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Conjectures of Mathematical Logic and Educational Games for Basic Education Based on the Guidelines of NCP, NCG and NBC

Antônio Lemos Régis[1], Raimundo Josedi Ramos Veloso[2], Fabrício Moraes de Almeida[3]

[1]Teacher of Computer Science Department in Federal University of Rondônia, Brazil. Master in Computer Science. E-mail: regis@unir.br.

[2]Teacher of Computer Science Department in Federal University of Rondônia, Brazil. Master in Computer Science. E-mail: veloso@unir.br.

[3]PhD in Physics (UFC), with post-doctorate in Scientific Regional Development (DCR/CNPq). Researcher of the Doctoral and Master Program in Regional Development and Environment (PGDRA/UNIR). Leader of line 2 — Technological and Systemic Development, and Researcher of GEITEC — Federal University of Rondônia, Brazil. E-mail: dr.fabriciomoraes001@gmail.com.

Abstract**—** *Current technological advances allow us to create, adapt or simply use numerous resources to achieve improvements in teaching-learning. The purpose of this article is to show the result of an analysis of the current normative documents and recommendations for national education in Brazil (National Curricular Guidelines - National Curricular Parameters and National Common Curricular Base), primary and secondary education, regarding the contents recommended in mathematical logic, complementing with the analysis of a pedagogical political project of the fundamental education of a public school, to verify the existence of this content, in it. From this analysis and reflection on the importance of educational games in teaching, the article proposes the development of an educational game especially to assist in teaching the functionalities on the symbols of logic. It highlights the contribution of this game to the teaching-learning of these rules and symbols and, finally, concludes by showing the importance of this activity in the educational process.*

Keywords**— Logic. Teaching in Logic. Educational Games.**

I. INTRODUCTION

The purpose of this article is to present the results of an analysis of National Curricular Parameters (NCP), National Curricular Guidelines (NCG) and National Curricular Basis (NCB), in primary and secondary education, regarding the recommendations of contents for mathematical logic. It was also analyzed a political pedagogical project of the fundamental education of a public school, as to presence of mathematical logic contents, which had as reference for its elaboration, the National Education Documents mentioned above. The Federal Constitution of 1988, in its article 210, establishes that "minimum contents for primary education should be established, so as to guarantee basic homogeny education and respect for cultural, artistic, national and regional values." This is ratified in the National Education Guidelines and Bases Law (law 9.394/96) and later official documents, such as the National Curricular Parameters (NCP) and the National Curricular Guidelines (CNG). CNG are mandatory standards, set by the National Education Council (NEC), which guide the curricular planning of schools and education systems. They address early childhood education, primary education, secondary education and teacher training. NCP are only curricular references (recommendations).

The Curricular National Base (CNB), in preparation since 2015, finally emerged in December 2017, in compliance with article 210 of the Federal Constitution of 1988. The document deals with early childhood education (kindergarten and pre-school) and elementary education (1st to 9th year). The NEC will discuss in another moment the curricular base of high school. CNB will now be the national benchmark for schools to develop their pedagogical projects. The Base does not exclude the official documents mentioned above. From the analysis of the contents, we want to base the importance of educational games in the teaching of mathematical logic and to elaborate a project of an educational game specially for teaching the rules and symbols of mathematical logic. It will not be approached the argument of the mathematical logic, as far as the rules and concepts of the premises and conclusions of a logical mathematical argumentation, the work will be focused only in the functionality of the symbols of the mathematical logic, contemplating an interdisciplinarity between the disciplines

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of Arithmetic, Statistics and Mathematical logic. (MEC, 2018).

The importance of educational games in primary and secondary education. Our experience as teachers allows us to conclude that educational games play a fundamental role in the student's development in the following areas: social interaction, cognitive, political and cultural development. Students who, because of shyness or other reason, do not interact with the teacher or classmates, find in games the opportunity to break down these barriers, develop their skills, become more participative, and even formators of opinions and ideas in the classroom educational and social interaction.

