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The Gamification of E-learning Environments for Learning Programming

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***Abstract*— Gamification is the most active methodology utilized in the E-learning environment for teaching-learning in computing; however, this does not restrict its use in other areas of knowledge. Gamification combines elements of play and its design techniques in a non-ludic context, achieving a motivation factor for the students. This systematic study aimed to collect and synthesize scientific evidence from the gamification field for learning programming through the E-learning environment. In order to do this, a systematic literature review was done, following the guidelines proposed by Petersen, which propose the definition of questions, search strategies, inclusion/exclusion criteria, and characterization. As a result of this process, eighty-one works were completely reviewed, analyzed, and categorized. The results revealed favorable learning among the students, the most used platforms and gamification elements, the most used languages and focuses of programming, and the education level, where gamification is most used to learn to program in an E-learning environment. These findings evidenced that gamification is a good active strategy for introducing beginning students to programming through an E-learning environment. Within this context, Learning programming through the use of gamification is a topic that is growing and taking force, and after what occurred during the pandemic, it is projected that there will continue to be more students who are focused on understanding its implementation and the impact it has on the different levels of education and the areas of knowledge.**

***Keywords*— Electronic learning; active methodology; learning based on games; game elements; serious games; gamified platforms.**

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I. INTRODUCTION

E-learning has become more and more common in learning [1]. This educational method is becoming more relevant for facilitating the activities in the task of learning programming [2]. Programming is a fundamental ability for students in the technology disciplines [3]. On occasion learning to program computers can be a complicated affair [4] for beginner students in computer sciences [5], who often perceive it to be a boring module that requires a lot of time and is hard [5]; This provokes a lack of interest, frustration, and desertion on behalf the beginner students in programming subjects.

Due to this fact, active methodologies were studied in order to improve the teaching-learning in the computation discipline [6], where it was concluded that gamification (GM – acronym in Spanish) was the most used active methodology, achieving positive results, as well as acting as a motivation factor for students. The use of game elements and their design techniques in a non-playful context is what is known as gamification [7]; in some fashion, the students' motivation decreases once they begin the course [8].

At the same time, in the literature, studies can be found related to serious games where analysis has been done on how serious games and the gamification elements that make them up were used and evaluated in their support of learning programming [9]. The insignias, followed closely by periods and the classification tables, have been the most widely recognized game elements in information systems education [10]. It is equally important to center around the feedback students give when taking a course in an e-learning environment [11]. The impact of gamification on motivation, academic performance, and the positive and negative effects were also measured [12], [13].

Thus, this work intended to carry out a systematic revision of literature in the field of gamification for learning programming in an e-learning environment during the 2015 – 2022 period. This study will keep specialists up to date on the topic, allowing for an understanding of the gamification elements, platforms, environments, languages, and focuses

found, and will also recognize the researcher's effort in the gamification field.

This paper is structured in the following parts. Section two contains the methodology that was carried out. Section three describes the results. Section four contains the conclusion and orientation for the future.

II. Material and Method

According to the process and guidelines and in order to carry out the study of a systematic literature review, the working methodology was used as a reference [14]. Also, this study was centered around the collection and synthesis of scientific evidence:

A. Research Questions

The objective was to collect scientific evidence related to the use of gamification for learning programming in an e-learning environment, which brought about seven research questions (RQ):

- RQ1: Which programming focuses are being used with gamification for learning via e-learning?
- RQ2: What are the most frequently used elements for learning programming via e-learning?
- RQ3: Which platforms were elaborated on or used to implement gamification in programming courses via e-learning?
- RQ4: Applying gamification to learning programming online is directed towards what level of education?
- RQ5: What type of license do the elaborated or used platforms have?
- RQ6: To what type of software environment do the platforms that were elaborated belong?
- RQ7: What programming languages were used for students learning through gamified platforms?

B. Review of the Reach

PICO (population, intervention, comparison, outcomes) was used to determine the reach and formulate the chain search starting with the research questions [14].

