

Experience in programming fundamentals through gamification

Sir-Alexci Suarez Castrillon¹, Albert Miyer Suarez Castrillon² and Elkin Gregorio Florez Serrano³

¹ Engineering Faculty, GRUCITE, University Francisco of Paula Santander Ocaña, Colombia.

^{2,3} Faculty of Engineering and Architecture. GIMUP, University of Pamplona, Colombia.

Abstract

An investigation is presented using gamification through the use of Kahoot, for teaching programming fundamentals. Evaluating topics covering analysis, design and coding, in addition to the conversion of numerical systems, using flowcharts and pseudocode. A group of 22 students divided into 4 tests is evaluated, with the topics described above. For the use of the gamification tool, the games are carried out using traditional and flipped classroom in such a way that the degree of commitment and motivation of the students can be measured, based on the percentage of correct answers.

Keywords: Gamification, classroom games, programming fundamentals, flowcharts, pseudocode.

I. INTRODUCTION

The elements that motivate the students in the classes are determinant to obtain good results in the teaching and learning process. One of these elements can be the implementation of games that through different techniques help students to participate, without them considering that it is a compulsory evaluation, so that they perceive it as a game of competences that will help them to improve their knowledge and skills in the topics of the subject. Games have been successfully implemented in the teaching of a language such as English, demonstrating a high effectiveness, where there are rules and objectives that allow to reach the knowledge in a more intuitive way [1], [2].

The use of games better known as gamification is one of the methodologies that has been demonstrating a great utility at all levels of education, coming to be used in grades of education through technological tools such as Educaplay and kahoot, the importance is the feedback that helps the teacher in improving their activities [3]. Within the areas that have been implemented more are engineering, technology, and mathematics, finding serious games with the use and online connection to learning with physical game tools [4]. Gamification must have 3 essential elements such as dynamics, mechanics and components. Which determine the motivations, game components, materials and didactic tools for game design. The purpose is to create challenges to the student where the teacher is not the only one responsible for the class [5].

Kahoot is one of the tools with greater application, used in multiple subjects such as biology, varying the number of questions and the time to give the answer, proving effective with 20 seconds without the need to extend the time, which

allows greater student concentration [6]. In addition to teaching language vocabularies it can be used for theoretical concepts being a didactic alternative for students [7]. Within the cycles of education it has been effective in primary, secondary and higher education with experiences that have emerged in the early stages incorporating them into higher education [8], giving an acceptable perception by students in all areas of knowledge [9].

In teaching programming it has been used in PHP courses [10], where control structures are taught and its importance lies in the fact that almost 90% of the students felt motivated and engaged, as well as would give a recommendation to be used by other teachers. It has also been used in teaching for a course of beginning in programming where it focuses on object-oriented programming, sequential and repetitive structures and finally in one-dimensional and two-dimensional arrays [11], the evaluations are made by showing the program code to find the answer from there, showing that of the 28 students evaluated considered a tool that helps to understand each of the topics described above.

In this research article the Kahoot tool is used, for teaching in a basic programming course using as central themes unit 1,2 and 3 covering numbering systems, design and coding using flowcharts and pseudocode in topics such as data types, variables, identifiers, creating formulas, evaluations of expressions, operands and operators, functions and symbols of the flowcharts as well as sentences with their reserved words in pseudocode, evaluations of expressions, operands and operators, functions and symbols of the flowcharts as well as the sentences with their reserved words in pseudocode, Performed at the University Francisco de Paula Santander for the group B of Fundamentals of programming in the second semester of 2021, using traditional classes and flipped classroom [12].

II. METHODOLOGY

The design of the game starts with the preparation of the material for the respective class and then the game and the appropriate questions for the evaluation are configured. The first two units of the thematic content of Fundamentals of Programming have been evaluated, in figure 1 you can see the steps that allow the realization of the game.

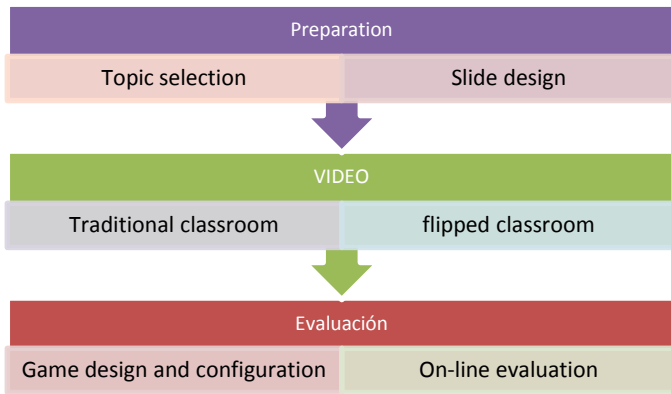


Fig. 1. Stages for the design, development and evaluation through the interactive game.