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This is especially recommended for high school NCP in relation to games in the educational environment. In our research we find in the descriptions of the NCP high school the following text: "Games and child play are very valuable elements in the process of knowledge appropriation. They allow the development of competences in the field of communication, interpersonal relations, leadership and teamwork, using the relationship between cooperation and competition in a formative context.

The game offers the stimulus and environment conducive to the students' spontaneous creative development and allows the teacher to broaden their knowledge of active teaching techniques, developing personal and professional capacities to stimulate in students the ability to communicate and express themselves by showing them new way, playful and enjoyable and participatory, to relate to the school content, leading to a greater appropriation of the knowledge involved. Using games as a pedagogical tool is not restricted to working with ready games, in which rules and procedures are already determined; but mainly, to stimulate the creation by the students of games related to the themes discussed in the context of the classroom. Content suitable enough to create games with students is the content related to the thematic unit."(BRASIL, 2000)

Table.1: Existence of mathematical logic content in elementary education

NCB	NCP	NCG
It does not cite directly mathematical logic. It cites in a very generic way the computational technology.	It does not cite directly mathematical logic. It cites in a very generic way the computational technology.	It does not cite directly mathematical logic. It cites in a very generic way the computational technology.

Source: MEC, 2018.

Analysis of the recommendations and obligatoriness regarding the existence of mathematical logic content, for elementary and secondary education. According to Table 1, the comparison of the existence of the content of mathematical logic in the national education documents is presented and in Table 2 the contents of mathematical logic for High School.

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Table.2: Existence of mathematical logic content in high school

NCG	NCP	High school PPC in a public school
It does not cite directly mathematical logic. It cites in a very generic way the computational technology.	Mathematics validates and presents its knowledge, as well as fostering the development of deductive logical thinking and the more structured aspects of mathematical language. To assert that something is "true" in Mathematics usually means to be the result of a logical deduction, that is, to prove an affirmation (theorem) one must show that it is a logical consequence of other previously proved propositions.	It does not cite directly mathematical logic. It cites in a very generic way the computational technology, it has as base for the teaching the contents of the didactic books, that also are not specific, as far as the content of the mathematical logic.
	Informing and informing oneself, communicating, expressing oneself, arguing logically, accepting or rejecting arguments, expressing preferences, pointing out contradictions, making proper use of different nomenclatures, different codes and different means of communication are general competences that make part of the resources of all the disciplines, and that, therefore, they must develop in the learning of each one of them.	

Source: MEC, 2018.

II. THE PROPOSAL (GAME IN TEACHING THE FUNCTIONALITIES OF THE SYMBOLS OF MATHEMATICAL LOGIC)

The proposal is the design and development of an educational game, to aid in the teaching of the functionalities of the symbols of the logic of mathematics and indirectly in the teaching of statistics.

The fundamental element, in spoken or written language, is the simple proposition formed by a name and a predicate. So when we say "Mars is a planet" we have a proposition, where "Mars" is a name or designation and "is a planet" is the predicate or attribute. Every proposition has one of two values, "false" or "true," there being no other, which is called the principle of the excluded third. From simple propositions we can form others, using the connectives "and", "or", "if ... then", "if and only if" and or exclusive, represented by the symbols, ∨, →, ↔, V , respectively. We can also use the modifier "no" (not true), represented by the symbol ¬, for the creation of new propositions (ALENCAR FILHO, 2002).

The game works with the symbols of mathematical logic ∧ (e), ∨ (or), → (if ... then) ↔ (if and only if), ¬ (no) and V (or exclusive). It has the following functionality: for the symbol ∧, called conjunction, the result of an operation is true, only if the two values assigned to the variables are true, in other cases the result will be false. For the symbol ∨, called disjunction, the result of an operation will be false only if the two values assigned to the variables are false, in other cases the result will be true. For the symbol →, called conditional, the result of an operation will be false, only if the second value is false; in other cases the result will be true. For the symbol ↔, denominated bicondictional, the result of an operation will be true, only if the two values assigned to the variables are false or true, in other cases the result will be false. For the symbol V, called *or unique*, the result of an operation is true only if the two values assigned to the variables P and Q are different, if these values are equal, the result will be false. Figures 1 and 2, below, show the configuration of the values of the variables and results, according to the logical connective.

