights without dropping the ball and reaching the end of the course. During the course the player is rewarded with points for collecting bananas. This framework analyses game event data and psychophysiological data by applying the Frequent Pattern Growth machine algorithm, which looks for patterns in large data sets, to identify game design patterns.

In the work of Cowley et al. (2014), Barata et al. (2016), Bharathi et al. (2016), Llorens-Largo et al. (2016), Siu et al. (2018), machine learning algorithms are applied on a database formed by the data collected during the interactions performed by the user in the games. The information in the databases is treated to facilitate the acquisition of knowledge through the learning of machine algorithm with successive training. And later, the information obtained is analyzed and revised to improve the performance of the machine learning algorithm. Finally, with this information, evaluations are made to understand the student's learning and the execution of their activities.

4.3 What Kind of Machine Learning Algorithms and Techniques Are Used in the Games?

Considering the selected works, it was identified that the most used machine learning algorithms are those that use supervised learning methods, such as the Support Vector Machine (SVM) and the Naive Bayes classifier. However, it was found that there is no preference for a particular machine learning algorithm, as they are chosen according to the authors' preference and the context of each application.

Cowley et al. (2014) applied the Unsupervised Frequent Pattern Growthe K-Means algorithms. In the work by Barata et al. (2016) were used Expectation Maximization Algorithm (EM), Naive

Bayes, Bayesian Networks, Sequential Minimal Optimization (SMO), Logistic Regression K-Nearest Neighbors (KNN).

Bharathi et al. (2016) applied the Support Vector Machine (SVM), Naive Bayes, IBK, Decision Trees, Random Forest, Sequential Minimal Optimization (SMO) and J48 to rank games to a maximum score and indicate whether they are successful or not.

Llorens-Largo et al. (2016) applied the Support Vector Machine (SVM) to program Pacman game rules and actions to interactively teach artificial intelligence lessons to computer science students. Finally, Siu et al. (2018) used the Decision Trees, Support Vector Machine (SVM) and K-Nearest Neighbor (KNN) algorithms. Table 3 presents the machine learning algorithms used in their respective years.

Table 3: Quantity of machine learning algorithms per year.

Algorithms	Classification	2014	2016	2018
Frequent Pattern Growth	Unsupervised	1		
K-Means	Unsupervised	1		
EM	Unsupervised		1	
Naive Bayes	Probabilistic		2	
Bayesian Networks	Probabilistic			1
Logistic Regression	Supervised			1
K-Nearest Neighbors (KNN)	Supervised		2	1
Support Vector Machine (SVM)	Supervised		2	1
Decision Trees	Supervised		3	1
Sequential Minimal Optimization (SMO)	Supervised		1	
TOTAL		2	1	5

The systematic mapping indicated that the researched works between the years 2003 and 2020, have a considerable variation in the use of machine learning algorithms, however the repetition of machine learning algorithms was identified, as shown in Table 3. The most used algorithm is Decision Trees, followed by Naive Bayes, K-Nearest Neighbors (KNN) and Support Vector Machine (SVM). In 2014, only 2 algorithms were used, Frequent Pattern Growth and K-Means. In 2016, a greater amount of work was applied, totalling 11 algorithms. In 2018, only 5 algorithms were used. One observed factor was the use of supervised learning algorithms in most of the studies, where the data sets are already labelled for training containing a predicted or desired response.

5 TRENDS

Machine learning played an important and significant role in education because it allows exploring various possibilities through which the system can perform a cognitive analysis using a base with a set of input data. Especially in an inverted classroom model, in which the student-centered approach is adopted; machine learning can be a revolutionary approach to meeting student requirements based on their existing skills (Naidu et al., 2018).

The systematic mapping process presented in this article showed that there are few educational games that are implemented with machine learning and gamification. The use of machine learning allows applying algorithms in a systematic way with the ability to learn and adapt to changes in a system, using criteria from examples of data or past experiences. This learning ability not only predicts a certain condition, but tries to find solutions to unpredictable situations, as certain tasks or events that arise during the execution of a system can be too complex to be solved using classical programming (Alpaydin, 2014). The works analyzed in the systematic mapping use machine learning after the execution of the game and not at the execution level.