- Population: ("Programming" OR "Programming Learning")
- Intervention: ("Gamification" OR "Gamification" OR "Gamified" OR "Gamify")
- Comparison: we did not compare technologies
- Outcomes: ("E-learning" OR "Electronic learning" OR "Online Learning")

C. Perform the Search

It was determined that the base chain search, given the PICO criteria, was the following: *("Programming" OR "programming learning") AND ("Gamification" OR "Gamification" OR "Gamified" OR "Gamify") AND ("E-learning" OR "Electronic learning" OR "Online Learning").*

The databases used were Scopus, ACM, IEEE, and ScienceDirect. The chain shown was adapted to the general syntax of each database to classify the articles found through the use of phases, which contained inclusion and exclusion criteria.

The chains provided the following quantity of searches per database. As a result, a total of 1303 articles related to the topic in the study were obtained, as shown in Table 1.

TABLE I
ARTICLES OBTAINED FROM THE INITIAL SEARCH

Source	Chain Search
ACM Digital Library	158
IEEE	23
ScienceDirect	536
Scopus	586
Total	1303

D. Selecting the Studies

The results that were obtained passed through filters containing inclusion and exclusion criteria, shown in Table 2.

TABLE II
INCLUSION AND EXCLUSION CRITERIA

Criteria	Criteria ID	Chain Search
Inclusion	I1	Articles from journals or conferences
	I2	Articles with English content
	I3	Articles centered around gamification and learning programming online
Exclusion	E1	Articles not centered around e-learning
	E2	Articles unrelated to gamification
	E3	Articles before the year 2015
	E4	Duplicate articles
	E5	Articles from secondary sources
	E6	Articles unrelated to learning programming

The inclusion and exclusion criteria were divided into three phases in order to filter the studies, as shown in Table 3.

TABLE III
FILTRATION PHASES

Phase	Criteria ID
1	I2, E3, E4
2	I1, E2, E5, E6
3	I3, E1

The result of the filtration process is shown in Figure 1.

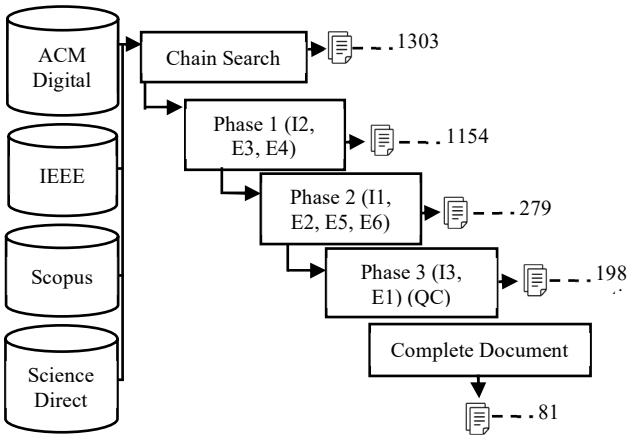

Fig. 1 Filtration Process by Phase

E. Evaluation of the Quality

In order to evaluate the quality of each article collected, three quality questions (QC – acronym in Spanish) were asked:

- The objectives of the study are related to gamification and learning programming online?
- The research method is described appropriately to be able to achieve the study objective?
- The results of the research are clearly expressed?

The quality of 108 articles was evaluated using these questions; the result was that eighty-one of the articles in study passed the quality questions.

F. Data Extraction

The following were the indicators for obtaining the data:

- Focus on Programming
- Gamification Elements
- Platforms Elaborated or Used
- Level of Education
- Platform License
- Programming Language
- Type of Software Environment

III. Results and Discussion

The arrival of the COVID-19 pandemic caused in-person education to take a hasty jump into online education. There are diverse studies regarding this transition process on many education levels. Programming courses require desire and interest for them to be carried out successfully; for this, many authors propose the incorporation of gamification through the use of online platforms to learn programming.

The studies related to gamification have taken off in the last five years; the publication from 2019 to 2022 maintained an average of nine and ten publications, evidence of the interest in researching gamification in order to propose and search for a solution to improve the learning of programming, as shown in Figure 2.