Two forms of evaluation have been implemented, one by traditional class where the teacher explains concepts and performs the exercises before evaluating them, and the second by flipped classroom where a video of the class was left in such a way that the student only came to class to evaluate and expand more knowledge on the subject. The game through Kahoot was carried out by the virtual class method where students play with each other live, better known as classic (See figure 2).

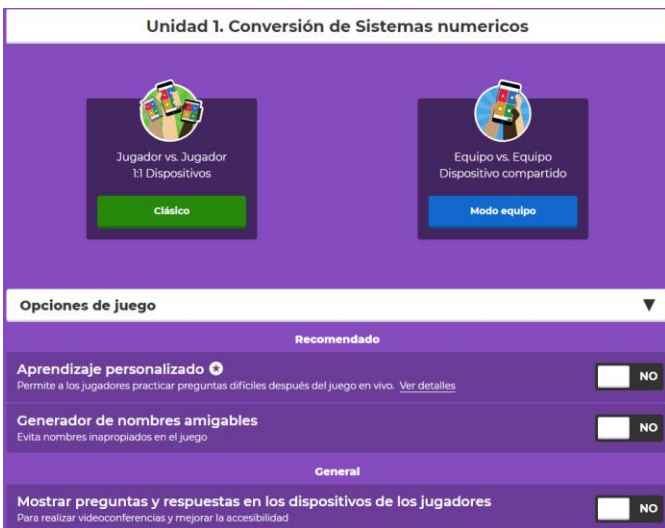


Fig. 2. Game start-up configuration screen.

Once the system is configured, the process begins by which a pin is generated, which allows each student through a device such as tablets, cell phones, laptops or desktops to enter the application to start the game (see figure 3).



Fig. 3. Generation of the PIN for the start of the game.

The questions start to appear and must be answered in the appropriate time for each of them. Each answer represents a color (see figure). The questions can be single, double and true or false. Each question is timed from 30 to 60 seconds (see figure 4).

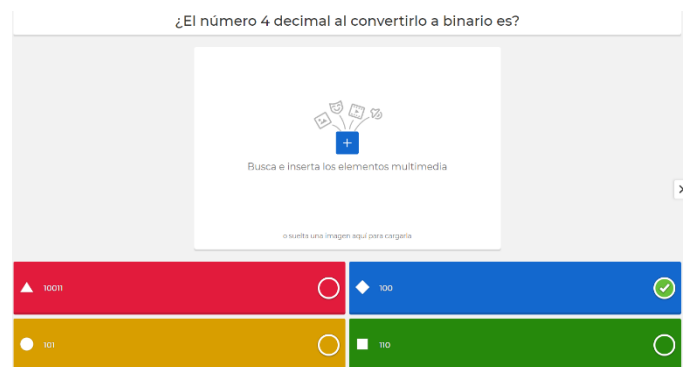


Fig. 4. Presentation of questions to be evaluated.

The game at the end gives a score per participant and selects the best 5 of the class, being innovative and competitive because not only the question must be correct but also begins to take relevance the response time, so the best performance in these two variables wins.

The motivation for the students lies in the use of the cell phone, which is a device that is widely used by human beings. In such a way that regardless of where the student is, he/she can participate in the class. Giving the teacher the possibility for everyone to participate, something that does not happen in a normal class.

There were 4 tests of the two thematic units covering number systems, sequential programming using flowcharts and pseudocode. In test 1 there were 5 questions based on the conversion of binary, decimal, octal and hexadecimal number systems (table 1).

Table 1. Test Questions 1 - Conversion of Numerical Systems

Number	Ask
Q1	The number 4 in decimal when converted to binary is?
Q2	When converting the number 111(8) to binary your answer is?
Q3	Does a Roman numeral belong to the positional system?
Q4	Select the item that belongs to the system software
Q5	The arithmetic sum of binary 111(2)+111(2) results in 1010(2).

Test 2 contains 10 questions and allows you to play on the evaluation of simple numeric (integer, real), character and logical data types (table 2).

Table 2. Test 2 Questions - Data Types.