According to Samuel (1959) a scientist who created the first learning program for checkers, describes that machine learning transfers the ability to the computer to learn without being programmed or stated explicitly. In his experiment, every move made by a person was analyzed and the machine learned from mistakes and successes. Thus, each match played by the computer gave the opportunity for improvement, and in the next moves or matches, enabled it to make tactical predictions of the game. Therefore, any additional event and not foreseen in the execution of a given move, made the system interpret it as a probable error, store the information, and then learn to avoid a possible repetition.

One of the characteristics of machine learning is to generalize each event experienced, transform it into a form of training and in subsequent executions generate a hypothesis or predict by reaching a more approximate estimate of a new process in question. It also allows performance to be increased in instances of non-visible data, providing greater accuracy for future data. However, machine learning does not have a well-defined or structured functionality to be optimized. As error events arise, they serve as a filter for adjusting learning errors (Awad and Khanna, 2015).

The learning process is a major resource in generalizing problems, as it is triggered according to historical experiences. Historical experiences or logs (activity records) are used to form the collections of data which are later consulted to form a machine learning domain model. Resources present in the K-Nearest Neighbors (KNN) algorithm serve as a support for classification indicators and discover patterns, Naive Bayes is used for categorization based on the frequency of information, Expectation Maximization (EM) to characterize data not yet observed and more appropriately point out what each student does during their studies in order to optimize learning (Barata et al., 2016).

Machine learning algorithms allow planning in the development of educational games by verifying the motivations, such as the Support Vector Machine (SVM), which for each data entry seeks to analyse and define patterns. With this assessment, developers can design features to retain more attention from players by encouraging them to overcome challenges (Bharathi et al., 2016). Xu et al. (2016) claim that the Random Forest algorithm points out which aspects can be incorporated into interactive platforms with different combinations between machine learning models allowing it to increase the overall result.

Gamification can be used in the development of educational games as a way of engaging students to overcome proposed challenges such as missions and more complex levels by intensifying interaction with games. And from this, with the events of the registered plays and matches it becomes possible to form a data base for later application of machine learning algorithms. With a data base having well-defined attributes, the main contribution of the application of machine learning algorithms is to favor the obtainment of reaction and play patterns, player and student profiles, behaviour and performance, and student satisfaction. The gamification application requires that ideal elements for the domain be identified. According to Denden et al. (2018) the elements are: points, levels, progress bar, feedback, avatar, badges, leader identification (leader board) and chat. Gamification theory has increased in the area of education for the teaching of various disciplines Lee and Doh (2012) and Domínguez et al. (2013).

We observed that the games are applied at various educational levels, however it is noted that their predominance is at the higher level. In addition, it is clear that the application of games aimed at the education of intellectual disabilities is non-existent, as in this systematic mapping on the application of machine learning algorithm in educational games, only one work related to deaf-mute people was found. The application of this resource is still quite limited to the area of computer science and scarce in other areas such as health, sales, commerce, engineering, administration, environmental, business and industrial. According to Hidalgo et al. (2020) concerns about unequal access to new technologies have given rise to several socioeconomic questions, especially gender, age, level, education, income and habitat.

6 CONCLUSION

This paper presented a systematic mapping in order to identify how educational games use machine learning algorithms. The application of learning algorithms is performed to extract information after the consolidation of a database, that is, after the game is over, the data are analyzed by the algorithm.

An identified matter was the use of supervised learning algorithms in most of the studied, with a considerable concentration in 2016. Another finding was the use of gamification and gamification elements such as those illustrated in the studies by Barata et al. (2016) and Siu et al. (2018) like educational games of their own authorship that use dynamic elements such as narrative, progression and restrictions, mechanical elements such as feedback and challenges, gamification components such as missions, points, classification (ranking) and achievements. The other works used existing games on the market that apply elements such as progression, restrictions, challenges, points and rewards (Cowley et al., 2014), (Bharathi et al., 2016) and (Llorens-Largo et al., 2016). As for future works, educational games with machine learning and gamification can be developed allowing students to improve their knowledge on a subject and the machine algorithm can provide solutions for unpredicted situations.

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REFERENCES

Alanne, K., 2016. An overview of game-based learning in building services engineering education. European Journal of Engineering Education, 41(2):204–219.

Alhammad, M. M. and Moreno, A. M., 2018. Gamification in software engineering education: A systematic mapping. Journal of Systems and Software,141:131–150.

Alpaydin, E. Introduction to Machine Learning. 2014. 3. ed. Cambridge, MA: MIT Press, 2014.