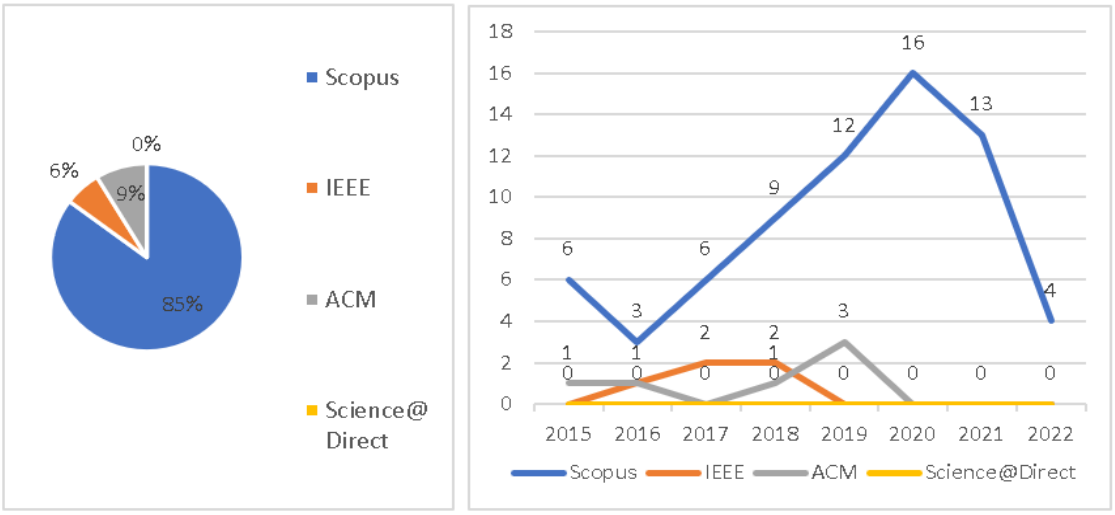

Fig. 2 Number of Articles Accepted by Year

A. RQ1: Which programming focuses are being used with gamification for learning via e-learning?

In Table 4, structured programming was the most utilized programming focus with 51.9% of reviewed studies; the programming oriented towards objects (17.3%) and based on blocks (13.6%) also maintained a constant rhythm, with the greatest interest being during the year 2019.

TABLE IV
THE FOCUS OF PROGRAMMING USED IN THE LAST SEVEN YEARS

#	Programming Focus	References							
		2015	2016	2017	2018	2019	2020	2021	2022
1	Programming Structure	[6], [7]	[4], [1]	[2], [3], [5], [8], [9], [10]	[11], [12], [13], [14], [15]	[16], [17], [18], [19], [20], [21], [22], [23], [24], [25]	[12], [26], [27], [28], [29], [30], [31], [32]	[33], [34], [35], [36], [37], [38], [39]	[40]
2	Programming Oriented Towards Objects	[41], [42], [43]	[44], [45]	[46]	[47], [48], [49], [50]		[51]	[52]	[53], [54]
3	Programming Based on Blocks	[55]	[56]	[57]		[58]	[59], [60], [61], [62], [63], [64], [65]		
4	Others				[66], [67], [68]	[69], [70], [71], [72]	[73], [74], [75]	[76], [77], [78]	[79]

B. RQ2: What are the most frequently used elements for learning programming via e-learning?

In Figure 3, the points were the most utilized gamification element by programming learning platforms online, with 18.6%; this was due to a belief that the points motivate those students who show a greater interest in the content of the programming courses online. Another of the most used elements was the classification table with 15.6%; this element increased the competency and motivation of the student in order for them to achieve the top positions. It was also found that the insignias (12.91%) also influenced the increase of motivation, interest, and interaction on behalf of the students.