Number	Ask
Q1	Data of numeric type are divided into
Q2	Selects the value that represents a real data type.
Q3	When you add "12" + "12" the result is
Q4	The identifier for a variable can be C8_2
Q5	The identifier for a variable can be Cannon
Q6	A variable is composed of:
Q7	The arithmetic operators are
Q8	The expression $A = 5 \leq 7$ returns a value of
Q9	The number of stars would be a data type:
Q10	If we add the values 23+24.5 the result is of the data type:

Test 3, which has 10 questions where you interact with the different flowchart symbols and their functionality (table 3).

Table 3. Test Questions 3 - General Flow Diagram Overview

Q1	The action of storing the value 6 in the variable A. ($A=6$), is called
Q2	The expression $X+Y=1$ is well written
Q3	The following symbol is used for
Q4	The following symbol is used for
Q5	The following symbol is used for
Q6	The parts of an algorithm are

Q7	If I want to print a message followed by the value of a variable, I separate them with
Q8	In DFD the logical operator AND is written as y
Q9	The expression (V and V or V) and F gives the result V
Q10	What is the maximum number of instructions that can be inserted in the assignment symbol in the DFD software?

Test 4, keeps the same 10 questions but focusing on pseudocode, evaluating each instruction, its functionality and when it should be used, as well as all the reserved words that can be used to develop a program (table 4).

Table 4. Test Questions 4 - Pseudocode Generalities

Q1	The instruction used to enter data by keyboard is:
Q2	The start of a program in Pseint begins with the instruction
Q3	The Finalgorithm instruction ends with a semicolon.
Q4	To calculate the remainder of a division by 8 and 3 and store it in the variable H, write it as
Q5	To display a message on the screen, you use the command
Q6	What type will the variable A be, if $B=4.5$ and $C=2$ and the operation is $A=B*C$;
Q7	Declaring a variable is the same as
Q8	The instruction Read "A"; it is well-written
Q9	Type in which lines the error is found in the following program
Q10	Determine on which line the error is in the following program

The set of each test is between 16 to 21 students, varying according to the technical availability of connection and access devices of each student.

III. RESULTS

In the evaluation results report of the game in class, the name of each student has been eliminated, keeping it as a reserve of the evaluation and only specified with the player number, the results have been taken globally for each test without going into individual detail of each participant as it progresses through the classes and the games of each test. One of the advantages of applying games for teaching is that it allows the teacher to know the lack of students in a fun and participatory way, keeping reserve and offering the student results of their evaluation in real time. For example the teacher can determine according to question Q6 of test 4, how many have given a correct answer and who are confused, for this particular case although the students understand the numerical data type, they still maintain a high range of ignorance between the integer and real numerical type (See figure 5).

Below are the results of the 4 tests, giving percentages of correct answers, number of players, total points and correct answers, as well as a detailed report per player for each question.



Fig. 5. Diagnosis of question Q6 of Test 4.

In table 5, it can be observed that only 27.5% of the students answered correctly, this game was played after the class had already been explained in a traditional way, which allows us to observe a low performance.

Table 5. Overview - Test 1.

Played with	16 players
Played	5 of 5
Overall Performance	
Total correct answers (%)	27,50%
Total incorrect answers (%)	72,50%
Average score (points)	1020,13 points

When observing table 6, it is verified that 3 students did not present the test, the reasons can be a slow internet connection, which harms the final results of the game and the evaluated group.

Table 6. Final Scores - Test 1.

FINAL SCORES			
Rank/ Player	Total Score (points)	Correct Answers	Incorrect Answers
1	3000	4	1
2	2349	3	2
3	1752	2	3
4	1427	2	3
5	1238	2	3
6	1135	2	3
7	909	1	4
8	906	1	4

9	865	1	4
10	788	1	4
11	744	1	4
12	636	1	4
13	573	1	4
14	0	0	5
15	0	0	5
16	0	0	5

By performing an evaluation of the players for each question it can be seen that question Q4 is mostly the cause of the poor performance, whereby students still have confusion with the system software, which is focused on operating systems (table 7).

Table 7. Summary - Test 1.

Rank	Q1	Q2	Q3	Q4	Q5
1	768	581	744	0	907
2	639	0	798	0	912
3	852	0	900	0	0
4	886	0	0	0	541
5	561	0	677	0	0
6	0	0	542	0	593
7	0	0	909	0	0
8	0	0	906	0	0
9	0	0	865	0	0
10	0	0	788	0	0
11	0	0	0	0	744
12	636	0	0	0	0
13	573	0	0	0	0
14	0	0	0	0	0
15	0	0	0	0	0
16	0	0	0	0	0

For test 2, a flipped classroom methodology was used, where they were left a video with the entire class recorded, and then in the next class began with an evaluation of that class, and then followed with a broader explanation of the topic. In this particular case, it was observed that the flipped classroom is a good proposal since it increased the percentage of success of the group, showing a greater participation and motivation of each player up to 36% (table 8).