Awad, M., Khanna, R., 2015. Machine learning. In: Efficient Learning Machines: Theories, Concepts, and Applications for Engineers and System Designers. Berkeley, 2015. 1–18.

Barata, G., Gama, S., Jorge, J., and Goncalves, D., 2016. Early Prediction of Student Profiles Based on Performance and Gaming Preferences. IEEE Trans. on Learning Tech., 9(3): 272–284.

Bharathi, A., Singh, A., Tucker, C., and Nembhard, H., 2016. Knowledge discovery of game design features by mining user-generated feedback. Computers in Human Behavior, 60:361–371.

Bodnar, C. A., Anastasio, D., Enszer, J. A., and Burkey, D. D., 2016. Engineers at Play: Games as Teaching Tools for Undergraduate Engineering Students. Engineering Education, 105(1):147–200.

Borges, R. P., Oliveira, P. R., Lima, R. G., and De Lima, R. W., 2018. A systematic review of literature on methodologies, practices, and tools for programming teaching. IEEE Latin America Transactions, 16:1468–1475.

Bozkurt, A., Durak, G., 2018. A systematic review of gamification research: In pursuit of homo ludens, International Journal Game-Based Learning (8) 15–33.

Brito, A. and Madeira, C., 2017. Metodologias gamificadas para a educação: uma revisão sistemática. Anais do XXVIII SBIE, 1:133.

Calderón, A., Trinidad, M., Ruiz, M., and O'Connor, R. V., 2018. Teaching software processes and standards: a review of serious games approaches. Communications in Computer and Information Science, 918:154–166.

Cordero-Brito, S. and Mena, J., 2018. Gamification in the social environment: A tool for motivation and engagement. In ACM International Conference Proceeding Series, 640–643.

Cowley, B., Kosunen, I., Lankoski, P., Kivikangas, J. M., Jarvela, S., Ekman, I., Kemppainen, J., and Ravaja, N., 2014. Experience Assessment and Design in the Analysis of Gameplay. Simulation and Gaming, 45(1):41–69.

De Avila dos Santos, J. and Luis Castro de Freitas, A., 2017. Gamificação Aplicada a Educação: Um Mapeamento Sistemático da Literatura. Renote, 15(1.

De Avila dos Santos, J. and Luis Castro de Freitas, A., 2017. Gamificação Aplicada a Educação: Um Mapeamento Sistemático da Literatura. Renote, 15.

De Sousa Borges, S., Durelli, V. H., Reis, H. M., and Isotani, S., 2014. A systematic mapping on gamification applied to education. In Proceedings of the ACM Symposium on Applied Computing, SAC '14, pages 216–222, New York, NY, USA.

Denden, M., Tlili, A., Essalmi, F., Jemni, M., 2017. Educational gamification based on personality, 2017 IEEE/ACS 14th International Conference on Computer Systems and Applications (AICCSA) 1399–1405.

Dicheva, D., Dichev, C., Agre, G., and Angelova, G., 2015. Gamification in education: A systematic mapping study. Educational Technology and Society, 18(3):75–88.

Gentry, S. V., Gauthier, A., Ehrstrom, B. L., Wortley, D., Lilienthal, A., Car, L. T., Dauwels-Okutsu, S., Nikolaou, C. K., Zary, N., Campbell, J., and Car, J., 2019. Serious gaming and gamification education in health professions: systematic review. Journal of Medical Internet Research, 21.

Hidalgo, et al., A., 2020. The digital divide in light of sustainable development: An approach through advanced machine learning techniques. Technological Forecasting and Social Change. 150 (1).

Inocencio, F. C., 2018. Using gamification in education: A systematic literature review. In:International Conference on Information Systems 2018, ICIS 2018.

Kamunya, S., Maina, E., and Oboko, R., 2019. A Gamification Model for E-Learning Platforms. In 2019 IST-Africa Week Conference, IST-Africa, 1–9.

Kapp, K. M., 2012. Theories Behind Gamification of Learning and Instruction. The Gamification of Learning and Instruction: Game-Based Methods and Strategies for Training and Education, 51–74.

Kitchenham, B. and Charters, S., 2007. Guidelines for performing systematic literature reviews in software engineering. School of Computer Science and Mathematics, 1–65.