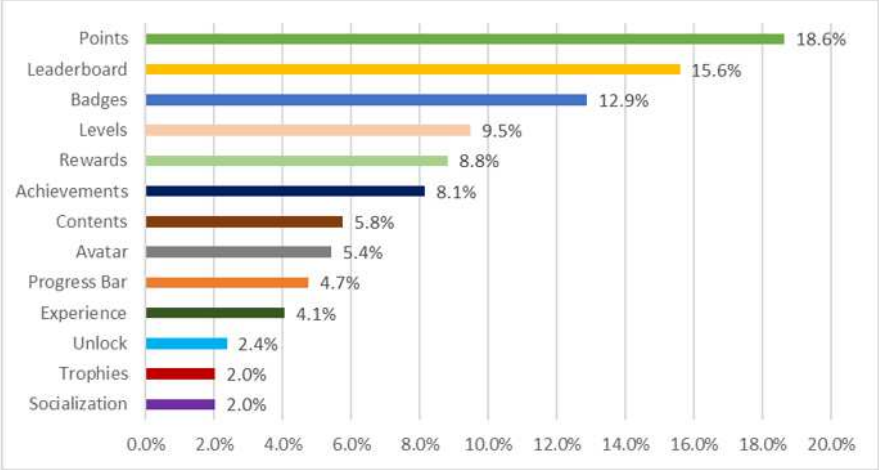

Fig. 3 The Gamification Elements Utilized for Learning Programming Online

C. RQ3: Which platforms were elaborated on or used to implement gamification in programming courses via e-learning?

Table 5 shows that the studies found that platforms created by the authors and existing platforms were used. A total of sixty-two platforms that include or may include gamification applied to learning programming online were recorded. It was found that Moodle was the platform with the most scientific evidence and with more gamification elements for learning. The rest of the platforms with little scientific evidence were scored positively for helping with the students' motivation and interest.

TABLE V
GAMIFICATION PLATFORMS ELABORATED AND USED

No	Reference	Platforms Elaborated or Used
1	[47]	CoMa
2	[46], [2], [17], [53], [40], [26], [26], [52], [30], [31], [72], [48], [50], [68]	Moodle
3	[11]	Prolounge
4	[44]	ClassGame
5	[41]	Javala
6	[16]	Achievement Profile Web Application
7	[12], [67]	Classcraft
8	[80]	UDPiler
9	[45]	Enki
10	[18]	Juez en línea de Waseda (WOJ)
11	[79], [77], [78]	Framework for Gamified Programming Education (FGPE)
12	[54]	CodeGym
13	[76]	Rimigs
14	[33]	CYourWay
15	[34], [28]	CodeCombat
16	[75]	Grasshopper
17	[35], [42]	Kahoot!
18	[36]	Hackerrank
19	[37]	Learn Programming Project
20	[38]	SuperDevBros
21	[39]	DFD-C
22	[59]	RoboTIC
23	[27], [20]	Feeper
24	[60]	EasyLogic
25	[61], [56]	NoBug's SnackBar
26	[62], [55]	Scratch
27	[29]	Priscilla
28	[63]	Lightbot: Code Hour
29	[51]	CodinGame
30	[64]	Alcody
31	[65]	Blockly Games
32	[73]	BlackBoard
33	[32]	APFication
34	[74]	Asura
35	[19]	KodeKurawai
36	[69]	LeaderBoard
37	[70]	UniCraft
38	[71], [66]	SEP-CyLE
39	[21]	C-Rocks
40	[22]	Diseño de prototipo de gamificación
41	[23], [81]	CodeAvengers
42	[24]	CENGO
43	[58]	CP m-Game
44	[25]	Khan Academy
45	[13]	LearnJS
46	[14]	Jutge.org

No	Reference	Platforms Elaborated or Used
47	[49]	InteractiveOOP
48	[15]	FunProg
49	[4]	TICademia
50	[57]	Reduct
51	[5]	Credly
52	[8]	CodeTraining
53	[9]	Point Moisture
54	[10]	Perobo
55	[3]	MyLab Programming
56	[1]	Kodr
57	[42], [5], [4]	Code Academy
59	[7]	Kodesh (Koding Shell)
60	[43]	Tower Defense Java
61	[50]	EdPuzzle
62	[31]	Open Badge Designer

D. RQ4: Applying gamification to learning programming online is directed towards what level of education?

In Figure 4, information about the platforms elaborated on or used and the focus of the most used programming was insufficient. Rather, the level of education where they are being used was considered. For superior university-level education, the greatest number of studies were done where gamification was applied to learning programming at 82.7%. Primary and secondary education were other levels of education where this was applied, with 4.9% and 7.4%, respectively. More scientific evidence can also be found for the structured focus, and it was also found that open and closed licenses were used.