Variable	**Variable**	**Conjunction**	**Disjunction**	**Condictional**	**Bicondictional**	**Exclusive Disjunction**
P	**Q**	**P ∧ Q**	**P ∨ Q**	**P → Q**	**P ↔ Q**	**P V Q**
V	V	V	V	V	V	F
V	F	F	V	F	F	V
F	V	F	V	V	F	V
F	F	F	F	V	V	F

Fig.1: Configuration of variable values and results.

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Variable	Negation
P	**¬ P**
V	F
F	V

Fig.2: The modifier for values of variables (negation).

The game consists of presenting the mathematical logic symbols for the player's choice and can be played by one or two players and a mediator . The Functionality of the game. After the player chooses a (connective) symbol, it is presented to the variables (P and Q) with the values of V (true) or F (false), so that he decides what the answer is, for the situation presented. After the answer, you are presented again with the variables (P and Q), now with some of the possible changes of their values (V or F), and so on, until the player chooses to stop at the end of the game when it is presented the performance summary (duration, number of hits, number of errors per symbol chosen and overall).

Conjunction (AND) **(∧)**			**Disjunction** (OU) **(∨)**		
P ∧ Q		**R**	**P ∨ Q**		**R**
V	**V**	**?**	**V**	**V**	**?**
V	**F**	**?**	**V**	**F**	**?**
F	**V**	**?**	**F**	**V**	**?**
F	**F**	**?**	**F**	**F**	**?**

Fig.3: If the choice was conjunction (AND) or disjunction (OR).

Example: If the choice was the conjunction, mediator would present the options to the player to answer V (true) or F (false), according to Figure 3.

III. RESULTS AND DISCUSSION

The contribution of this game to teaching and learning is to enable the student to develop logical reasoning, from learning the rules of the symbols of mathematical logic, so that the student will know the logical functionality, and when he has to learn mathematical logic in its fullness, rules, concepts and applicability, will already be familiar with the functionality of the symbols of logic, facilitating the acquisition of knowledge consistently and productively. This game can be applied to students in the 6th grade of elementary school onwards, with estimated time of one hour-class, for explanations of the rules of functionality.

Materials needed to apply the game are: a sheet of paper, a pen, a clock and a mediator or whiteboard, a brush and a clock. The time needed for who determines is the player or the players: it can be one minute, two minutes and so on. At the end, the mediator shows the game summary and makes the statistical calculations (duration of the game, number of errors, number of correct answers), and can use the following parameters: to find the index of errors, for example, make the quotient of the number of errors by the number of operations played, to find the ratio of hits divides the amount of hits by the amount of operations played and to find the average response time of each player's operation, divides the player's used time by the amount of operations. The implementation of this game requires a programming language and a database to store the information of the game and the players. In the implementation, the statistical summary calculations would also be demonstrated.

The game was applied to a group of 25 (twenty-five) elementary students and 28 (twenty-eight) high school students, the achievement result in the understanding of mathematical logic was excellent, it was noticed that students understood the dynamics of the game, although there was some difficulty in understanding and memorizing the meaning of some symbols ("if ... then" and "if only") in the class of primary school students, but after the application of three exercises, the difficulties of understanding the rules of functionality and concepts of values, were overcome and the average achievement was 75% of correct answers with high school students and an average of 70% of correct answers, with elementary students. Overall the result was very good, considering that the subject is little explored in the textbooks currently adopted.

IV. FINAL CONSIDERATIONS

From the researches, on educational games, proposed in the NCP, and on-site verification, we noticed that the practice of using educational games is little used by teachers, and that this practice should be more applied in classrooms, helping the teacher in working with students who present difficulties in learning. The classes would become much more dynamic, the acquisition of knowledge would have better rates of achievement and the student would feel much better able to learn what he is studying. There is a need for better preparation of education managers to motivate and assist teachers in the preparation and elaboration of intuitive and deductive games as aids in the acquisition of student knowledge. From the time that teachers start to use educational games more in classrooms without departing from the proposed objectives for the subjects, the level of learning will certainly be better and other educational indices may also improve. Often the student becomes a quitter because he feels unable to learn.

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