Lara, J. A., Aljawarneh, S., and Pamplona, S., 2019. Special issue on the current trends in e-learning assessment. Journal of Computing in Higher Education.

Lee, J. and Hammer, J., 2011. Gamification in education: What, how, why bother? Academic Exchange Quarterly, 15(2):146.

Llorens-Largo, F., Villagrá-Arnedo, C. J., Gallego-Durán, F. J., Satorre-Cuerda, R.,Compañ-Rosique, P., and Molina-Carmona, R., 2016. LudifyME: An Adaptive Learning Model Based on Gamification. In Caballé, S. and Clarisó Learning Data Analytics and Gamification, R. B. T. F. A., editors, Formative Assessment, Learning Data Analytics and Gamification: In ICT Education, pages 245–269.

Lopes, R. P., Mesquita, C., Rio-Rama, M. de la C. del, & Alvarez-Garcia, J. (2018). Collaborative Learning Experiences for the Development of Higher-Order Thinking. ESPACIOS, 39(17).

Mora, A., Riera, D., González, C., and Arnedo-Moreno, J., 2017. Gamification: a systematic review of design frameworks. Journal of Computing in Higher Education, 29(3):516–548.

Morelock, J. R., 2013. Systematic literature review: An exploration of gamification in the context of engineering education. In IIE Annual Conference and Expo 2013, 453–462.

Naidu, V. R., Singh, B., Farei, K. A., Suqri, N. A., Al-Masri, A. N., Al-Assaf, Y. Machine Learning for Flipped Teaching in Higher Education: A Reflection. In: Conference Sustainable Devel. and Social Responsibility. v. 2. Switzerland: ASTI, 2018. p. 129-132.

Ortiz-Rojas, M., Chiluiza, K., and Valcke, M., 2017. Gamification and learning performance: A systematic review of the literature. In Proceedings of the 11th European Conference on Games Based Learning, ECGBL 2017, 515–522.

Osatuyi, B., Osatuyi, T., De La Rosa, R., 2018. Systematic review of gamification research in is education: A multi-method approach, Commun. Assoc. Inf. Syst. (42) 95–124.

Peixoto, M. M. and Silva, C., 2015. Requirements for gamified educational software: A systematic literature review [requisitos para softwares educacionais gamificados: Uma revisão sistem´atica de literatura]. In CIBSE 2015 - XVIII Ibero-American Conference on Software Engineering, 618–631.

Rodrigues L. F., Oliveira A., Rodrigues H., 2019. Main gamification concepts: A systematic mapping study. Heliyon, v. 5, n. 7, p. e01993.

Samuel, A. L., 1959. Some studies in machine learning using the game of checkers. IBM Journal of Research and Development, v. 44, p. 210–229.

Seaborn, K. and Fels, D. I., 2015. Gamification in theory and action: A survey. International Journal of Human Computer Studies, 74:14–31.

Siu, W. L., Lim, T. S., Chen, Y. R., Chen, Y. L., Jou, Y. A., and Chen, Y. C., 2018. Using an english language education app to understand the english level of students. In 2018 27th Wireless and Optical Communication Conference, WOCC 2018, pages 1–3.

Souza, M. R. A., Veado, L., Moreira, R. T., Figueiredo, E., and Costa, H., 2018. A systematic mapping study on game-related methods for software engineering education. Information and Software Technology, 95:201–218.

Stevenson, M. P., Hartmeyer, R., and Bentsen, P., 2017. Systematically reviewing the potential of concept mapping technologies to promote self-regulated learning in primary and secondary science education. Educational Research Review, 21:1–16.

Subhash, S. and Cudney, E. A., 2018. Gamified learning in higher education: A systematic review of the literature. Computers in Human Behavior, 87:192–206.

Tenório, M. M., Reinaldo, F. A. F., Góis, L. A., Lopes, R. P., and dos Santos Junior, G., 2018. Elements of gamification in virtual learning environments: A systematic review. Advances in Intelligent Systems and Computing, 716:86–96.

Trinidad, M., Calderón, A., and Ruiz, M., 2018. A systematic literature review on the gamification monitoring phase: How spi standards can contribute to gamification maturity. Communications in Computer and Information Science, 918, 31–44.

Truong, H. M., 2016. Integrating learning styles and adaptive e-learning system: Current developments, problems and opportunities. Computers in Human Behavior, 55:1185–1193.