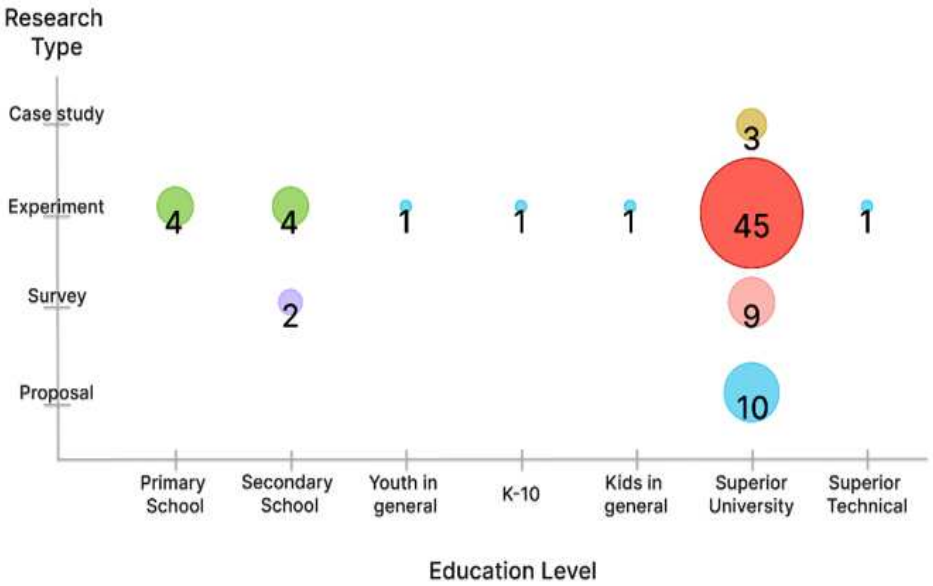

Fig. 4 Quantity by Type of Research per Education Level

E. RQ5: What type of license do the elaborated or used platforms have?

Figure 5 shows that of the reviewed studies, some institutions planned and created their own gamification tools and platforms to adapt them to their programming courses, and others preferred to use existing ones. It was found that for most platforms, their code was open, 51.9%, and 48.1% of the platforms had closed code; they have also maintained a constant rhythm.