Table 8. Overview - Test 2.

Played with	16 players
Played	10 of 10
Overall Performance	
Total correct answers (%)	63,75%
Total incorrect answers (%)	36,25%
Average score (points)	5397,19 points

In table 9, it can be seen that all players have intervened with their answers, which helped to improve the percentage of correct answers.

Table 9. Final Scores - Test 2.

FINAL SCORES			
Rank/Player	Total Score (points)	Correct Answers	Incorrect Answers
1	7522	8	2
2	7440	8	2
3	6990	8	2
4	6624	7	3
5	6431	7	3
6	6175	7	3
7	5656	7	3
8	5590	7	3
9	5330	6	4
10	5160	6	4
11	4972	7	3
12	4649	6	4
13	4556	5	5
14	3762	6	4
15	3110	4	6
16	2388	3	7

In table 10, we can see the inconvenience of players 15 and 16, who were unable to complete the entire test due to connection problems, affecting the final result of the test. Also in question Q3 there is a lack of knowledge between the numeric data type and a character data type, when numbers are used within the values of the character type. This is again explained by the teacher. It can also be determined that the students have a very good knowledge of how to create an identifier to call a variable, which can be seen in the results of question Q5.

Table 10. Summary - Test 2.

Rank	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10
1	959	889	975	974	960	0	893	913	0	959
2	959	928	914	976	981	807	0	0	916	959
3	891	930	0	919	986	637	850	0	822	955
4	975	925	0	974	978	0	0	886	941	945
5	980	934	0	841	951	0	0	803	968	954
6	822	892	0	884	934	0	901	777	0	965
7	930	840	0	698	956	615	815	0	0	802
8	883	875	0	651	902	0	902	684	693	0
9	937	932	0	783	922	893	0	0	0	863
10	936	0	960	741	939	855	0	0	0	729
11	687	0	0	632	973	554	560	0	618	948
12	873	819	0	0	889	578	0	0	599	891
13	940	0	0	911	973	878	0	0	0	854
14	788	0	533	551	616	0	678	0	596	0
15	0	0	0	646	0	0	795	738	0	931
16	0	0	0	689	865	0	0	0	0	834

Test 3 is carried out with an flipped classroom and its results remain stable, although it decreases slightly, due to the fact that 3 students presented connection problems (table 11 and 12).

Table 11. Overview - Test 3.

Played with	21 players
Played	10 of 10
Overall Performance	
Total correct answers (%)	58,57%
Total incorrect answers (%)	41,43%
Average score (points)	7093,62 points

Table 12. Final Scores - Test 3.

Rank/Player	Total Score (points)	Correct Answers	Incorrect Answers
1	11173	9	1
2	11060	9	1
3	10887	9	1
4	10672	9	1
5	10500	8	2
6	9986	8	2
7	9834	8	2
8	9223	7	3
9	8382	7	3
10	8085	7	3
11	7766	7	3
12	6789	6	4
13	6675	5	5
14	6606	6	4
15	6133	5	5
16	5603	5	5
17	4879	4	6
18	4713	4	6
19	0	0	10
20	0	0	10
21	0	0	10

In table 13, it can be observed that some players did not complete the answer because it is a multiple-choice answer, which can have more than one answer, this led to a decrease in their final points. Questions Q6 and Q9 let us know that they have weaknesses in the solutions of programming expressions and confuse the parts of the algorithm with the parts of a program. However in answers Q, Q7 and Q8 they have full knowledge of the evaluation process and how to write logical operators in a flowchart.

Table 13. Summary - Test 3.