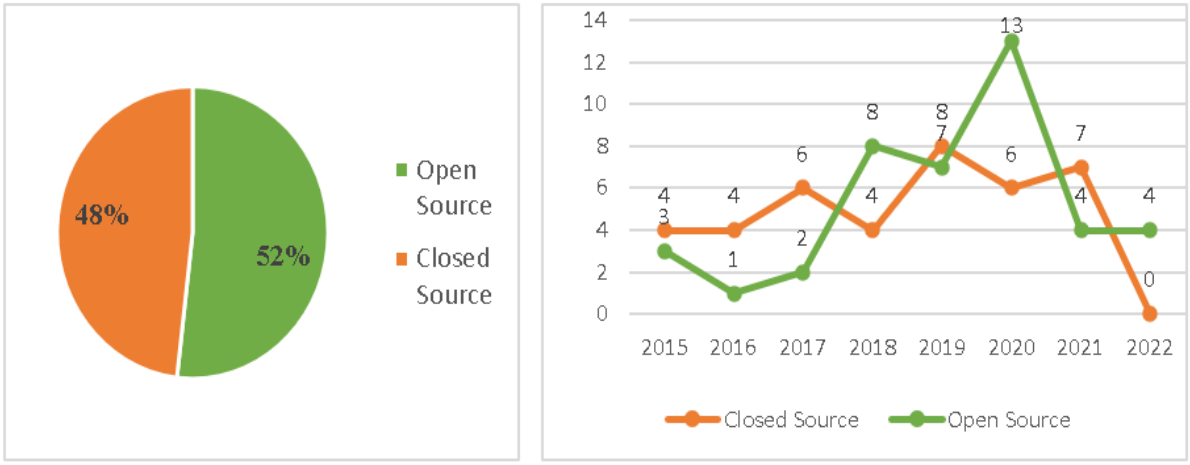

Fig. 5 License of the Platforms Elaborated or Used

F. RQ6: To what type of software environment do the platforms that were elaborated belong

In Figure 6, most of the gamified platforms were from the web, at 85.2% and 17.3% were from phone applications, which continues to grow; however, desktop applications fell behind at 6.8%, along with portable applications at 1.2% (1). The accessibility criteria played an important role in the election of the environments, according to the authors.

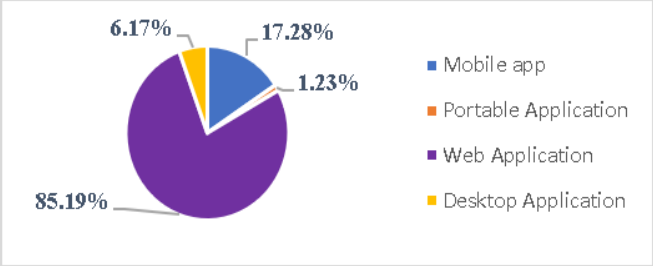

Fig. 6 Environment of the Platforms Elaborated or Used

G. Q7: What programming languages were used for students learning through the use of gamified platforms?

Languages are another essential part at the point in time that gamification is applied to learning. According to Figure 7, the most used language in the application of gamification was Java for 24.7% of the studies, and C was 14.8%; this language and Java were used for superior education. After C, was Python with 13.6% and JavaScript with 9.9%, the growth of which had a relatively increasing rate in recent years. Finally, the least considered languages to which gamification was applied were C++ at 6.2%, C# at 4.9%, Scratch at 4.9%, and PHP at 1.2%. There were also agnostics which came to 19.8%.

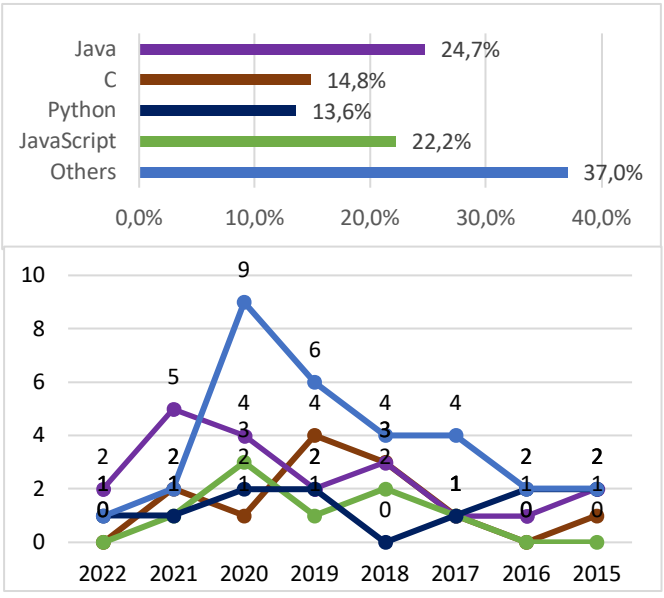

Fig. 7 Programming Languages Used on the Platforms

IV. Conclusion

These findings were evidence that gamification is a good active strategy for learning programming to captivate the interest of researchers worldwide, understand its application, and the impact it has at different levels of education. It was found that the most concurrent focus was that of structured programming, while the elements most representative of gamification were points and classification tables, elements that incentivize competition, motivation, and interaction on behalf of the students. Moreover, most platforms are closed source, on the web, and mainly applied to superior education. Just as the focus of programming is considered to be learning to program, another important topic is the programming languages, which are also important to consider when a platform is involved. There were platforms that used just one language, just as there were platforms that used more than one programming language. The languages which stood out were Java, C, Python, and agnostics. Learning programming through gamification is a topic that is growing and taking force. After what happened during the pandemic, it is projected that there will continue to be more studies centered around gamification, programming, and e-learning.

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