Rank	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10
1	898	829	1844	1916	1890	946	971	0	895	984
2	889	979	1688	1930	1866	0	933	980	806	989
3	847	960	1568	1882	1850	0	901	960	935	984
4	896	0	1318	1914	1904	938	944	918	852	988
5	920	0	938	1910	1910	925	979	969	959	990
6	820	906	868	1830	1724	0	949	956	945	988
7	892	902	709	1902	1844	0	910	853	872	950
8	827	0	1816	945	1880	938	926	901	0	990
9	735	743	731	1806	1776	0	897	848	846	0
10	815	956	0	1748	1742	0	953	883	0	988
11	727	0	1408	941	1610	870	768	745	0	697
12	853	0	868	0	894	923	619	822	932	878
13	898	0	1450	1866	769	0	873	819	0	0
14	875	732	919	1824	0	0	566	773	0	917
15	857	0	0	824	894	937	794	851	0	976
16	767	845	1646	1738	0	0	607	0	0	0
17	708	901	766	1838	0	666	0	0	0	0
18	890	977	0	924	0	0	0	933	0	989
19	0	0	0	0	0	0	0	0	0	0
20	0	0	0	0	0	0	0	0	0	0
21	0	0	0	0	0	0	0	0	0	0

Test 4 was carried out with traditional class obtaining worse results than the flipped classroom, this may demonstrate the student's interest is to learn their knowledge before entering a class (table 14).

Table 14. Overview - Test 4.

Played with	22 players
Played	10 of 10
Overall Performance	
Total correct answers (%)	52,73%
Total incorrect answers (%)	47,27%
Average score (points)	5457,64 points

In table 15, it can be seen that only two students could not answer the assessment. And it can be seen that one player has completed all the questions correctly.

Table 15. Final Scores - Test 4.

Rank/Player	Total Score (points)	Correct Answers	Incorrect Answers
1	9867	10	0

2	9486	9	1
3	8673	8	2
4	7421	8	2
5	7266	7	3
6	7088	6	4
7	7012	7	3
8	6495	6	4
9	6388	6	4
10	6244	5	5
11	6072	6	4
12	5643	6	4
13	5465	5	5
14	5160	6	4
15	4850	4	6
16	4460	4	6
17	4390	4	6
18	3645	4	6
19	2476	3	7
20	1967	2	8
21	0	0	10
22	0	0	10

Table 16 shows serious problems with questions Q8 and Q9, in such a way that they present problems with the instruction of reading data from the keyboard. While question Q2 shows that they know the reserved words that should be used in the programming language when using pseudocode.

Table 16. Summary - Test 4.

Rank	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10
1	89 8	90 9	75 9	176 8	78 9	93 6	87 1	69 2	88 3	136 2
2	95 1	84 8	91 9	187 8	82 0	90 3	85 1	0	88 2	143 4
3	90 2	94 0	0	182 6	89 5	88 0	85 5	0	90 7	146 8
4	67 2	86 7	97 7	638	92 0	75 1	58 7	91 1	0	109 8
5	96 5	97 9	98 4	172 0	79 2	96 1	86 5	0	0	0
6	0	87 8	95 6	185 2	0	90 6	91 1	80 7	0	778
7	97 0	95 8	95 8	163 0	76 5	93 6	79 5	0	0	0
8	0	98 3	0	189 4	84 0	0	91 8	94 2	91 8	0
9	0	96 6	81 1	183 8	92 2	0	82 5	0	0	102 6
10	96 6	95 1	84 4	962	0	91 9	94 5	0	0	657
11	96 9	86 4	95 0	165 4	74 9	88 6	0	0	0	0
12	93 4	0	92 3	140 0	72 0	87 4	79 2	0	0	0
13	92 5	87 0	0	703	74 8	75 0	86 4	0	0	605

14	92 1	91 4	85 9	0	87 6	86 1	72 9	0	0	0
15	0	96 0	94 0	173 8	0	0	56 8	0	0	644
16	97 9	92 9	60 9	702	65 9	0	0	0	0	582
17	0	94 5	88 9	859	85 2	84 5	0	0	0	0
18	97 0	92 7	0	0	88 9	0	85 9	0	0	0
19	0	95 1	0	0	90 3	62 2	0	0	0	0
20	0	0	68 8	0	0	0	51 5	0	0	764
21	0	0	0	0	0	0	0	0	0	0
22	0	0	0	0	0	0	0	0	0	0

IV. CONCLUSION

Teaching through game tools such as Kahoot offers a possibility to actively incorporate students in the subject of programming fundamentals, while the teacher maintains a feedback of group and individual learning. The results of the 4 tests determine that when they are evaluated through flipped classroom, higher scores are obtained than with traditional classes, due to the commitment and responsibility that each student adopts, through the role of creating their own knowledge, allowing to determine the weaknesses of each topic and deepen through the teacher to improve their performance. Students feel more relaxed and at the same time with more initiative to participate, without seeing it as a compulsory evaluation, but rather as a learning game.

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